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Critical care

Can physical assessments in the Intensive Care Unit predict post-hospital rehabilitation requirements in patients requiring prolonged mechanical ventilation? – A service evaluation

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Abstract

Introduction

Patients requiring prolonged mechanical ventilation (MV) experience significant physical morbidity, necessitating ongoing rehabilitation post-hospital discharge. Early prediction of the need for ongoing rehabilitation could expedite discharge planning and improve patient outcomes.

Aim/Objectives

To assess the predictive accuracy of the Chelsea Critical Care Physical Assessment Tool (CPAx), Medical Research Council Sum Score (MRC-SS) and Manchester Mobility Score (MMS), with respect to the need for ongoing rehabilitation post-hospital discharge in patients requiring prolonged MV at our institute.

Methods

A retrospective service evaluation was performed for consecutive patients admitted to the Queen Elizabeth Hospital Birmingham intensive care unit (ICU) between September 2022-June 2024 requiring ⩾4 days MV, without severe traumatic or neurological injury. The predictive accuracies of physical assessments performed on first mobilisation in ICU and at ICU discharge were quantified using the area under the receiver operating curve (AUROC).

Results

Of N=141 patients, N=113 survived to hospital discharge, of whom 51% (N=58) required ongoing rehabilitation. At the first mobilisation in ICU, all physical assessments were significantly predictive of the need for post-discharge rehabilitation, with the CPAx (AUROC: 0.79; 95% CI: 0.71-0.87) outperforming the MRC-SS (0.72; 0.63-0.82) and MMS (0.65; 0.55-0.75); the optimal thresholds were: CPAx⩽10, MRC-SS⩽25 and MMS=2. At ICU discharge, all assessments had similar predictive accuracy (AUROCs: 0.78-0.80).

Conclusion

For patients treated at our institute, the CPAx had superior accuracy for the prediction of ongoing rehabilitation post-hospital discharge compared to the MRC-SS and MMS, when performed at first mobilisation. All three outcomes demonstrated very good predictive accuracy when performed at ICU discharge. Further research is required to identify a core outcome dataset within the ICU to guide clinician decision making.

INTRODUCTION

Critical illness often necessitates prolonged periods of mechanical ventilation (MV) and hospitalisation, and is associated with significant physical, cognitive, and psychological morbidity.[1] A sequela of critical illness is the development of Intensive Care Unit Acquired Weakness (ICU-AW), defined as muscle weakness that cannot be attributed to causes other than critical illness,[2] and characterised by symmetrical weakness of all four limbs and respiratory muscles. Consequently, ICU survivors demonstrate reduced activity levels and quality of life (QoL),[3] which often persist for 6-12 months post-hospital discharge, and can last for up to 10 years.[4] Patients with ICU-AW often require ongoing rehabilitation.[5]

Early discharge planning and organisation of post-ICU rehabilitation is paramount to facilitate recovery and prevent prolonged morbidity.[6] This can also lead to improved hospital flow through minimising delays in hospital discharge; reduced risk of secondary hospital-acquired morbidity[7]; and improved patient satisfaction, due to the seamless transition from acute to primary and secondary care services, and the management of patient and family expectations.[8] National Institute for Health and Care Excellence (NICE) guidance states that discharge planning should commence at hospital admission[9] and emphasises the importance of comprehensive and early assessment of ICU patients' rehabilitation needs.[10] However, NICE does not provide guidance in which assessments should be used. The International Classification of Functioning framework[11] outlines 26 self-reported and physical assessments to measure whole body function, whilst a 2015 systematic review[12] identified 33 different assessments of muscle mass, strength, and function. However, only six, including the Chelsea Critical Care Physical assessment (CPAx) tool, have undergone rigorous clinometric evaluation within ICU populations.[13] A 2014 study found CPAx performed at ICU discharge to be significantly associated with the hospital discharge location,[14] with a 2023 study reporting an area under the receiver operating characteristic curve (AUROC) of 0.78 (95% confidence interval [CI]: 0.64-0.91) for the prediction of patient's ongoing rehabilitation requirements.[15] Additionally, the first five items of the CPAx have been shown to be significantly predictive of the development of new physical disability after hospital discharge, with an AUROC of 0.68 (95% CI 0.61-0.76).[16] Limited research has been undertaken to evaluate the predictive accuracy of the Manchester Mobility Score (MMS)[17] or Medical Research Council Sum-Score (MRC-SS)[18]; however, being able to step transfer to a chair or mobilise (MMS ⩾5) and the absence of ongoing ICU-AW (MRC-SS >48) at ICU discharge have been associated with improved hospital survival in patients requiring ICU admission[19,20] and these assessments are included in previous systematic reviews and have been integrated within standard practice at our institute.

There is currently no consensus on the optimum set of physical assessments to include in an ICU core outcome dataset, leading to varied use of physical assessments in clinical practice. There is also limited evidence for the utility of these physical assessments to support timely decision-making pertaining to discharge planning or rehabilitation requirement. As such, we aimed to assess and compare the predictive accuracy of three physical assessments commonly used at our institute: the CPAx, MMS and MRC-SS. The primary outcome was the need for ongoing rehabilitation post-hospital discharge, with secondary outcomes being ICU and subsequent hospital length of stay (LOS).

METHODS

SETTING

This service evaluation was based at the 100 bed, mixed speciality ICU at Queen Elizabeth Hospital Birmingham. The ICU has an embedded Critical Care Physiotherapy Rehabilitation Team (CCPRT), which is staffed as per Guidelines for the Provision of Intensive Care Service recommendations, and provides enhanced rehabilitation Monday-Friday. The CCPRT treats patients requiring ⩾4 days of MV who are at risk of prolonged physical, psychological and cognitive morbidity, and who are appropriate for enhanced rehabilitation. Inappropriate patients include those admitted with severe neurological or traumatic injury, and those with poor pre-admission function (i.e. unable to mobilise >10 metres). For the remainder, the CCPRT commence rehabilitation after cessation of sedation, aiming to mobilise patients either within 24 hours or as soon as they are deemed medically stable, based on clinical expertise. Due to the absence of the CCPRT, first mobilisations are not routinely performed during the weekend, unless deemed to be essential for respiratory care by the weekend physiotherapy team.

PHYSICAL ASSESSMENTS

Since September 2022, the CCPRT has routinely performed and recorded the CPAx, MMS and MRC-SS at patient milestones in the ICU. Specifically, these assessments are performed at the first mobilisation (defined as first time able to sit on the edge of bed, or better, i.e. MMS⩾2) and on the day of ICU discharge (or the nearest weekday, where discharge was expected over the weekend). The MMS is a simple, quick to complete seven-point ordinal scale, which scores mobility from passive in-bed movements (one) to mobilising >30m (seven).[17] The MRC-SS is a numerical rating scale used to quantify the strength of six muscle groups bilaterally (i.e. 12 assessments). Each muscle group is scored based on the Oxford Muscle Scale, ranging from no detectable contraction (zero points) to normal strength (five points), with the results added to give a total score out of 60.[21] The CPAx is a comprehensive assessment score of physical and respiratory function comprising ten items which are each scored from completely dependent (zero points) to independent (five points), giving a maximum score out of 50.[22]

DATA EXTRACTION

Consecutive patients admitted to the ICU between September 2022-June 2024 under the care of the CCPRT were retrospectively identified from the electronic healthcare records system (EHR). Patients were excluded if they died prior to mobilising in ICU. For the remainder, data for patient demographics, management in ICU, and outcomes including discharge destination and LOS were extracted from the EHR. To assess the primary aim of the need for ongoing rehabilitation post-hospital discharge, the hospital discharge destination was dichotomised into ongoing rehabilitation (i.e. at home or as an inpatient) or no ongoing rehabilitation. This outcome was not defined in patients who died in hospital; hence, these patients were excluded from the primary analysis. However, a sensitivity analysis was additionally performed for the composite outcome of ongoing rehabilitation or death, to assess the potential impact of selection bias resulting from these exclusions.

SAMPLE SIZE

The service evaluation was based on a convenience sample of patients under the care of the CCPRT, with the period starting when routine measurement of the physical assessments commenced. As such, since the sample size was predetermined, no statistical power calculation was performed *a priori*. However, a *post-hoc* power calculation was performed, to ensure that the sample size attained was sufficient for reliable analysis. For the observed numbers of cases and controls for the primary aim, namely the prediction of the need for ongoing rehabilitation (i.e. N=58 and N=55), this returned a minimal detectable AUROC of 0.65 at 80% power and 5% alpha.

REGISTRATION

The findings of this service evaluation were intended to optimise the future use of physical assessments at our institute, rather than to be generalisable to other institutes. As such, the project was registered and approved as a service evaluation at our institute (ID: CARMS-19462).

STATISTICAL METHODS

Correlations were assessed using Spearman's rank correlation coefficients (rho), with Kruskal-Wallis tests used to compare the physical assessments between subgroups. Predictive accuracy of the physical assessments was quantified using the AUROC, with p-values from Mann-Whitney U tests; comparisons between AUROCs were performed using the algorithm proposed by DeLong et al.[23] Binary logistic regression models were used to visualise prediction of the composite outcome. Optimum thresholds for each physical assessment were identified, based on the value that maximised the Youden's J statistic. Correlations with LOS outcomes were visualised using regression models; since LOS was skewed, values were $\log_2$-transformed prior to analysis, to improve model fit.

Continuous variables are reported as "mean ± standard deviation" where approximately normally distributed, or "median (interquartile range; IQR)" otherwise. Cases with missing data were excluded from the analysis of the associated factor. Analyses of predictive accuracy only included patients with data for all physical assessments at the time point being considered. All analyses were performed using IBM SPSS 24 (IBM Corp. Armonk, NY) and Stata 14 (College Station, TX), with p<0.05 deemed statistically significant throughout.

RESULTS

COHORT CHARACTERISTICS

During the period of the service evaluation, N=240 patients were referred to CCPRT. Of these, N=75 were not added to the CCPRT caseload, either due to insufficient capacity or being deemed not to require enhanced physiotherapy input. Of the remaining N=165 who were under the care of CCPRT, N=24 were subsequently excluded since they died in ICU prior to mobilising. The remaining N=141 patients mobilised in the ICU and were included in the analysis. Of these, N=12 (9%) died in ICU, with the remaining N=129 discharged from ICU to a hospital ward (***Table 1***). Thirteen (9%) patients subsequently died in hospital, and three patients (2%) underwent an inter-hospital transfer; the remainder were either discharged home, with (N=40; 28%) or without (N=55; 39%) ongoing rehabilitation; or discharged to inpatient rehabilitation facilities (N=18; 13%).

PHYSICAL ASSESSMENTS

At first mobilisation, patients had a median CPAx of 12 (IQR: 10-17) and MRC-SS of 24 (IQR: 9-36, ***Table 2***); MMS scores followed a highly skewed distribution, with 79% achieving an MMS of 2. A strong correlation was observed between the CPAx and MRC-SS (rho: 0.73), with noticeably weaker correlations with the MMS (rho: 0.59 and 0.54), largely due to the preponderance of patients scoring an MMS of 2 (***Supplementary Figure 1***). The MRC-SS was not recorded for N=1 patient at ICU discharge; for the remainder, strong correlations were observed between each pair of physical assessments (all rho: 0.8).

ASSOCIATIONS BETWEEN PHYSICAL ASSESSMENTS AND HOSPITAL DISCHARGE DESTINATION

All three physical assessments differed significantly with hospital discharge destination, whether performed at first mobilisation or ICU discharge, following similar trends across the four subgroups (***Table 2***). For example, the CPAx at first mobilisation decreased progressively across patients discharged home without ongoing rehabilitation (median: 16; IQR: 12-24); home with rehabilitation (median: 11; IQR: 9-14); and to inpatient rehabilitation (median: 9; IQR: 8-10). Patients who died in hospital had comparable CPAx scores to those discharged home with rehabilitation (median: 11; IQR: 10-13).

PREDICTIVE ACCURACY OF PHYSICAL ASSESSMENTS WITH RESPECT TO THE NEED FOR ONGOING REHABILITATION POST-HOSPITAL DISCHARGE

Analyses of predictive accuracy excluded patients who died in hospital; hence, were based on N=113, of whom 51% (N=58) required ongoing rehabilitation post-hospital discharge. When performed at the first mobilisation in ICU, all three physical assessments were significantly predictive of this outcome (***Table 3***). The CPAx had the best performance (AUROC: 0.79; 95% CI: 0.71-0.87), which was significantly

Table 1. Cohort characteristics

	N	Statistic
Demographics at ICU Admission		
Age at Admission (Years)	141	60 (48-69)
Gender (% Male)	141	90 (64%)
Body Mass Index (kg/m^2)	141	29.0 ± 7.3
Ethnicity	141	
White		113 (80%)
Asian		19 (13%)
Black		6 (4%)
Mixed/Other		3 (2%)
APACHE II	133	18.2 ± 5.8
Charlson Comorbidity Index	141	4 (2-5)
ICU Management		
Duration of Sedation (Days)	141	12 ± 6
Neuromuscular Blockade	141	56 (40%)
Tracheostomy	141	101 (72%)
Duration of MV (Days) [a]	131	18 (11-31)
ICU Admission to First Mobilisation (Days)	141	13 ± 6
Outcomes		
First Mobilisation to ICU Discharge [b]	129	12 (7-20)
ICU Length of Stay (Days) [b]	129	26 (16-35)
ICU Discharge to Hospital Discharge [c]	116	17 (10-26)
Hospital Length of Stay (Days) [c]	116	46 (29-64)
Discharge Destination	141	
Home with No Ongoing Rehabilitation		55 (39%)
Home Requiring Ongoing Rehabilitation		40 (28%)
Inpatient Rehabilitation		18 (13%)
Died on Ward (After ICU Discharge)		13 (9%)
Died in ICU		12 (9%)
Inter-Hospital Transfer		3 (2%)

Data are reported as "N (%)", "median (interquartile range)" or "mean ± standard deviation", as appropriate.
[a] Excludes patients who died whilst receiving MV. [b] Excludes patients who died in ICU. [c] Excludes patients who died in hospital. ICU: intensive care unit, MV: mechanical ventilation.

superior to the MRC-SS (p=0.043; AUROC: 0.72; 95% CI: 0.63-0.82) and the MMS (p<0.001; AUROC: 0.65; 95% CI: 0.55-0.75); performance did not differ significantly between the MRC-SS and MMS (p=0.110). At ICU discharge, all three physical assessments remained significantly predictive of this outcome, with near identical predictive accuracy (AUROCs: 0.78-0.80, all p<0.001, ***Figure 1***). Optimum thresholds for each physical assessment are reported in ***Table 4***.

A sensitivity analysis was additionally performed, to assess the impact of excluding the patients who died in hospital. This combined these patients with those who required ongoing rehabilitation, on the basis that they had the most similar physical assessment scores (***Table 2***); hence, the sensitivity analysis used the composite outcome of ongoing rehabilitation or death. The resulting analysis returned near-identical results to the primary analysis (***Supplementary Table 1*** and ***Supplementary Figure 2***).

PREDICTIVE ACCURACY OF PHYSICAL ASSESSMENTS FOR LOS

For the physical assessments performed at first mobilisation, the outcome of interest was subsequent ICU LOS (i.e. from first mobilisation to ICU discharge). For the N=129 ICU survivors, all three physical assessments demonstrated significant negative correlation with this outcome, with this being strongest for the CPAx (rho: -0.34, p<0.001) and weakest for the MRC-SS (rho: -0.24, p=0.006, ***Supplementary Figure 3***). For the physical assessments completed at ICU discharge, the outcome of interest was the subsequent hospital LOS (i.e. from ICU discharge to hospital discharge). For the N=115 patients surviving to hospital discharge with physical assessments recorded, the CPAx again showed the strongest correlation with outcome (rho: -0.43, p<0.001), marginally outperforming the MRC-SS (rho: -0.36, p<0.001) and MMS (rho: -0.38, p<0.001).

Table 2. Physical assessments by discharge destination

		Hospital Discharge Destination				
	Whole Cohort (N=141/129[a])	***Home – No Rehab (N=55)***	***Home – With Rehab (N=40)***	***Inpatient Rehab (N=18)***	***Died in Hospital (N=25/13[a])***	**p-Value**
Physical Assessments at First Mobilisation in ICU						
CPAx	12 (10-17)	16 (12-24)	11 (9-14)	9 (8-10)	11 (10-13)	**<0.001**
MRC-SS	24 (9-36)	34 (22-44)	22 (6-33)	6 (0-20)	20 (6-30)	**<0.001**
MMS						**<0.001**
2	111 (79%)	33 (60%)	35 (88%)	16 (89%)	24 (96%)	
3	3 (2%)	2 (4%)	-	1 (6%)	-	
4	16 (11%)	9 (16%)	5 (13%)	1 (6%)	1 (4%)	
5	10 (7%)	10 (18%)	-	-	-	
6	1 (1%)	1 (2%)	-	-	-	
7	-	-	-	-	-	
Physical Assessments at ICU Discharge [a]						
CPAx	35 (29-40)	38 (34-43)	34 (29-37)	27 (20-31)	29 (24-34)	**<0.001**
MRC-SS	48 (40-55) [b]	52 (48-56)	48 (40-50) [b]	35 (21-44)	40 (35-44)	**<0.001**
MMS						**<0.001**
2	1 (1%)	1 (2%)	-	-	-	
3	15 (12%)	-	5 (13%)	6 (33%)	2 (15%)	
4	30 (23%)	2 (4%)	12 (30%)	9 (50%)	7 (54%)	
5	15 (12%)	9 (16%)	4 (10%)	1 (6%)	1 (8%)	
6	23 (18%)	8 (15%)	11 (28%)	1 (6%)	2 (15%)	
7	45 (35%)	35 (64%)	8 (20%)	1 (6%)	1 (8%)	

Data are reported as "median (interquartile range)" or "N (%)", with p-values from Kruskal-Wallis tests, comparing across the four subgroups; bold p-values are significant at p<0.05. Analyses by discharge destination exclude the N=3 patients who underwent an inter-hospital transfer; hence are based on N=138. **a** Analyses of physical assessments at ICU discharge additionally exclude the N=12 patients who died in ICU. **b** MRC-SS data were unavailable for one patient at ICU discharge. CPAx: Chelsea critical care physical assessment tool, ICU: intensive care unit, MMS: Manchester mobility score, MRC-SS: Medical Research Council sum score, Rehab: rehabilitation.

Table 3. Predictive accuracy of physical assessments with respect to the need for ongoing rehabilitation post-hospital discharge

	Ongoing Rehabilitation			
	No (N=55)	***Yes (N=58/57 [a])***	**AUROC (95% CI)**	**p-Value**
Physical Assessments at First Mobilisation in ICU				
CPAx	16 (12-24)	10 (8-13)	0.79 (0.71-0.87)	**<0.001**
MRC-SS	34 (22-44)	18 (4-30)	0.72 (0.63-0.82)	**<0.001**
MMS (>2) [b]	22 (40%) [b]	7 (12%) [b]	0.65 (0.55-0.75)	**0.006**
Physical Assessments at ICU Discharge [a]				
CPAx	38 (34-43)	31 (26-35)	0.80 (0.72-0.88)	**<0.001**
MRC-SS	52 (48-56)	44 (35-50)	0.78 (0.70-0.87)	**<0.001**
MMS	7 (6-7)	4 (4-6)	0.80 (0.72-0.89)	**<0.001**

Analyses are based on the N=113 patients who survived to hospital discharge, after excluding those who died in hospital (N=25) or underwent inter-hospital transfers (N=3). The hospital discharge destination was dichotomised, based on the need for ongoing rehabilitation post-hospital discharge (i.e. at home, or as inpatient). Data are reported as "median (interquartile range)", unless stated otherwise; p-values are from Mann-Whitney U tests, and bold p-values are significant at p<0.05. **a** Analyses of physical assessments at ICU discharge additionally exclude N=1 patient for whom the MRC-SS was not recorded. **b** The MMS at first mobilisation followed a highly skewed distribution, hence the proportion of patients scoring >2 points was reported, to more clearly demonstrate the difference between groups; the actual MMS scores were then used when calculating the AUROC. 95% CI: 95% confidence interval, AUROC: area under the receiver operating characteristic curve, CPAx: Chelsea critical care physical assessment tool, ICU: intensive care unit, MMS: Manchester mobility score, MRC-SS: Medical Research Council sum score.

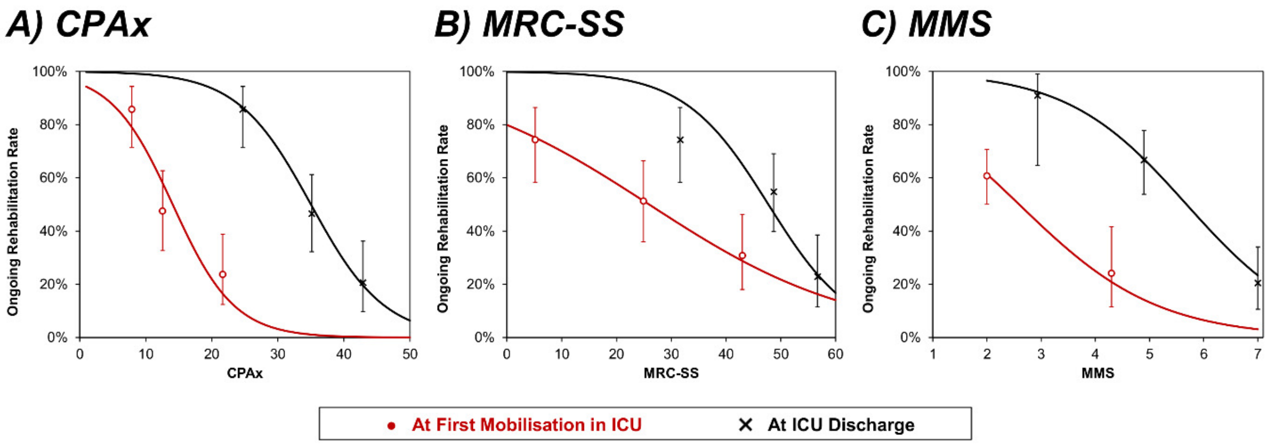

Figure 1. Physical assessments and prediction of the need for ongoing rehabilitation post-hospital discharge

Hospital discharge destination was dichotomised, and exclusions were applied as per Table 3. Lines represent binary logistic regression models; points represent observed rates within tertiles of each physical assessment (plotted at the mean score within the subgroup), with whiskers representing 95% confidence intervals. Physical assessments performed at the first mobilisation in ICU (red lines) and at ICU discharge (black lines) were analysed separately. CPAx: Chelsea critical care physical assessment tool, ICU: intensive care unit, MMS: Manchester mobility score, MRC-SS: Medical Research Council sum score, Rehab: rehabilitation.

Table 4. Optimal thresholds for physical assessments for the prediction of the need for ongoing rehabilitation post-hospital discharge

Assessment/ Threshold		N	Ongoing Rehabilitation *No (N=55)*	Ongoing Rehabilitation *Yes (N=58/57 [a])*	Classification Accuracy
Physical Assessments at First Mobilisation in ICU					
CPAx	*≤10*	35	5 (14%)	30 (86%)	**Sens:** 52%
	>10	78	50 (64%)	28 (36%)	**Spec:** 91%
CPAx [b]	*≤13*	63	19 (30%)	44 (70%)	**Sens:** 76%
	>13	50	36 (72%)	14 (28%)	**Spec:** 65%
MRC-SS	*≤25*	60	19 (32%)	41 (68%)	**Sens:** 71%
	>25	53	36 (68%)	17 (32%)	**Spec:** 65%
MMS	*2*	84	33 (39%)	51 (61%)	**Sens:** 88%
	>2	29	22 (76%)	7 (24%)	**Spec:** 40%
Physical Assessments at ICU Discharge [a]					
CPAx	*≤36*	65	19 (29%)	46 (71%)	**Sens:** 81%
	>36	47	36 (77%)	11 (23%)	**Spec:** 65%
MRC-SS	*≤51*	70	22 (31%)	48 (69%)	**Sens:** 84%
	>51	42	33 (79%)	9 (21%)	**Spec:** 60%
MMS	*≤4*	34	3 (9%)	31 (91%)	**Sens:** 54%
	>4	78	52 (67%)	26 (33%)	**Spec:** 95%
MMS [b]	*≤6*	68	20 (29%)	48 (71%)	**Sens:** 84%
	7	44	35 (80%)	9 (20%)	**Spec:** 64%

Analyses are based on the N=113 patients who survived to hospital discharge, after excluding those who died in hospital (N=25) or underwent inter-hospital transfers (N=3). The hospital discharge destination was dichotomised, based on the need for ongoing rehabilitation post-hospital discharge (i.e. at home, or as inpatient). The thresholds used were the ones that maximised the Youden's J statistic, unless stated otherwise. [a] Analyses of physical assessments at ICU discharge additionally excluded N=1 patient for whom the MRC-SS was not recorded. [b] Data are additionally reported for alternative thresholds with the second-best value of the Youden's J statistic, since these gave a balance of sensitivity and specificity that was more consistent with the other physical assessments. CPAx: Chelsea critical care physical assessment tool, ICU: intensive care unit, MMS: Manchester mobility score, MRC-SS: Medical Research Council sum score, Sens: Sensitivity, Spec: Specificity.

DISCUSSION

Patients requiring prolonged MV often develop ICU-AW, leading to prolonged physical dysfunction and rehabilitation after hospital discharge. To our knowledge, our service evaluation is the first to quantify and compare the utility of MRC-SS, MMS and CPAx, performed at both the first mobilisation and ICU discharge, in predicting ongoing rehabilitation requirement in patients requiring prolonged MV. When performed at first mobilisation, all three physical assessments were significantly predictive of the requirement for post-hospital discharge rehabilitation for patients treated at our institute, with the CPAx having the greatest predictive accuracy. As such, the superiority of the CPAx in predicting rehabilitation requirement, earlier in the rehabilitation process than the other measures, may provide justification for the additional time required to complete this more laboursome physical assessment. Enhanced prediction of discharge destination and the requirement of ongoing rehabilitation could improve patient care and flow in several ways at our institute. Firstly, it may help manage patient and family expectations and support conversations relating to discharge planning and discharge destination. Secondly, it allows clinicians to provide more accurate handovers of likely rehabilitation requirements and trajectory of recovery to ward or secondary care services following ICU discharge, allowing commencement of earlier discharge planning in line with NICE clinical recommendations, improving continuity of care.[7] Lastly, it highlights patients with significant rehabilitation requirements, where enhanced rehabilitation may translate into improved outcomes from both a patient and service perspective. For example, at our institute, the earlier identification of ongoing rehabilitation needs has led to timely referrals and improved collaboration with ward-based specialist rehabilitation services, who can assist with both rehabilitation and early pathway planning. The AUROC for the CPAx at our institute was similar to that reported found by Eggman et al.,[15] but superior to that of Milton et al., likely since the latter only considered the first five items of the CPAx and assessed a different outcome (i.e. new physical disability after hospital discharge).[16] In line with other published literature lower MRC-SS and MMS at ICU discharge were associated with ongoing rehabilitation input or poor outcome at our institute, specifically MRC-SS ⩽44/60 and MMS ⩽4.[19,20]

When completed at ICU discharge, all three physical assessments remained significantly predictive of ongoing rehabilitation requirement for patients treated at our institute. However, at this time point, the three physical assessments were found to be highly correlated and, consequently, had near-identical performance. Given the MMS is inherently faster and simpler to perform than the CPAx and MRC-SS, it could be considered to have the highest clinical utility at ICU discharge for patients treated at our institute. The three physical assessments also demonstrated moderate negative correlations with the secondary outcomes, namely subsequent ICU LOS when assessed at first mobilisation, and subsequent hospital stay when assessed at ICU discharge, with CPAx again having the best performance. This implies that the CPAx may additionally have some utility in identifying expected LOS and recovery trajectories for patients treated at our institute, which may further aid personalisation of rehabilitation pathways and early discharge planning.

In addition to quantifying the predictive accuracy using summary statistics (i.e. AUROCs and Spearman's rho), we have also visualised the observed relationships between the physical assessments and outcomes (i.e. ***Figure 1*** and ***Supplementary Figure 3***). Furthermore, we identified threshold values for each physical assessment to identify patients at the highest risk of ongoing rehabilitation requirement or in-hospital mortality. Reporting the data in this way, rather than only using summary statistics, has two major benefits. Firstly, it makes the results easier to comprehend for clinicians and patients. Secondly, it means that the findings can potentially guide clinical decision making, by using the observed outcome rates in our cohort to make predictions of the future rehabilitation requirements and likely LOS of individual patients treated at our institute.

The main strength of this service evaluation was the data completeness, with the three physical assessments being recorded across two time points for all but one patient. However, there are also several limitations, which need to be considered when interpreting the results. Firstly, as with all service evaluations, the results are only generalisable to the cohort included in the analysis. As such, the findings may not translate to other institutions, especially given the highly specific cohort of patients included in the evaluation. The service evaluation design also restricted the extent of analysis that was possible and, specifically, precluded performing adjustment for potentially confounding factors, further limiting the generalisability of the findings. Secondly, the convenience sampling approach meant that the sample size was relatively modest; hence, whilst this yielded sufficient statistical power to detect meaningful associations with outcomes, the resulting estimates of predictive accuracy will only have moderate precision. Thirdly, since the CCPRT did not routinely perform mobilisations or physical assessments during the weekend, these will have been conducted pre-emptively or delayed in patients amenable to first mobilisation or ICU discharge during a weekend. As such, this may have introduced additionally variability into the analyses of predictive accuracy.

CONCLUSION

In patients requiring prolonged MV, physical assessments performed in ICU were predictive of the need for ongoing rehabilitation post-hospital discharge for patients treated at our institute; hence, are potentially useful in early discharge planning. In this cohort, the CPAx had the best predictive accuracy when performed at first mobilisation, with the three physical assessments having similar accuracy when performed at ICU discharge. Further research is required to validate these findings, and to identify a core outcome dataset that can be used to guide clinician decision making.

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SUPPLEMENTARY MATERIALS

Supplementary material

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