Acta Anaesth. Bel., 2024, 75 | Suppl. 1: 47-53

Masterthesis / Original study

Foot Drop as a complication of critical illness: a retrospective analysis

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Abstract

Background: **Foot drop (FD) is commonly encountered in critical care patients, however, the exact pathophysiology and incidence remains unknown.**
Design: **Retrospective single-center study.**
Objectives: **We aim to describe the incidence of FD in long lie critically ill patients and propose a protocol to enhance early screening in this population.**
Methods: **Between 1st of January 2020 and 31 December 2022, we screened all patients with a prolonged ICU stay of seven days or more for the presence of clinical FD, using a Medical Research Council foot dorsiflexion score of less than two. In this group, an ICU physician reviewed medical charts to assess clinical and electrodiagnostic (EDX) signs of peroneal neuropathy.**
Outcome measures: **We screened for risk factors such as severity of illness, duration of ICU and hospital stay and organ failure.**
Results: **57 out of 879 long lie ICU patients had clinical FD, of which 26 had EDX confirmed peroneal neuropathy. Compared to the group without FD, patients with clinical FD had significantly higher APACHE III scores (77.5 versus 72, $p < 0.05$), ICU length of stay (30 versus 13.6 days, $p < 0.05$) and hospital length of stay (58.4 days versus 27.3 days, $p < 0.05$). Furthermore, more patients had received mechanical ventilation (89% versus 62%, $p < 0.05$) and duration of mechanical ventilation was longer (19 versus 10 days, $p < 0.05$). Also renal failure (54% versus 22%, $p < 0.05$), need for renal replacement therapy (33% versus 10%, $p < 0.05$) and duration of renal replacement therapy (13 days versus 7 days, $p < 0.05$) was higher in the FD group. Extra-Corporeal Membrane Oxygenation (ECMO) was more prevalent in the FD group (14% versus 2.5%, $p < 0.05$); duration of ECMO run however was similar in both groups (11.4 days versus 11 days, $p = 0.9$).**
Conclusions: **FD is common and associated with a higher degree of organ failure most likely both as cause and effect. Early screening by means of MRC foot dorsiflexion and EDX testing in patients with prolonged ICU stay is essential to avoid delay in treatment and revalidation.**

Keywords: **Peroneal Nerve Entrapment, Peroneal neuropathies, Polyneuropathy, Critical Illness, Critical Care, Intensive Care.**

Ethical approval was granted by ZOL ethical committee under number Z-2023042.
Date of ethical approval: June 1st 2023 - Chairman: Prof Patrick Noyens.
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Introduction

Peroneal neuropathy is a well-known cause of foot drop (FD) and the most frequent encountered entrapment neuropathy of the lower limb[1]. The common peroneal nerve (CPN) is prone to compression at the level of the fibular head due to its superficial course. In addition, the vascular arrangement that supplies the CPN might make it more susceptible for ischemia due to thrombosis or limited blood flow[2]. Important risk factors that may predispose to peroneal nerve palsy (PNP) are excessive weight loss, diabetes mellitus and prolonged bed rest[1,3]. Also, profound hypotension and severe limb edema due to positive fluid balances may predispose for hypoperfusion of the CPN.

Although the exact pathophysiologic mechanism and incidence rate is not well known in critical care, patients requiring intensive care may have both pre-existing and intensive care disease specific risk factors for acute FD. Since the COVID pandemic, new interest in critically ill patients with FD has emerged[4]. In many reports and review articles however, FD is mostly seen in conjunction with the presence of Intensive Care Unit Acquired Weakness (ICU-AW), which may not be surprising given a potential overlap in risk factors such as hyperglycemia, prolonged bed rest and muscle wasting[5,6].

Early detection and treatment of PNP is imperative since up to 35% of untreated patients will suffer from limb disability affecting functional outcome and quality of life[1]. In a community dwelling population, patients with PNP will report gait difficulties. In critically ill patients, however, this classical presentation may not be present or may go undetected. Bedridden patients that are conscious and interactive can be screened for foot drop clinically by using the Medical Research Council summation score or MRC-sum score[4]. This score evaluates global muscle strength by assessing manual strength of six muscle groups (shoulder abduction, elbow flexion, wrist extension, hip flexion, knee extension and foot dorsiflexion) on both sides of the body. Each muscle group is evaluated and given a score ranging from zero (no movement) to five (normal power). Summation of scores gives the MRC sum score which ranges from zero to 60. It has proven to be a valid and reliable scoring system to detect ICU-AW if the MRC-sum score falls below 48.

In this retrospective analysis, we aimed to describe the incidence of FD in long lie patients in our intensive care unit. We also screened for risk factors such as severity of illness, duration of ICU stay, organ failure and steroid use. In addition, we propose a new locally implemented protocol to further increase the awareness of acute foot drop and improve patient care.

Methods

Ethical committee approval

The study was approved by the local ethics committee under study number Z-2023042. Given the retrospective nature of the study, patient consent was waived by the ethics committee.

Patient selection and data collection

We retrospectively screened all patients, admitted to the tertiary mixed type (medical and surgical patients) ICU of the East-Limburg Hospital in the period from 1st of January 2020 until 31 December 2022 and having a prolonged intensive care stay of seven days or more, for the presence of FD. This time frame of 7 days was set based on previous literature on ICU-AW in which the risk of ICU-AW increased when ICU stay was up to 7-10 days[7]. Out of a total of 7250 admitted patients, 879 stayed for at least seven days. Electronic records were queried for baseline characteristics such as age, sex, weight, Body Mass Index (BMI), Charlson Comorbidity Index (CCI) and APACHE III score. We used the foot dorsiflexion score of the MRC sum score to screen for clinical foot drop[4]. The MRC scoring is performed in patients with expected prolonged ICU stay and is done in patients that are awake and cooperative. MRC scoring is part of our early mobilization protocol and is executed by a fixed team of experienced physiotherapists. After the first selection of patients with clinical foot drop, an experienced ICU physician (XW) reviewed the physiotherapy and neurophysiology notes to assess the clinical and electrophysiological signs of foot drop. Despite the presence of electronic patients records, the required data had been entered as 'free text' in the medical file and given the retrospective nature of the study, the review process required a careful reading and interpretation of the available data.

In this group, patients with foot drop due to other causes (e.g. stroke, paraplegia, traumatic brain injury) were excluded. In the patients that had received electrodiagnostic testing or EDX, the incidence and type (myopathy versus polyneuropathy) of ICU-AW was noted.

In this retrospective analysis, we specifically focused on the MRC foot dorsiflexion score since this reflects the activity of the anterior muscle compartment of the lower leg and hence reflects peroneal nerve activity. MRC foot dorsiflexion

score was used to dichotomize the main outcome parameter of foot drop: a score of zero (no visible contraction) or one (visible contraction but no limb movement) in minimum one foot was considered as clinical foot drop. Scores of two (active movement but not against gravity) and above were considered as normal or no foot drop.

Patient baseline characteristics and post admission variables

A pre-specified set of baseline characteristics (age, sex, body mass index or BMI, APACHE III score, Charlson Comorbidity Index or CCI) and post admission variables (ICU length of stay (ICU LOS), hospital length of stay (HOS LOS), MRC sum at discharge (if not available the value closest to the date of discharge was taken), incidence and duration of invasive ventilation, renal failure as defined by a creatinine clearance below 30 mg/dL or urea level > 150mg/dL, the need for renal replacement therapy and ECMO) were assessed. The incidence of hyperglycemia and the maximum glycemic values were also noted. A patient was considered as having a day of poor glycemic control if at least one glycemic measurement was above 180mg/dL.

Statistical analysis

Categorical data are presented as numbers and percentages and compared by chi-square testing. Continuous data were presented as median and interquartile ranges and compared using the two sided t-test. Statistical analyses were performed using PRISM software. Two sided p-values < 0.05 were deemed statistically significant. No correction for multiple testing was done.

Results

From the grand total of 7250 admitted patients in the specified time period, we selected 879 patients that were admitted to our ICU for a period of at least seven days. Patient selection and main results are shown in Figure 1. From the 879 patients, we recovered MRC sum and MRC foot dorsiflexion scores in 577 patients (65%); unfortunately 302 patients (35%) did not have any notes on MRC scores. Ninety-one patients had an MRC score for foot dorsiflexion ≤ 1. An alternative diagnosis was established in 34 patients based on medical chart review: ischemic and hemorrhagic stroke (n=11), spine injury (n=10), traumatic brain injury (n = 4), encephalopathy (n=4), pre-existing neurological condition (n=3), Guillain Barré Syndrome (n=1) and multi-trauma with limb fixation (n=1). These patients were excluded from further analyses. In our study population (n = 879), 57 patients were thus believed to have clinical FD. The incidence of FD in our study is therefore estimated to be 3.2 per 100 long-stay ICU patients per year. Patient baseline characteristics are shown in Table I.

EDX was available in 48 of the remaining 57 patients. EDX confirmed the clinical suspicion of FD due to peroneal neuropathy in 26 patients. EDX was negative in three cases and inconclusive in one case. Since EDX was primarily performed to detect and distinguish the type of ICU-AW in this patient population, the EDX technician did not routinely screen for peroneal nerve palsy, as such the diagnosis remained a clinical diagnosis on the basis of the physiotherapist's notes in 18 patients.

Regarding laterality of clinical foot drop, left sided FD was found in 13 patients (23%), right

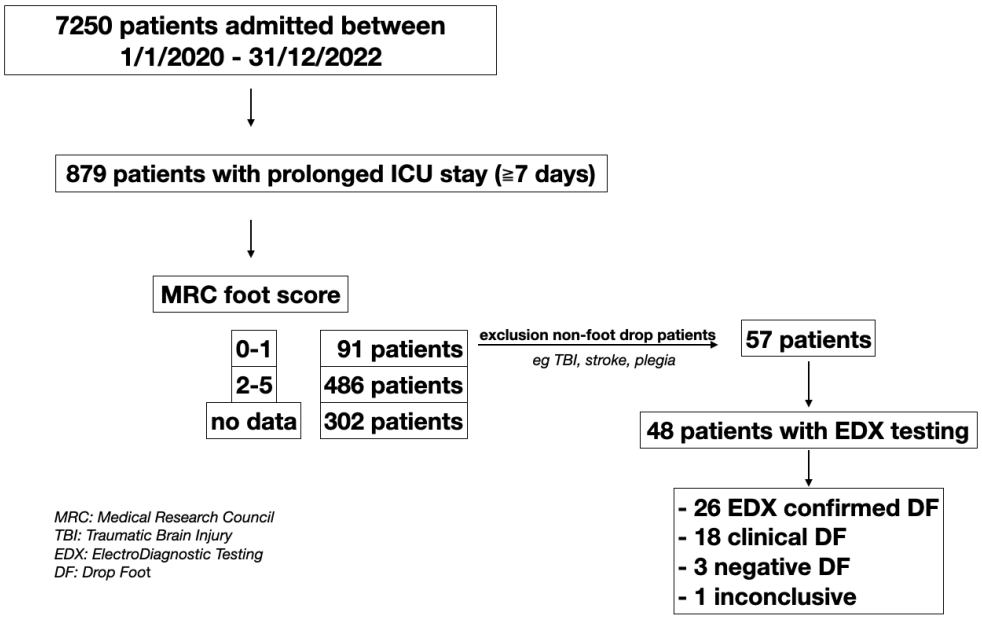

Fig. 1 — Patient selection flow chart and main outcome results.

Table I. — Patient baseline characteristics.

	NO FOOT DROP (n=486)	FOOT DROP (n=57)	
Age, median (IQR)	68 (58-75)	64.5 (58-74)	p = 0.35
Male sex (%)	64%	61.4%	p = 0.7
BMI, median (IQR)	27 (23-31)	28 (25-31)	p = 0.4
APACHE 3, median (IQR)	72 (58.5-83)	77.5 (59-94.5)	p < 0.05
CCI, median (IQR)	4 (2-6)	3 (2-6.5)	p = 0.4
Medical patients, non-COVID	171 (35%)	23 (40%)	p = 0.16
Medical patients, COVID	129 (27%)	16 (28%)	p = 0.83
Surgical patients	186 (38%)	18 (32%)	p = 0.32

sided FD in 10 patients (17%) and bilateral FD in 34 patients (60%).

ICU-AW was found in 35 of the 48 patients (73%) who underwent EDX studies. ICU-AW type myopathy was found in 24 patients (69%) and ICU-AW type polyneuropathy in 11 patients (31%). Interestingly, FD did not only occur in patients with ICU-AW: 13 patients with EDX proven absence of ICU-AW had clinical FD (of which nine had EDX confirmation of DF).

As shown in Table II there are significant differences in the predefined post admission variables in between both groups. The median length of ICU stay (ICU LOS) and hospital length of stay (HOS LOS) were significantly longer in the FD group: FD patients had ICU LOS and HOS LOS of respectively 30 and 58.4 days versus ICU LOS and HOS LOS of 13.6 and 27.3 days respectively in patients without FD (table 2). In the FD group, more patients had received invasive mechanical ventilation (89% versus 62%) and the duration of mechanical ventilation was significantly longer (median 19 versus 10 days) compared to patients without FD.

In spite of implementing a rigorous glycemic protocol, the regulation of blood glycemia levels seemed to be inadequate. Both the proportion of days with suboptimal glycemic control in relation to the length of stay in the ICU and the median measured maximum glycemic levels were higher in the FD group compared to the no FD group. It is important to highlight that while this observation holds statistical significance, the disparity is merely descriptive and may not indicate a causal relationship.

Renal failure was more prevalent in the FD group. More patients received renal replacement therapy in the FD group (33% versus only 10% in the no FD group) and the median total duration of renal replacement therapy was longer in the FD group: 13 days versus 7 days.

ECMO was more prevalent in the FD group: 14% of patients had been on ECMO in the FD group, versus only 2.5% in the patient group without signs of FD. Duration of ECMO run was similar between both groups in absolute numbers: 11 days versus 13 days in the no FD and FD group respectively.

Prevalence of patients having received at least one gift of corticosteroids was comparable in both

Table II. — Patient post-admission variables.

	NO FOOT DROP (n=486)	FOOT DROP (n=57)	
MRC at discharge, median (IQR)	48 (42-56)	36 (30-43)	p < 0.05
ICU LOS, median (IQR)	13.6 (9.2-22.4)	30 (18.4-47.8)	p < 0.05
HOS LOS, median (IQR)	27.3 (18-48.8)	58.4 (39.3-77)	p < 0.05
Invasive ventilation, number of patients (%)	301 (62%)	51 (89%)	p < 0.05
Duration of invasive ventilation, median (IQR)	10 (5-19)	19 (10-29)	p < 0.05
n of days with poor glycemic control, median (IQR)	4 (1-8)	8.5 (4-14)	p < 0.05
Glucose max, median (IQR)	228 (200-264)	254 (224-276)	p < 0.05
Blood urea > 150; n of patients (%)	81 (17%)	24 (42%)	p < 0.05
Creat clearance < 30; n of patients (%)	109 (22%)	27 (54%)	p < 0.05
RRT; n of patients (%)	50 (10%)	19 (33%)	p < 0.05
RRT; n of days, median (IQR)	7 (3.3-13)	13 (8-23)	p < 0.05
ECMO; n of patients (%)	12 (2.5%)	8 (14%)	p < 0.05
ECMO; n of days, median (IQR)	11 (6-20.5)	11.4 (8.8-13.6)	p = 0.9
Corticosteroids; n of patients (%)	51 (10.5%)	8 (14%)	p = 0.4

groups: 10.5% in the no FD group versus 14% in the FD group; the exact dose of administered corticosteroids however was not evident from the available data.

Median MRC sum score at discharge from the intensive care unit was significantly lower in the FD group versus the no FD group: 36 versus 48; indicating that patients with foot drop are generally weaker when leaving the unit.

Discussion

Discussion of results

Our data suggest that FD patients have higher median APACHE III scores than the no FD group. This finding might be explained by the fact that patients with higher APACHE III scores are in general more fragile and have more co-morbidities, acute physiologic abnormalities or major preexisting physical disabilities, all being possible risk factors for the development of peroneal nerve palsy. For example, risk factors that are also criteria in the APACHE III score include hyperglycemia, elevated blood urea or prolonged hospital stay prior to ICU admission. It is somewhat surprising that despite APACHE III scores being different in between both groups, the CCI appears to be balanced between groups. A potential explanation might be that APACHE III score was designed to predict mortality in the acute setting of critical care. It focuses on the acute dysregulations in physiology and only takes into account a couple of the chronic co-morbidities such as the presence of heart failure, cirrhosis, chronic lung disease and dialysis. CCI on the other hand was primarily created to assess the risk of mortality in longitudinal studies; as such it focuses much more on the chronic health condition of a patient[8,9]. The lack of difference in CCI could indicate that acute foot drop is much more the effect of disruptions in acute physiology rather than pre-morbid chronic health conditions.

Another important finding of this study is that out of all FD patients with EDX data, 73% also showed electromyographic signs of ICU-AW, the myopathy type being more frequent than the neuropathy type. In addition, the majority of our patients had bilateral foot drop. Our results are in line with the study performed by Zifko et al. and support the theory that ICU-AW could be an important risk factor in the development of foot drop or at least share common risk factors[6].

The presence of FD seems to be correlated with longer median hospital and ICU stay. A possible explanation for this is that prolonged bed rest is one of the risk factors for developing peroneal nerve palsy. On the other hand, patients with foot drop might face more difficulties during their recovery as a consequence of limb disability, gait problems or falling. This could in turn lead to longer revalidation periods and thus prolonged hospital stay.

Diabetes is often complicated with diabetic neuropathy, even in the earlier stages of the disease. Although the exact pathophysiological mechanism remains unclear, it is believed that hyperglycemia can lead to microvascular damage and subsequently cause neuropathy. Previous studies from Van der Velde et al. and Chiles et al. have already shown that diabetes and hyperglycemia are associated with sensorimotor peripheral nerve dysfunction, objectively measured with electrophysiological techniques[10,11]. Accordingly, our study data show that patients in the FD group had significantly more days with poor glycemic control and reached higher peaks of blood glucose levels compared with the no FD group.

It is known that corticosteroids elevate blood glucose and cause steroid related diabetes mellitus and associated diabetic peripheral neuropathy or DPN. Despite the fact that DPN is usually seen in patients with a long history of diabetes, acute onset neuropathy has been described[12]. The use of corticosteroids has also been linked with ICU-AW[13]. In our study, however, an equal proportion of patients in both groups received at least one dose of corticosteroids. Corticosteroid use could thus not be linked with the onset of FD. Also, we found no literature describing a link between corticosteroid use and the occurrence of peroneal nerve palsy and foot drop.

In our study population, there was an association between the presence of FD and higher levels of blood urea, lower creatinine clearance and a higher need for renal replacement therapy. These findings are not surprising as chronic kidney disease and accumulation of uremic toxins are well-known risk factors in the development of neuropathy, although the underlying pathophysiologic mechanism is not really clear. It is believed that neuropathy becomes more prevalent with progressive renal failure. High prevalence of neuropathy in patients with end-stage renal disease was also reported in the FINESSE study, a randomized controlled trial that compared the effect of hemodiafiltration and hemodialysis on neuropathy progression by clearance of uremic toxins[14].

Significantly more patients in the FD group received ECMO support compared with the no FD group, although there was no significant difference in duration of ECMO run between both groups. Literature describing FD related to ECMO support was scarce. However, in their retrospective review

of 153 patients receiving V-A ECMO, Bergeron et al. described an incidence of FD of 7.8%[15]. The authors believe that FD might be a result of ischemic injury to the common peroneal nerve due to the non-pulsatile flow of V-A ECMO, which could lead to poor perfusion of the microcirculation supplying the nerve[2,15]. Other risk factors might include prolonged immobility and the use of knee immobilizers. In the future, larger studies with more qualitative data are needed to support these findings.

Finally, MRC sum scores at discharge are significantly lower in the FD group indicating that these patients are weaker at discharge. In the FD group the median total MRC sum score in the upper extremity is 20 (on a total of 30 points) while this score is up to 24 in the no FD group, which is a statistically significant difference. The median total MRC score in the lower extremity in the FD group was also significantly lower at 14.5 (on a total of 30 points) versus 24 in the no FD group. It is clear from these numbers that the relative contribution of the foot drop may play an important role in the total MRC sum score.

Limitations of study

Our study has several limitations. First of all the retrospective nature of the study makes it prone for bias. Also one in three patients did not have an MRC sum score performed. It may be possible that these patients were ambulating well during their recovery phase in critical care and that MRC sum scoring was deemed irrelevant. However, it may also very well be that this patient group was too ill to have MRC sum scores performed.

During chart review, we aimed to retrieve the parameters that we believed play a role in the onset of FD, however, data on episodes of hypotension or low flow, fluid balances, limb edema, patient positioning and more importantly patient weight and muscle mass at the end of critical illness were not obtained.

Implementation of new protocol

During the analyses of the EDX data we noted that the use of EDX in critical care at our institution is merely to detect and distinguish subtypes of ICU-AW. In the patients that had received EDX, almost 55% had an incidental finding of foot drop. We believe that foot drop is an under-diagnosed but important clinical entity complicating critical illness. For this reason we have changed our practice since April 2023. Not only is there a higher degree of clinical suspicion by our medical team and physiotherapists, also the EDX reporting has changed and routine screening for brachial plexopathy, ulnar nerve and peroneal nerve neuropathy has become standard of care. In a positive screening, an increased bedside and post-ICU physical therapy is initated. Awaiting the results from the FOOTDROP trial, performed by Dr. T. Theys and Dr. C. Oosterbos, these patients are often referred for neurosurgical evaluation and potential nerve decompression.

Conclusion

In our study we described the occurrence of foot drop as a complication of critical illness. We highlighted the association of foot drop and organ failure as shown by higher APACHE III scores, increased occurrence and duration of invasive mechanical ventilation and renal failure in the foot drop group. Acute foot drop was also shown to be associated with prolonged ICU and hospital stay. We believe that foot drop is probably under-diagnosed in this patient population and we advocate an active clinical screening in combination with electrodiagnostic testing in long lie critically ill patients.

Funding and disclosure of interest: The authors declare no conflicts of interest. No financial support was provided to perform this study.

Data sharing policy: All authors agree on sharing data reported in this study. Please contact the corresponding author.

References

1. Poage C, Charles R, Scott B. Peroneal Nerve Palsy: Evaluation and Management. J Am Acad Orthop Surg. 2016;24(5):1–10.
2. Ugrenovic SZ, Jovanovic ID, Kovacevic P, Petrovič S, Simic T. Similarities and dissimilarities of the blood supplies of the human sciatic, tibial, and common peroneal nerves. Clin Anat. 2013;26(7):875–82.
3. Oosterbos C, Decramer T, Rummens S, Weyns F, Dubuisson A, Ceuppens J, et al. Evidence in peroneal nerve entrapment: A scoping review. Eur J Neurol. 2022;29(2):665–79.
4. Turan Z, Topaloglu M, Ozyemisci Taskiran O. Medical Research Council-sumscore: A tool for evaluating muscle weakness in patients with post-intensive care syndrome. Crit Care. 2020;24(1):4–5.
5. Latronico N, Shehu I, Seghelini E. Neuromuscular sequelae of critical illness. Curr Opin Crit Care. 2005;11(4):381–90.
6. Zifko UA. Long-term outcome of critical illness polyneuropathy. Muscle and Nerve. 2000;23(SUPPL. 9):49–52.
7. Hermans G, Van den Berghe G. Clinical review: intensive care unit acquired weakness. Crit Care. 2015;19(1):274.
8. Hermans G, Van Mechelen H, Clerckx B, Vanhullebusch T, Mesotten D, Wilmer A, et al. Acute outcomes and 1-year mortality of intensive care unit-acquired weakness: A cohort study and propensity-matched analysis. Am J Respir Crit Care Med. 2014;190(4):410–20.

9. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A New Method of Classifying Prognostic Comorbidity in Longitudinal Studies : Development and Validation. J Chronic Dis. 1987;40(5):373–83.
10. Van der Velde JHPM, Koster A, Strotmeyer ES, Mess WH, Hilkman D, Reulen JPH, et al. Cardiometabolic risk factors as determinants of peripheral nerve function: the Maastricht Study. Diabetologia. 2020;63(8):1648–58.
11. Chiles NS, Caroline L. Phillips, Volpato S, Bandinelli S, Ferrucci L, Guralnik JM, et al. Diabetes, Peripheral Neuropathy, and Lower Extremity Function. J Diabetes Complicat. 2014;28(1):91–5.
12. Yuan JL, Sun L, Su BL, Hong CX. Case report: Corticosteroids-induced acute diabetic peripheral neuropathy. Front Endocrinol (Lausanne). 2022;13(August):3–6.
13. Yang T, Li ZQ, Li HL, Zhou JX, Chen GQ. Corticosteroid use and intensive care unit-acquired weakness: A systematic review and meta-analysis. Crit Care. 2018;22(187):1–10.
14. Kang A, Arnold R, Gallagher M, Snelling P, Green J, Fernando M, et al. Effect of hemodiafiltration on the progression of neuropathy with kidney failure: A randomized controlled trial. Clin J Am Soc Nephrol. 2021;16(9):1365–75.
15. Bergeron A, Nathan S, De Armas IS, Smith K, Gilley C, Janowiak L, et al. Is Foot Drop an Underreported Sequela of Extracorporeal Membrane Oxygenation? ASAIO J. 2022;68(6):839–43.

doi.org/10.56126/76.S1.011