Volume 57 Issue 2 December 2025
ISSN 2059–0199 (Online)

Journal of the Association of Chartered Physiotherapists in Respiratory Care

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Editorial

Editorial

Elizabeth King, Owen Gustafson

Journal of the Association of Chartered Physiotherapists in Respiratory Care

Vol. 57, Issue 2, 2025

We are delighted to share the latest issue of The ACPRC Journal, which highlights the breadth and depth of respiratory physiotherapy. This edition represents the final edition of the journal in its current format, with a number of changes planned for 2026. Members of the ACPRC should receive details of these developments in the January newsletter.

This edition includes seven articles that encompass a wide range of methodology and clinical speciality. We open with a thought-provoking commentary on the use of Mechanical Insufflation-Exsufflation in ventilated paediatric patients by Hamilton et al. The authors clearly identify an area of investigation for ACPRC members to explore in the future.

The critical care section includes three articles spanning the continuum of critical care recovery. Harriman et al. evaluate the use of physical assessments to predict ongoing rehabilitation needs after discharge from hospital, while Wilson et al. evaluate exercise therapy post-hospital discharge. Douglas et al. report the results of their national survey of therapy support worker activity in critical care, which demonstrates lack of standardised training and competencies. This is supported by the repeated high attendance and success of the ACPRC support worker study day. Members of the ACPRC who are interested in exploring training opportunities for therapy support workers should contact criticalcare@acprc.org.uk.

Following the successful ACPRC priority setting exercise on on-call service provision, Cook et al. have undertaken a comprehensive scoping review of the literature. They identify a variety of service models, workforce configurations, and training protocols. This further highlights the importance of understanding this complex service in the current financial climate.

Finally, the edition finishes with two studies in major surgical populations. Butler et al. consider the predictive ability of the repeated sit-to-stand test on hospital acquired pneumonia. Yadav et al. finish the edition by exploring the effectiveness of the ELTGOL technique in post cardiac surgical patients.

We continue to receive a rising number of submissions which are of increasing methodological rigour. We remain very keen to support members in developing their academic writing for publication, specifically those wishing to turn local service evaluations or dissertations into manuscripts. Please contact us at journal@acprc.org.uk if you would like support or guidance on writing your manuscript or developing potential ideas for articles.

Dr Liz King and Dr Owen Gustafson

Hamilton C, Foster Z, Brown H. Mechanical Insufflation-Exsufflation in Acutely Ventilated Children: A useful tool or another white elephant? *ACPRC Journal*. 2025;57(2):2-4. doi:10.56792/DNNO9966

Commentary

Mechanical Insufflation-Exsufflation in Acutely Ventilated Children: A useful tool or another white elephant?

Colin Hamilton[1], Zoe Foster[1], Holly Brown[1]

[1] Physiotherapy, Cambridge University Hospitals NHS Foundation Trust

Keywords: Paediatrics, Mechanical Insufflation-Exsufflation, PICU

https://doi.org/10.56792/DNNO9966

Journal of the Association of Chartered Physiotherapists in Respiratory Care

Vol. 57, Issue 2, 2025

How best to support the secretion clearance and lung mechanics of our children who are acutely ventilated on the Paediatric Intensive Care Unit (PICU) is a challenge that physiotherapists face every day.[1] Whilst we have a variety of techniques that we have used for many years, we must acknowledge the risks that come with physiotherapy in such a vulnerable population[2] and continually question whether we are doing the best for our patients. This questioning brings with it the challenge to always be thinking about how we can improve our practice and being open to changes in care.

Recently, we were joined on our PICU by two wonderful rotational physiotherapists who again challenged us on our lack of use of Mechanical Insufflation-Exsufflation (MI-E) with our children who are acutely ventilated. They had worked in our adult units and seen its use there. Using the age-old educator trick,[3] we encouraged them to go find the evidence and come back to us. After a thorough but fruitless search by our librarians, and a generous discussion with an adult physiotherapist who had published in the area,[4] they ultimately came back largely empty-handed, apart from a survey looking at current practice.[5]

This raises the head of the age-old challenge for Children's Physiotherapists who work in many areas, but especially PICU. How do we know what the best treatments are for the children in our care? Do we stick with our old favourites, which inevitably sees me reaching for the Mapleson bag time and time again, along with the majority of my colleagues,[5] or do we embrace the new techniques with no evidence to support us? I have been practicing long enough to remember the excitement around High-Frequency Chest-Wall Oscillation, for example "The Vest".[6] I have therefore seen its trajectory from being a panacea to finding relatively niche (but anecdotally effective) use in a small number of patients. In the end, work was done which found it was not better than traditional techniques, and may even be worse in some situations.[6] This and its high price point, appears to be what has limited its practice.

MI-E has broken through in the adult world,[4] with dedicated researchers investigating its use. In paediatrics as well, MI-E has been a staple in neurodisability and long-term ventilation for a decade.[7] A survey of PICUs in the UK found that a majority of clinicians who responded are using MI-E in ventilated children,[5] and we have recently published on our unit's use of MI-E in children with cystic fibrosis.[8] We still, however, do not have the data in children to convince me that it is better in safety or clinical effectiveness than the standard manual hyperinflation (MHI).

As we know, it is used in many PICUs.[5] I, myself, have used it on self-ventilating and long-term ventilated patients a great deal. The acutely ventilated cohort I would argue is different, and as always in paediatrics we have the privilege of dealing with neonates whose lungs are taking their first breath in a fundamentally different way to adults, all the way through to young people who if they had been admitted a day later would have been admitted to an adult intensive care.[9] During our rotational staff's 7 months with us, they only identified one acutely ventilated child who had an impaired cough secondary to a neurological condition and who, despite the use of all the treatment modalities in our toolkit, the patient continued to deteriorate, and we felt MI-E may possibly benefit the child over traditional techniques. This leads my "gut" to tell me that MI-E will find its place in a limited number of patients for whom MHI is too risky. However, I am excited to be proved wrong.

I haven't answered the question that I have set in this commentary, and at this point, I can't. My greatest hope is that a researcher takes on this question, as has happened in adults, and provides us with the answers on safety and effectiveness that we need. In the meantime, however, I would encourage my colleagues who use MI-E in practice to start publishing their data on safety and effectiveness to allow all to benefit from their experience. In paediatrics, again and again, we have said the children in our care are not little adults,[9] so like our medical colleagues do, we should take note of evidence in adults but not rely on them for our evidence base.

Also, again, I am reminded of the benefits that passionate rotational staff bring to a unit through the pollination of ideas and challenging of established practice. To all rotational staff out there, please know that yes, you are here to learn, but also know that without you patient care would stagnate. Until you decide to become static, keep rotating, keep challenging, you are a vital part of a living paediatric team.

Key points

- Mechanical Insufflation-Exsufflation is being used in many Paediatric Intensive Care Units in acutely ventilated children.
- There is no evidence to show its effectiveness in children.
- While it is important to take into account adult data, significant risks exist if we do not understand how children respond to this treatment.

DECLARATION OF INTEREST

No authors have any interests to declare.

FUNDING

No funding was received for this work.

ACKNOWLEDGEMENTS

We were supported by Dr Veronica Phillips, Liaison Librarian (School of Clinical Medicine), University of Cambridge Medical Library, for the literature review.

Submitted: July 01, 2025 GMT. Accepted: September 18, 2025 GMT. Published: November 01, 2025 GMT.

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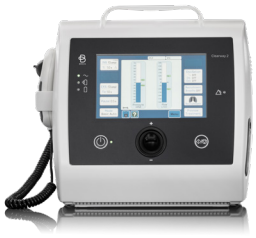

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Douglas E, Moore C, Hendrick P, Shannon H, Twose P. The role and responsibilities of critical care therapy support workers: A national survey. *ACPRC Journal*. 2025;57(2):6-14. doi:10.56792/OQJD3774

Critical care

The role and responsibilities of critical care therapy support workers: A national survey

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Keywords: Therapy Support Workers, Critical Care, National Survey, Role, Responsibilities

https://doi.org/10.56792/OQJD3774

Journal of the Association of Chartered Physiotherapists in Respiratory Care

Vol. 57, Issue 2, 2025

Abstract

Background

Guidelines for the Provision of Intensive Care Services (V2.1) recommend therapy support workers are considered as part of the multidisciplinary rehabilitation workforce. An understanding of their contribution to the workforce is required to guide the future direction of this role. This study explored the role responsibilities of therapy support workers currently employed in United Kingdom (UK) critical care units.

Method

In this cross-sectional study, a bespoke online survey was completed by therapy support workers employed in UK critical care units. Participants were recruited during October 2023 via the Association of Chartered Physiotherapists in Respiratory Care and professional networks employing snowball sampling.

Results

Sixty-two respondents completed the survey. Most were employed at Band 4 level (74%, n=46) and worked fulltime (63%, n=39). Sixty percent (n=37) described their role as a combination of physiotherapy and occupational therapy. A wide range of rehabilitation activities were undertaken by the respondents. Physical rehabilitation tasks including mobilising (58%, n=36) and repositioning patients (44%, n=27) were predominant. Twenty-six percent(n=16) intended to remain in their role, with the same number being unsure what job role they would pursue in the future. A lack of standardised training, education and competency achievement was identified.

Conclusion

The wide range of activities and interventions delivered by the therapy support workers demonstrates their varied and valuable contribution to the critical care workforce. Further work is required to ensure the provision of relevant training and career development, this would support the desire of those who wish to further their career in the critical care speciality.

INTRODUCTION

Allied health professional (AHP) support workers work under the delegation of registered AHPs in the United Kingdom (UK).[1] Support workers often hold relevant professional qualifications and their role can be either uni or multi-professional.[2]

The Guidelines of the Provision of Intensive Care Services (GPICS V2.1)[3] provide standards and recommendations for the UK critical care workforce. However, only the physiotherapy chapter makes direct reference to the roles of AHP support workers, noting that these should be considered as part of the multidisciplinary workforce.[3] Previous studies exploring the AHP workforce in critical care have reported the presence of AHP support worker roles but make limited reference to scope of practice, responsibilities and training requirements.[4-7]

The primary aim of this study was to identify the contribution of Critical Care Therapy Support Workers (CCTSW) to the critical care workforce, by exploring their role and responsibilities.

Secondary aims were to:

1. Describe the demographic characteristics of UK CCTSW.

2. Explore the current training, education and competency frameworks provided to UK CCTSW.

METHODS

STUDY DESIGN AND DATA SOURCE

In this cross-sectional observational study, and the absence of any existing validated tool, the researchers (ED and CM) designed a bespoke electronic survey using Microsoft Forms. Survey questions were informed and developed from the researchers' clinical experience, current literature,[8-10] and written feedback provided by members of the UK AHPs in Critical Care Group (NAHPCCG). The survey was piloted by two experienced CCTSW from the host NHS hospital trust, providing verbal information on completion times, ease of access and minor refinement of questions.

The survey consisted of 37 items, divided into five sections. These were: 1) Demographics (13 questions); 2) Role and responsibilities (13 questions); 3) Professional development (8 questions); 4) future career plans of respondents (2 questions); and 5) job satisfaction (1 question).[1] The survey used a mixture of multiple-choice questions (n=19), Likert scales (n=6), rating scales (n=1) and open text boxes (n=11). Some questions allowed respondents to select one or multiple options (Questions 17, 21, 33) with the opportunity to explain or give an alternative response in an open text box as required. Further survey details can be found in supplementary material, File 1.

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines have been followed to report this study.[11]

PARTICIPANTS

Participants were recruited using a purposive target audience and snowball sampling. Electronic advertisements were shared via the Association of Chartered Physiotherapists in Respiratory Care (ACPRC), East Midlands Critical Care Network, NAHPCCG and social media (Platform X). Weekly reminders were sent. The survey was open for four weeks throughout October 2023. No incentives were offered for survey completion.

CONSENT

Participants were provided with an electronic link to a participant information sheet. They were asked to confirm they had read this prior to consenting as a mandatory question. No personal identification details were collected.

DATA HANDLING

Data were extracted from Microsoft Forms to an Excel spreadsheet. Descriptive statistics were used to analyse quantitative responses, including rounding to nearest whole number for frequency and percent of responders. Content analysis was used to analyse responses from free text boxes by the researchers (ED and CM) using the five step approach described by Vears and Gillam, (2022)[12] see Figure 1.

RESULTS

DEMOGRAPHICS

Sixty-two CCTSW completed the survey, with responses received from across the UK apart from Northern Ireland and the Northeast of England. The overall response rate is unknown, given the lack of information regarding the overall workforce. The only metric tracked on survey completion was the mean time to complete the survey, this was 19 minutes. Of those who completed the survey, 71% (n=44) were aged over 30 years of age and employed at Agenda for Change Band 4 (74%, n=46). A third (34%, n=21) were educated to degree level with 37% (n=23) in post for 2-4 years. Further demographic data is provided in Table 1.

ROLE AND RESPONSIBILITIES

Most respondents (60%, n=37) described their role as being a combination of occupational therapy and physiotherapy, just over half (57%, n=35) reported that they spent between 60-100% of their time each week delivering physical rehabilitation interventions. A minority of responders had roles wholly in speech and language therapy (3%, n=2) and dietetics (3%, n=2).

Over 60% (n=38) of respondents reported working in multiple clinical specialities, aligned with the working pattern of the overarching therapy service, including general surgery (36%, n=22), acute medicine (29%, n=18), cardiothoracic surgery (27%, n=17) and respiratory medicine (26%, n=16). Only 19% (n=12) respondents reported their job role solely involved delivering therapy to patients in critical care. Despite this variation, around half of respondents (54%, n=34) reported spending >75% of their working day delivering therapy or undertaking tasks related to patients in critical care.

Clinical activity was separated into assessments and rehabilitation tasks. Assessments encapsulated physical, cognitive and functional tools. Fifty-three percent (n=33) of respondents reported performing mobility assessments independently and 32% (n=20) independently performed the Chelsea Critical Care Physical Assessment Tool. See Table 2 for the most frequently reported clinical assessments performed independently by CCTSW. Further information is available in supplementary material file 2, Table 1.

For rehabilitation tasks, CCTSW were predominantly involved with physical rehabilitation, 58% (n=36) reported being involved in mobilising patients. The most frequently delivered physical rehabilitation tasks can be seen in Table 3. Further information can be found in supplementary material file 2, Table 2. Respondents reported completing these activities daily, either in conjunction with another member of staff (76% of days) or independently (61% of days).

The majority of CCTSW reported that their role was 'not applicable' in recovery services such as follow up clinics

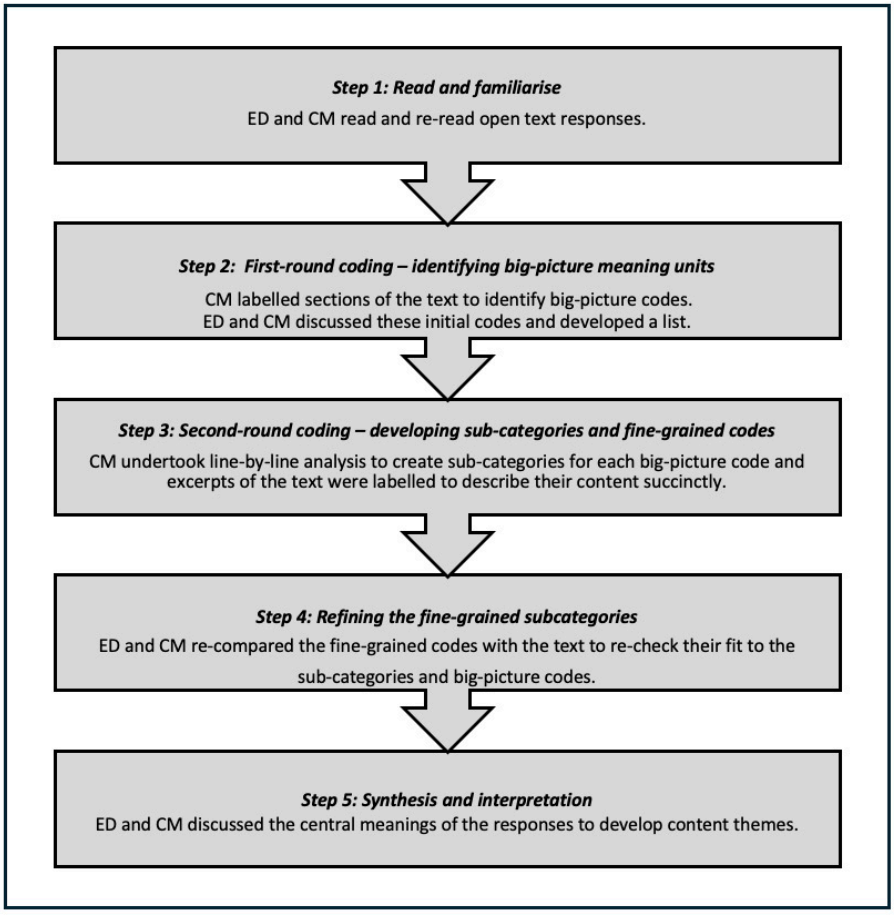

Figure 1. Five step approach to content analysis

(76%, n=47) and post-critical care rehabilitation classes (81%, n=50).

For non-direct patient tasks, writing patient diaries (40%, n=25) and inputting data (44%, n=27) were reported with the highest frequency. Further information is provided in supplementary file 2, Table 3.

TRAINING AND EDUCATION

Most respondents (74%, n=46) reported not having any support worker specific training, although 24% (n=15) reported attending a critical care therapy support worker study day provided by the ACPRC. Where training did exist, the focus was tracheostomy care and exercise rehabilitation.

Competency frameworks were related to physical rehabilitation tasks including use of hoist equipment (90%, n=56) and issuing walking aids (86%, n=53), see Table 4. Further information on competency achievement is provided in supplementary file 2, Table 4.

Support through critical care therapy support worker (TSW) networks was rare, with only 11% (n=7) responders reporting involvement. However, respondents suggested that they felt appropriately trained and prepared for the role (visual analogue score: median=7, IQR 5-7).

JOB SATISFACTION AND FUTURE CAREER PLANS

Based on content analysis of free-text responses, the overarching themes related to job satisfaction were progress of long-term patients; helping patients achieve their goals and regain independence; building relationships with patients and their family; individualising patient care; and learning from registered staff.

However, only a quarter of respondents stated they intended to remain in their critical care TSW job role (26%, n=16) with a similar number unsure what job role they would pursue in future (26%, n=16). Of those considering future opportunities, 18% (n=11) reported that they would like to become a registered physiotherapist and 11% (n=7) a registered occupational therapist. The remaining respondents described the critical care TSW role as a bridge for making a career decision about what healthcare profession role to pursue.

DISCUSSION

This study is the first to explore the demographics, roles and responsibilities and future career aspirations of CCTSW in the UK. The results may be used to inform the future role

Table 1. Demographic details of survey respondents

Characteristic	Number of respondents % (N=62)
Age (years)	
18-20	0% (0)
21-30	29% (18)
31-40	36% (22)
41+	36% (22)
AfC Banding	
Band 2	3% (2)
Band 3	19% (12)
Band 4	74% (46)
Band 5	3% (2)
Highest level of education	
GCSE	5% (3)
NVQ	19% (12)
A Level	11% (7)
Undergraduate Degree	34% (21)
Post graduate Degree	10% (6)
Apprenticeship	7% (4)
Other	15% (9)
Hours of employment per week	
Full-Time	63% (39)
Part-Time	37% (23)
UK geographical region	
Northern Ireland	0% (0)
Scotland	2% (1)
Wales	3% (2)
England	0% (0)
North East	3% (2)
Central	3% (2)
North West	5% (3)
Yorkshire and Humber	13% (8)
West Midlands	15% (9)
South East	16% (10)
London	18% (11)
East Midlands	23% (14)
South West	
Length of time working in critical care therapy support worker role	
Less than 1 year	19% (12)
1 year	13% (8)
2-4 years	37% (23)
5-7 years	8% (5)
7-10 years	10% (6)
> 10 years	13% (8)

Key: *AfC = Agenda for Change*

Table 2. Most frequently reported clinical assessments performed independently by CCTSW

Variable	Number of respondents % (N=62)
Mobility	53% (33)
Chelsea critical care physical assessment tool	32% (20)
Functional e.g. washing, dressing	16% (10)
Orientation	13% (8)
Post intensive care unit presentation scheme	11% (7)
Sedation	11% (7)

development, education and training need and assist the design of competency frameworks.

The utilisation of CCTSW to provide and support rehabilitation interventions has previously been shown to reduce ventilation days, overall critical care length of stay and improve patient experience.[13,14]

DEMOGRAPHICS

Our findings suggest the critical care TSW role is established in most regions in the UK, particularly across London, the Southeast and East Midlands (with similarities in roles and responsibilities). Our findings provide insight into

Table 3. Most frequently reported tasks and treatments delivered by CCTSW

Variable	Number of respondents % (N=62)
Mobilising patients	58% (36)
Repositioning patients	44% (27)
Passive range of movement	40% (25)
Bed exercises	36% (22)
Hoisting patients out of bed	36% (22)
Goal Setting	36% (22)
Cycle Ergometry	26% (16)
Humanising activities	26% (16)

Table 4. Most frequently reported formal competencies achieved by CCTSW

Variable	Number of respondents % (N=62)
Using hoist equipment	90% (56)
Issuing walking aids	86% (53)
Performing passive movements	81% (50)
Assessment e.g. chart reading	77% (48)
Using exercise equipment	68% (42)

current models of working and profession specific biases towards occupational therapy and physiotherapy.

ROLES AND RESPONSIBILITIES

Much of the focus of critical care TSW activity was on direct clinical activities. Furthermore, and perhaps reflective of the professional profiles, significant focus was on provision of physical rehabilitation. Similar findings were reported from other clinical specialities, particularly musculoskeletal settings.[4]

Respondents also reported involvement in occupational therapy activities such as supporting patients with activities of daily living, delirium management and humanisation activities. This finding is interesting in the context of previous research exploring therapy workforce in critical care, which suggests many services having either none or minimal occupational therapy services, and very high therapist to patient ratios.[15-18] Involvement in direct clinical activities traditionally undertaken by registered dietitians or speech and language therapists was rare. The reasons for this are unclear but may be a result of the survey distribution approach or be reflective of existing AHP practice in critical care.

The findings indicate that the critical care TSW role is currently predominantly in the critical care unit itself, but there is scope for this role to expand if services continue to develop. It is also reflective of the national provision of post critical care recovery services within the UK.[19] There was limited involvement in patient case conferences or completion of patient diaries. This is reflective of previous research within critical care[15] but in contrast to findings from musculoskeletal settings where administrative tasks were more common.[4]

TRAINING, EDUCATION AND FUTURE DEVELOPMENT

Whilst critical care TSW roles appear to be present in most areas of the UK, there is need to ensure adequate training, competency completion and ongoing professional development. Similar findings have also been identified outside of critical care, with support workers reporting frustrations with the lack of specific training and career progression.[4, 6] The recent release of the Intensive Care Society AHP Capability Framework includes supportive and assistive levels of practice.[20] Given its release after the completion of our data collection, future research should explore the impact of the capability framework, and its utilisation by CCTSW.

Many respondents suggested a desire to become registered therapy staff. This potentially creates a two-fold challenge; 1) how to support CCTWS looking to progress to professional degree programmes, and 2) how to ensure adequate staff retention. With most participants only in post for less than 4 years, and similar numbers looking to progress out of the role, continuous cycles of recruitment and training to fill roles may be challenging. This is clearly an area for future development.

LIMITATIONS

At present, it is unknown how many TSWs work in the critical care speciality in the UK, the researchers were therefore unable to calculate the overall response rate. The number of responses from the devolved nations was poor (5%) and no responses were received from the Northeast of England or Northern Ireland. The researchers do not know if this is because they do not employ CCTSW or if the survey invitation failed to reach them. Similarly, the bias toward those undertaking physiotherapy activities may be a true reflection (particularly given the larger physiotherapy workforce) but may also be a result of the survey distribution approach.

Alternative approaches to data collection should be considered for future research.

CONCLUSION

This survey shows the critical care therapy support worker role exists in most regions of the UK, with greatest focus on provision of physical rehabilitation. The wide range of clinical and non-clinical activities undertaken by the respondents to our survey highlights the beneficial contribution CCTSW can bring to the AHP rehabilitation workforce. This survey suggests they make a significant contribution to the workforce and their impact on patient and organisational outcomes should not be underestimated.

Ongoing work is needed to ensure an adequate career structure for CCTSW, including the provision of training and development. This should be aligned with national capability frameworks. This would support the desire of CCTSW to further their career in the critical care speciality in conjunction with demonstrating their contribution to the critical care workforce.

Key Points

1. At the time of this survey the CCTSW role was present in most regions of the UK and their roles and responsibilities were similar.
2. The majority of CCTSW work in a combined occupational therapy and physiotherapy role in the acute setting with a predominance of delivering physical rehabilitation tasks.
3. Further research exploring the contribution of CCTSW to the critical care workforce and how to effectively train and develop those in the role is required.

ETHICS STATEMENT

Ethical approval was obtained from University of Nottingham, Faculty of Medicine and Health Sciences Research Ethics Committee. (Ref: FMHS 378-0923).

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

DECLARATION OF INTEREST

The Authors declare that there is no conflict of interest.

ACKNOWLEDGEMENTS

The authors wish to thank the ACPRC for assisting with the distribution of the survey, and the National AHP's in Critical Care Group and Tom Roffey, Sonja Parnell and Emma Dimmock for assisting the survey design.

Submitted: February 19, 2025 GMT. Accepted: November 19, 2025 GMT. Published: December 01, 2025 GMT.

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SUPPLEMENTARY MATERIALS

Supplementary Material File 1 - Survey Questions

Download: https://acprcjournal.scholasticahq.com/article/147697-the-role-and-responsibilities-of-critical-care-therapy-support-workers-a-national-survey/attachment/311263.docx?auth_token=jGTD80zWsQ7K6NMKDMns

TSW Survey Supplementary Material 2 - Results Tables

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Harriman A, Hodson J, Weblin J. Can physical assessments in the Intensive Care Unit predict post-hospital rehabilitation requirements in patients requiring prolonged mechanical ventilation? – A service evaluation. *ACPRC Journal*. 2025;57(2):15-24. doi:10.56792/WSCT8907

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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Keywords: Critical care, rehabilitation, physiotherapy

https://doi.org/10.56792/WSCT8907

Journal of the Association of Chartered Physiotherapists in Respiratory Care

Vol. 57, Issue 2, 2025

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 of-

ten 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.

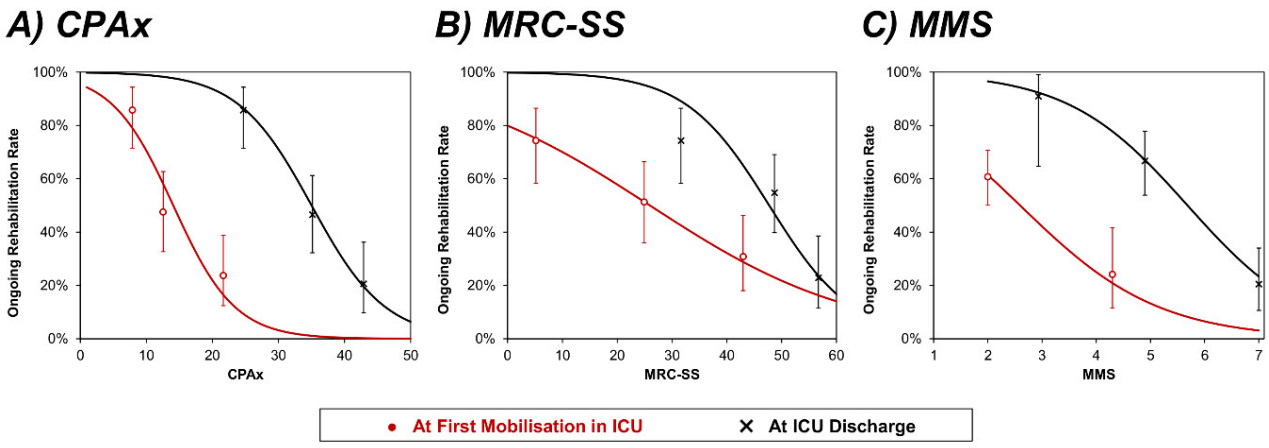

Figure 1. Physical assessments and prediction of the need for ongoing rehabilitation post-hospital discharge

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)*	*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 re-

habilitation 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.

Submitted: May 15, 2025 GMT. Accepted: November 19, 2025 GMT. Published: December 01, 2025 GMT.

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SUPPLEMENTARY MATERIALS

Supplementary material

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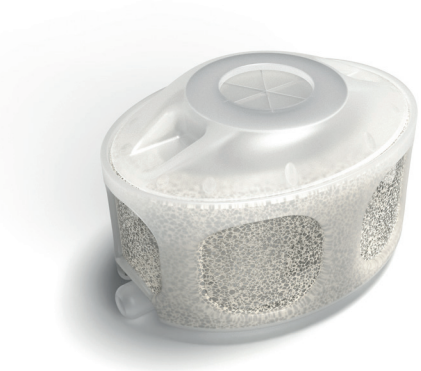

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Wilson C, Newey V. Rehabilitation after critical illness –a pilot exercise programme to support intensive care unit survivors: A service evaluation. *ACPRC Journal*. 2025;57(2):26-31. doi:10.56792/SOXC1470

Critical care

Rehabilitation after critical illness –a pilot exercise programme to support intensive care unit survivors: A service evaluation

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Keywords: intensive care, rehabilitation, exercise programme

https://doi.org/10.56792/SOXC1470

Journal of the Association of Chartered Physiotherapists in Respiratory Care

Vol. 57, Issue 2, 2025

Abstract

Background

Intensive care survival is increasing, resulting in patients living with physical and psychological symptoms for many months following their discharge from the ICU and hospital. Support in the community is often not available to support patients to return to higher levels of physical activity, previous employment or social interactions.

Objective

The aim of this service evaluation was to evaluate the addition of a semi- individualised, group-based exercise programme and education programme to our ICU follow up service and to measure physical and psychological outcomes of ICU survivors following participation in the programme.

Methodology

Patients attending the ICU follow up clinic and meeting the follow up criteria were offered the opportunity to attend a new weekly exercise group and education session. This service evaluation measured the uptake of this exercise group by ICU survivors and recorded physical and psychological outcomes before and after completion of the program.

Results

10 patients completed the program over 3 cohorts. All patients improved on their physical outcome measures and all patients subjectively reported a positive improvement in their mood, confidence and feelings of support. However, there was no improvement in psychological outcome measures. There were no adverse events throughout the programme.

Conclusion

In this small pilot service evaluation, a post ICU exercise program was a beneficial addition to a follow up service. Positive outcomes in physical function were demonstrated and patients reported a subjective improvement in mood and social inclusion.

INTRODUCTION

Survival from an intensive care unit (ICU) admission is improving, however it is widely reported that patients recovering from critical illness have impaired mobility and function often lasting for a number of years post critical illness.[1,2] The causes are multifactorial but ICU-Acquired Weakness is widely recognised as a major contributor to impaired function. Significant skeletal muscle wasting alongside physiological changes to nerve structure leads not only to significant weakness but structural changes to muscle fibre type[3] and exercise capacity. Patients have also reported cognitive or psychological changes[4] as well as social isolation due to low levels of functional ability and confidence.[5] These persistent symptoms post critical illness are knows as Post Intensive Care Syndrome (PICS).

There are multiple guidelines[6,7] which recommend ongoing rehabilitation for ICU survivors with a view to reduce the impact of PICS, by reviewing at 2-3 months post discharge to assess and provided onward referrals as appropriate and an exercise programme for completion at home.

There is minimal evidence available regarding class-based rehabilitation following an ICU admission, although those available demonstrated an improvement in health-related scoring but not exercise capacity[8] and reported success in supporting individuals and their families to start exercising again after a critical illness.[9,10]

It was found in the ICU follow up clinics at an acute London NHS Trust that patients regularly had ongoing mobility and functional impairments and an inability to participate in social or work activities up to 6 months post illness, despite the input from inpatient and community rehabilitation services at the time of discharge. This is supported by studies[1,2,10] that demonstrated the longer-lasting physical and socio-economic impact of ICU survivorship.

As a service evaluation, this project was not classed as research, therefore formal ethical approval was not required. It was registered and approved by the Imperial College Healthcare NHS trust/local (audit number 780). The aim of this service evaluation was to evaluate the addition of a semi- individualised, group-based exercise programme and education programme to the ICU follow up service and to measure physical and psychological outcomes of ICU survivors following the programme.

METHOD

DESCRIPTION OF SERVICE

All patients who spent four days or more in ICU, across the three ICUs at a London NHS Trust, meeting the criteria to be followed up were invited to join the exercise programme after review at either the six week or three month follow up post ICU discharge.

The criteria to be followed up were:

- Four or more days in ICU, not due to a pathway i.e. UGI surgical patients unless indicated;
- patients who have on-going physical rehabilitation needs that cannot be met by community therapy services;
- patients who are cognitively and physically able to participate in a class.

Patients were not followed up if they:

- suffered from severe or uncontrolled heart failure or cardiac arrhythmias;
- had other significant co-morbidities rendering them unable or unsafe to exercise;
- would attend another established exercise programme, such as cardiac rehabilitation.

Any patients meeting the criteria and consenting to the programme attended a pre-assessment appointment where on-going issues and goals were discussed as well as baseline outcome measures collected.

The programme was held once weekly for 6 weeks and consisted of an hour-long circuit-based exercise programme with a mix of strengthening and cardiovascular exercises appropriate to the individual. The exercise class was followed by an educational talk provided by members of the MDT. The topics covered were the medical impact of critical illness, the psychological impact of critical illness, nutrition in critical illness and recovery, fatigue management, cognitive changes in critical illness, and the patient perspective of critical illness and recovery.

SERVICE EVALUATION METHODS

Of those referred to the programme, records were taken for how many were willing to participate, attendance levels and reasons for non-attendance. Demographic information including age, gender and reason for ICU admission was also recorded, as were any adverse events occurring during the programme using an adapted adverse event tool from the Woodbridge et al study.[11]

Outcome measures were recorded pre and post programme to tailor individual exercise regimes, measure individual patient progress, and as part of the service evaluation. The outcome measures used were the 1-minute sit to stand test (STS), 6-minute walking test (6MWT) or Timed Up and Go (TUAG) if patients were unable to complete the 6MWT. The EQ – 5D – 3L, Hospital anxiety and depression scale (HADS) and the Work and Social Adjustment Scale (WSAS) were used to collect psychological and social outcomes. Subjective feedback from patients was also collected.

RESULTS

33 patients were referred into the programme between June 2022 and May 2023. Three patients declined to attend; six patients withdrew from the waiting list prior to being enrolled. Three patients were not medically fit at the time of assessment and three patients did not respond to correspondence regarding the programme.

18 patients were enrolled into the programme; four patients withdrew at short notice due to travel issues. 11 patients across three cohorts completed the programme. One patient did not attend the post assessment and one patient withdrew twice due to illness, so no post programme data was recorded for them (Table 1).

The median age of participants was 57 years old, 73% were male and the median time from ICU discharge to attending the programme was six months. (Table 2)

PHYSICAL FUNCTION OUTCOME MEASURES

Two patients were unable to complete the sit to stand in one minute at pre-assessment due to poor balance, but all nine patients attending the post programme assessment completed the test at this point. The median change was eight repetitions (Table 3).

Three patients were unable to complete the 6MWT at pre-assessment. All nine patients attending the post programme assessment completed the 6MWT, with a median improvement of 60metres. At pre-assessment, three patients required standing or seated rests during the test, no patients required a rest at post assessment (Table 3).

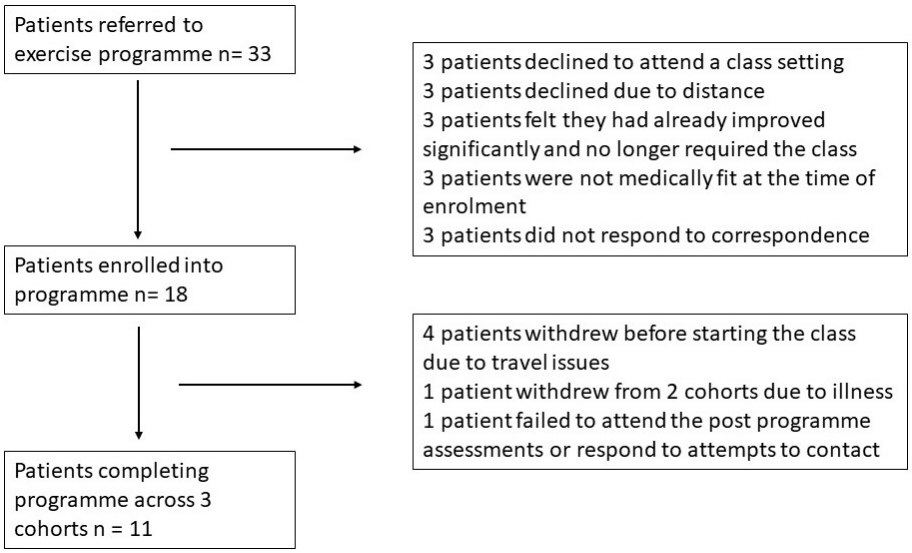

Table 1. Flow chart of patient enrolment

Table 2. demographics for patients who participated in the exercise programme

Patient characteristics	No. (%)
Gender	
Male	8(73)
Female	3 (27)
Age Median (IQR)	59 (47 – 70)
Reason for admission to ICU	No. (%)
COVID	1 (9)
Cardiac event/ surgery	3 (27)
General surgery	2 (18)
Neuro surgery	2 (18)
Thoracic surgery	1 (9)
Respiratory failure	1 (9)
Trauma	1 (9)

Two patients demonstrated an improved Timed Up and Go outcome at the post assessment (Table 3).

PSYCHOLOGICAL OUTCOME MEASURES

Table 4 demonstrates the results of the HADS, where a small improvement was seen. Results at both pre and post assessment levels indicate that the majority of patients had abnormal scores according to the scoring criteria and should be referred for on-going psychological input.

The WSAS shows scores for only seven of the nine patients; one was retired and one did not complete the form. Two patients had returned to work at pre-assessment. At post assessment, five patients had returned to work, two of whom were in a modified role. Generally, the results show an improvement in patients' ability to perform social and work-related tasks (Table 4).

EQ-5D-3L AND PATIENT HEALTH SCORING VAS

At the initial assessment point, 100% of patients reported some problems with mobility and all patients scored themselves having some or significant problems with pain and depression. 44% of the patients also reported significant problems completing ADL's. Following completion of the rehabilitation programme, 33% of patients reported themselves having no problems with mobility, an increase of 10% from pre-programme numbers. There was a reduction of 33% in those scoring themselves having significant problems completing ADL's. At the post assessments, 100% of the patients scored themselves as experiencing some pain, and scores for self-care did not change between the two assessment points (Table 5). Using the VAS, all patients marked their health score as improved between the two assessment points, with a median improvement of 22.

Table 3. Physical function outcome measures

	Pre	Post	Difference
STS in reps Median (IQR)	15 (6 – 20.5) (n=11)	23 (20.5 – 25.5) (n=9)	8 (3 – 15.5)
6MWT in Metres Median (IQR)	376 (200 – 419.5) (n =9)	420 (276 – 474.5) (n=9)	60 (40 - 86)
TUAG in Seconds Median (IQR)	25.7 (22.5 – 31.5) (n=4)	15.5 (n=2)	16

Table 4. Psychological outcome measures

	Pre	Post	Difference
HADS Anxiety Median (IQR)	9.5 (8 – 11) (n = 10)	9 (7.5 - 12) (n= 9)	
HADS Depression Median (IQR)	8.5 (7-12) (n=10)	7 (6 - 11) (n= 9)	
WSAS Median (IQR) (n=XX)	23 (12 - 31) (n=7)	14 (6 - 16) (n=7)	9 (0 – 18) (n = 7)

Table 5. EQ-5D-3L

	Mobility Pre (%)	Mobility Post (%)	Self care Pre (%)	Self care Post (%)	ADL's Pre (%)	ADL's Post (%)	Pain Pre (%)	Pain Post (%)	Depression Pre (%)	Depression Post (%)
1	2 (22.2)	3 (33.2)	5 (55.5)	5 (55.5)	2 (22.2)	4 (44.4)	0	0	0	2 (22.2)
2	7 (77.7)	6 (66.6)	4 (44.4)	4 (44.4)	3 (33.3)	4 (44.4)	8 (88.8)	9 (100)	8 (88.8)	5 (55.5)
3	0	0	0	0	4 (44.4)	1 (11)	1 (11)	0	1 (11)	2 (22.2)

Where 1 relates to "no problems", 2 relates to "some problems" and 3 relates to "significant problems"

At the post assessment, five patients were referred for on-going psychology input, four were referred to local gyms for on-going exercise provision and two patients were assisted with financial aid applications.

The subjective feedback from patients was all positive. Patients reported feeling less isolated in their recovery "the class has helped me realise I am not alone in what I'm feeling". Patients felt sharing their experiences with others in a similar situation helped them significantly and they felt more confident returning to exercise "I'm already doing more and feel more confident (at week 3)". There were no adverse events recorded during the programme.

DISCUSSION

The pilot programme demonstrated that offering an exercise programme following critical illness is a beneficial and safe addition to follow up services.

All the patients demonstrated positive improvements physically after participation in the exercise programme. The psychological outcome measures did not show an improvement despite patients subjectively reporting they felt better psychologically and reporting feeling less isolated having shared their experiences with others in a similar position. Quality of life scores improved in some areas such as mobility and completing ADLs. Patients reported improved confidence in continuing to exercise following the programme. Although this was not explored in detail, it is in keeping with the barriers outlined in literature covering rehabilitation following critical illness.[10,12]

Whilst there were positive outcomes for patients, there were limitations to the pilot programme. Being a service evaluation with no control group, there is no way of determining whether the positive results demonstrated may have occurred naturally over time regardless of whether patients participated in the rehabilitation programme or not.

The service evaluation ended prematurely leading to small patient numbers and limited data. The Trust where patients were recruited runs three follow up clinics on different sites using many different members of staff and whilst the programme was well advertised, unfortunately only a small number of patients were referred. Data was not recorded regarding how many patients were offered the service in follow up clinic and declined at the point of discussion. Without this data, it cannot be established how many patients were offered the class and declined, and for what reason, therefore the actual "need" was difficult to determine. A high dropout rate was experienced and some declined to attend, which may be attributed to two main factors: the Trust is a tertiary centre so patients were referred from a large geographical area; the programme was only held at one site, on one day a week resulting in travel and attendance restrictions for participants.

The programme was run in a cohort design rather than a rolling programme due to staffing and time pressures of other clinical and non-clinical duties for the therapists involved. This design however, led to prolonged waiting times with at least an 8 week wait occurring between cohorts. The design, alongside time constraints of the team, led to small group numbers and when patients withdrew at short notice their spaces were not able to be filled. A rolling programme may counteract these issues as patients can join the programme at any time point. There would however, be an increased time burden on the team to undertake pre and post assessments on a regular basis, rather than at the beginning and end week of the 8-week block.

This service evaluation did not collect any qualitative outcome measures related to social integration or confi-

dence. This would be beneficial in any future programmes as the health-related scores did not always reflect the feedback received from participants. The outcome measures chosen may not be valid for use in the post ICU population and therefore might not be strong indicators to demonstrate meaningful recovery within this demographic. This would be worth considering in any future programmes or research in this field.

To establish this programme in the long term, it would be recommended to implement an improved method of recording the offer of the programme to patients, and the outcome of this offer. Increased staffing or a dedicated staff member for this programme, considering a rolling programme, and additional classes offered would allow for increased numbers accessing the programme.

Key points

1: A follow up exercise programme may be a beneficial addition to an ICU follow up service if adequate staffing allows.

2: Participation in the post ICU exercise programme was associated with improvements in physical function.

3: Patients reported they enjoyed the social, educational and supportive aspects of the programme and felt more confident to return to activity outside the programme setting. It would be beneficial to collect more data regarding this in future programmes.

4: None of the enrolled patients were able to access this support from any other community service, highlighting a service need for the post ICU population.

ACKNOWLEDGEMENTS

The author would like to thank the Intensive Care Follow up team and the Intensive Care multi-disciplinary team at Imperial College Healthcare NHS Trust, Vicky Newey, Professor Stephen Brett and Dr Huw Woodbridge for their support.

DECLARATIONS OF INTEREST

There are no declarations of interest to be made

FUNDING

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Submitted: September 05, 2024 GMT. Accepted: August 11, 2025 GMT.

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Cook S, Thomas A, Smyth S, Leslie R, Sedgley C, Swingwood E. Out-of-Hours Service Models for Acutely Deteriorating Respiratory Patients: A Scoping Review. *ACPRC Journal*. 2025;57(2):33-42. doi:10.56792/ZWGM2532

Service Delivery

Out-of-Hours Service Models for Acutely Deteriorating Respiratory Patients: A Scoping Review

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Keywords: out-of-hours, on-call, service delivery, respiratory, physiotherapy

https://doi.org/10.56792/ZWGM2532

Journal of the Association of Chartered Physiotherapists in Respiratory Care

Vol. 57, Issue 2, 2025

Abstract

Background

Acute respiratory deterioration in hospitalised patients requires timely intervention to prevent further clinical decline. Out-of-hours respiratory care is typically provided through on-call physiotherapy rotas, extended hour cover, or 24/7 on-site services. However, models of care vary widely internationally, and little is known about how these services are structured, delivered, and evaluated for acutely deteriorating respiratory patients.

Objectives

To map and describe international models of care for out-of-hours services for acutely deteriorating respiratory patients, including key model characteristics, workforce configurations, referral processes, reported barriers and facilitators, and associated outcomes.

Methods

A scoping review was undertaken following the Joanna Briggs Institute and PRISMA-ScR guidance. This included a comprehensive search of electronic databases and grey literature. Papers were included if they reported models of out-of-hours care relevant to respiratory physiotherapy or multidisciplinary care for patients with acute respiratory deterioration. Data were extracted independently by four reviewers and synthesised descriptively using a narrative approach.

Results

Thirteen international papers published between 2002 and 2023 were included. The majority (77%) described out-of-hours physiotherapy models; others reported extended hours or multidisciplinary rapid response teams. Operating hours, referral processes, and protocols varied widely, with many services relying on non-specialist physiotherapists for out-of-hours provision. Barriers to service provision included staffing limitations, variability in competence, and organisational challenges. Facilitators included presence of senior support, structured training, protocols, and institution support for extended hours models. Evidence on clinical outcomes was limited and heterogeneous.

Conclusions

Out-of-hours care for acutely deteriorating respiratory patients is delivered through a range of models internationally, with considerable variation in structure and workforce configuration. Further research is needed to evaluate model effectiveness, impact on staff well-being, and relevance to evolving workforce demands.

INTRODUCTION

Out-of-hours respiratory care involves the delivery of time-sensitive interventions outside routine clinical hours and is typically provided through respiratory physiotherapy-led out-of-hours rota.[1] This model often covers evenings, overnight periods, and occasionally weekends, depending on local service design. Respiratory physiotherapy plays a critical role in supporting patients whose respiratory needs require timely intervention that cannot be safely deferred until standard business working hours.[2] Interventions include chest clearance, positioning, adjuncts to increase lung volumes, non-invasive support, and suctioning.[3,4] Interventions are tailored to individual patients to optimise respiratory function and mitigate clinical deterioration.

Internationally, out-of-hours respiratory care is delivered through a range of models, including traditional out-of-hours services where physiotherapists are contacted as needed,[1] extended hours service with physiotherapists on-site beyond standard hours,[5] and in some settings multidisciplinary rapid response teams provide respiratory care out-of-hours.[6] Many out-of-hours services rely on specialist and non-specialist physiotherapists,[2] resulting in variation in the quality and confidence of care delivery due to infrequency of out-of-hours shifts and the challenges of working outside of their usual practice areas. While training initiatives including simulation[7] have been developed to address these issues, concerns remain around staff confidence, stress, and model sustainability.

Despite the time-sensitive nature of these interventions and the vulnerability of the patient group, there is limited formal guidance outlining how out-of-hours respiratory care should be organised, staffed, or delivered. While the Chartered Society of Physiotherapy (CSP) published a toolkit[8] in 2025 to support the redesign of on-call services, this resource offers principles rather than prescriptive national standards. As a result, services have developed in isolation, leading to wide variation in model structure, workforce configuration, and clinical governance. The lack of national or international consensus on what constitutes safe and effective out-of-hours respiratory physiotherapy further complicates efforts to evaluate impact on clinical outcomes, staff wellbeing, and service sustainability.

This scoping review aimed to explore and describe the models of care for out-of-hours services that are currently being implemented internationally for acutely deteriorating respiratory patients. The term "out-of-hours" is used as an umbrella term to describe services delivered outside standard working hours, recognising that definitions and terminology vary. The review sought to identify key model characteristics, including operating hours, referral processes, workforce arrangements, and the use of protocols or guidelines, and to explore how these models may support staff confidence, patient outcomes, and workforce sustainability.

METHODS

STUDY DESIGN

Scoping review methodology was adopted to systematically explore international models for out-of-hours care of acutely deteriorating respiratory patients. This approach was chosen to examine the breadth and nature of evidence available on this topic and to identify key concepts, gaps, and areas for future research. The review followed the methodological framework proposed by Arksey and O'Malley,[9] further refined by Levac *et al*,[10] and adhered to the updated guidance from the Joanna Briggs Institute (JBI) for conducting scoping reviews.[11]

A protocol was developed *a priori* to guide the review process and ensure methodological transparency. The protocol was prospectively registered on the Open Science Framework and is publicly available at https://osf.io/mbq7j.

ELIGIBILITY CRITERIA

Papers were included if they reported on models of care, service delivery approaches, or multidisciplinary interventions aimed at managing acutely deteriorating respiratory patients out-of-hours in any healthcare setting. International papers were included regardless of healthcare system structure as there may be adaptations that would be applicable to UK healthcare systems. All study designs, including qualitative, quantitative, and mixed-methods research were included. Only English-language publications were included due to resource constraints.

INFORMATION SOURCES AND SEARCH STRATEGY

A three-step search strategy was utilised in this review. First, an initial limited search of MEDLINE (via PubMed) and CINAHL (via EBSCO) was undertaken to identify relevant articles and refine the search terms. Keywords and index terms from the titles and abstracts of retrieved papers were analysed to inform the development of a full search strategy. The full strategy was then adapted and applied across all included databases and information sources. Databases and search terms are in Appendix 1.

STUDY SELECTION

All search results were imported into Rayyan,[12] a platform for systematic review management. Duplicates were removed, and titles and abstracts screened independently by two reviewers against the inclusion criteria. Full-text articles were retrieved and assessed for eligibility. Discrepancies were resolved through discussion or consultation with a third reviewer.

DATA EXTRACTION

The data extraction form was developed and piloted prior to full data extraction by all four independent reviewers. Extracted information included author(s), year of publication, country, study design, setting, population, description of

the care model, components of multidisciplinary involvement, reported outcomes, key findings, and barriers and facilitators to model implementation.

DATA SYNTHESIS

Extracted data were synthesised descriptively using a narrative summary approach. Findings were grouped thematically by model type, operating hours, professions involved, referral processes, use of protocols or guidelines, and reported service or clinical outcomes. The review aimed to highlight both the diversity and commonalities in international approaches to out-of-hours care for acutely deteriorating respiratory patients, and to identify elements of care models that may be transferable to the UK context.

RESULTS

STUDY SELECTION

The results of the search and screening process are presented in the PRISMA flow diagram[13] (Figure 1). Thirteen papers published between 2002 and 2023 were included in this review. Studies were conducted across seven countries and comprised various designs, including trials, observational studies, audits, surveys, reviews, and guidance documents. Most focused on intensive care (ICU) settings, with two examining paediatric populations.[2,14] Full study characteristics are presented in Table 1.

MODELS OF CARE

Out-of-hours respiratory physiotherapy models were the most common, described in 10 of the 13 papers (77%), where physiotherapists were contacted as needed to provide emergency respiratory care.[1,2,14-21] Extended hours physiotherapy services were reported in one study (8%)[5] where physiotherapists were present on-site beyond standard hours to reduce reliance on out-of-hours provision. In addition, a rapid response team (RRT) model was described in one study (8%)[6] where multidisciplinary teams, including medical and nursing staff, responded to acute respiratory deterioration on a 24/7 basis. Guidance documents, such as the Association of Chartered Physiotherapists in Respiratory Care (ACPRC)[1] position statement, recommended out-of-hours respiratory physiotherapy as a minimum standard, with progression towards 24/7 cover where feasible.

HOURS OF OPERATION

Five out of thirteen papers (38.5%) provided detailed information on service operating hours. Where reported these hours varied widely depending on the model. Berney *et al*[16] defined out-of-hours physiotherapy as care provided between 21:00 and 06:00. Devroey *et al*[17] described 24/7 on-site cover, with shifts running from 16:00 to 08:00 on weekdays and 12:00- 08:00 on weekends and holidays. Lim *et al*[19] reported out-of-hours shifts starting from 17:00-21:00 daily, and 21:00 to 08:00 overnight, 12:00- 17:00 on Saturdays and 08:00- 17:00 on Sundays. Thomas *et al*[20] reported an average out-of-hours shift from 16:30-08:00, seven days a week. Gustafson and Grant[5] described an extended hours model with physiotherapists on-site from 08:00-20:00 on weekdays.

REFERRAL PROCESS

Referral processes were described in seven of the thirteen papers (54%), with notable variation in approach. In most physiotherapy-led models, referrals were typically initiated by nursing or medical staff using phone or bleep systems.[15,17,18] Lim *et al*[19] described both pre-planned referrals handed over by daytime physiotherapists, and unplanned/emergency referrals initiated by medical staff. Fernando *et al*[6] reported that RRTs could be activated by any healthcare provider or family member in response to concerns about acute deterioration. Triggers for referral commonly included clinical indicators including sputum retention, dyspnoea, ineffective cough, or the need for post-extubation support.[2,6,15]

PROFESSIONALS INVOLVED IN OUT-OF-HOURS SERVICES

Out-of-hours models mostly relied on non-respiratory or general physiotherapists, often supported by senior colleagues by telephone or in-person as well as specialist physiotherapists (*n*=5,38.5%). [2,14,17,19,29] Specialist respiratory or ICU physiotherapists delivered extended hours and 24/7 physiotherapy services.[5,17] Where no physiotherapist was available, basic respiratory care tasks such as suctioning and patient positioning were undertaken by nursing staff.[16,21] In the RRT model, care was delivered by multidisciplinary teams consisting of medical staff, nurses, and respiratory therapists.[6]

PROTOCOLS AND GUIDELINES

Three of the thirteen papers reported the use of protocols (23.1%). Protocols primarily addressed service logistics, including referral method and response time, rather than clinical treatment decision-making. In a UK audit of 20 large NHS trusts in the Trent region, Dixon and Reeve reported that 16 departments had emergency duty protocols in place, 89% of which were documented in written form.[18] These protocols, often based on ACPRC Guidelines,[1] covered aspects such as referral method, expected response time, contact systems, security arrangements, and reimbursement processes. Babu *et al*[15] reported out-of-hours referrals in an ICU setting in India followed The CSP and ACPRC guidance, although no clinical protocols were described. The ACPRC guidance[1] set out recommendations for service structure and competence requirements but did not provide data on implementation outcomes. Most other papers reported reliance on individual clinical judgement, with no formal physiotherapy protocols described to guide intervention selection or delivery.[2,5,6,14,16,17,19-22]

Table 1. Study Characteristics

Author	Year	Country	Study Design	Setting	Model Type	Hours of Operation	Professions Involved	Referral Process	Protocols/ Guidelines
ACPRC[1]	2017	United Kingdom	Guidance documentation	Acute hospitals	On-call	Not applicable	Physiotherapists	Not applicable	ACRPC and CSP Standards
Babu *et al*[15]	2010	India	Single centre randomised controlled trial	ICU	On-call	Not specified	Physiotherapists	From Nurse/Doctor with specified clinical triggers	CSP/ACPRC on-call standards for referral triggers
Berney *et al*[16]	2002	Australia	Single centre case-control	ICU	On-call	21:00- 06:00	Physiotherapists/ Nurses	Not specified	Not specified
Brusco *et al*[22]	2006	Australia	Systematic review	Mixed hospital settings	On-call, weekend, and extended hours	Not specified	Physiotherapists	Not specified	Not specified
Devroey *et al*[17]	2016	Belgium	Single centre service evaluation	Acute hospital	On-call	Weekday: 16:00- 08:00 Weekend: 12:00- 08:00	ICU Physiotherapists	From Nurse/Doctor with specified clinical triggers	Not specified
Dixon and Reeve[18]	2003	United Kingdom	National audit	Acute hospitals	On-call	Not specified	Physiotherapists	Bleep/Phone	ACPRC on-call standards
Fernando *et al*[6]	2018	Canada	Single centre cohort study	Acute hospitals	Rapid Response Team	24/7	Medical, nursing, respiratory therapists	Referral from staff/ family	Not specified
Gustafson and Grant[5]	2017	United Kingdom	Single centre service evaluation	ICU	Extended Hours	08:00- 20:00 Weekdays	ICU Physiotherapists	Pre-arranged by Physiotherapist	No formal protocol
Lim *et al*[19]	2008	Singapore	Single centre retrospective study	Hospital wards	On-call	Weekdays: 17:00-21:00 Sat: 12:00-17:00 Sun: 08:00-17:00 Overnight: 21:00- 08:00	Physiotherapists	Physiotherapist and Medical Staff	Not specified
Shannon *et al*[2]	2015a	United Kingdom	Single centre randomised crossover trial	Paediatric ICU	On-call	Not specified	Respiratory specialist and non-respiratory specialist physiotherapists	Not specified	Not specified
Shannon *et al*[14]	2015	United Kingdom	Single centre randomised crossover trial	Paediatric ICU	On-call	Not specified	Respiratory specialist and non-respiratory-specialist physiotherapists	Not specified	Not specified
Thomas *et al*[20]	2023	Australia and New Zealand	Multicentre cross-sectional survey	ICU	On-call	16:30- 08:00, Seven days a week.	Physiotherapists	Not specified	Not specified
Van Der Lee *et al*[21]	2018	Australia	Multicentre cross-sectional survey	ICU	On-call	Not specified	Physiotherapists	Initiated by daytime treating physiotherapist	Not specified

Abbreviations- ACPRC: Association Chartered Physiotherapists in Respiratory Care; CSP: Chartered Society of Physiotherapy; ICU: Intensive Care Unit.

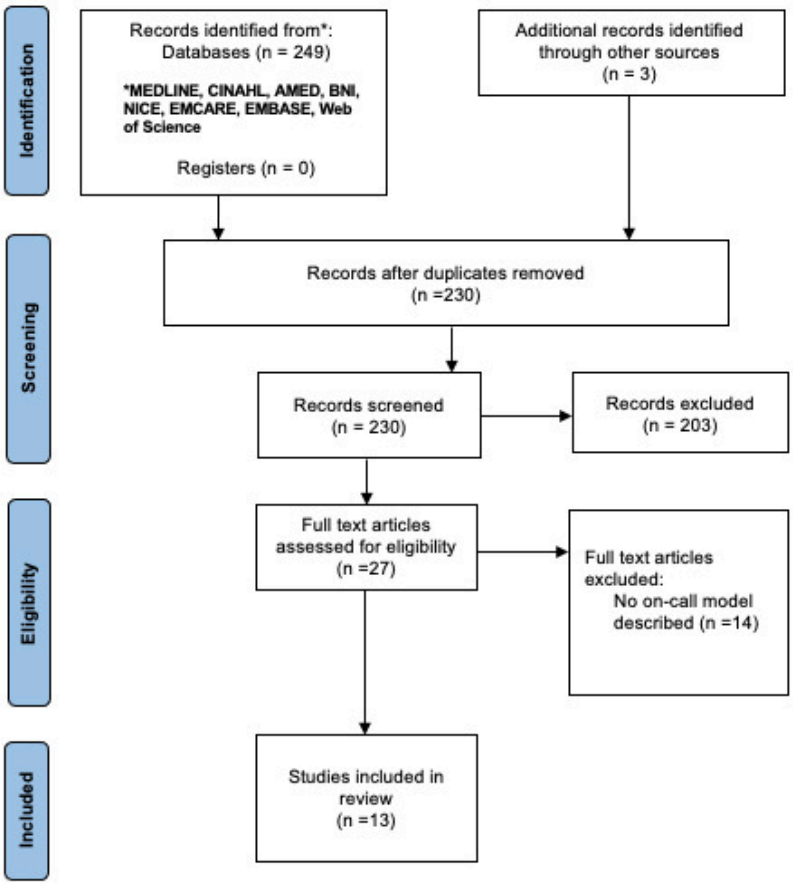

Figure 1. PRISMA flow diagram for scoping review process.[13]

OUTCOMES

Patient and service outcomes were reported in twelve of the thirteen papers (92.3%). These outcomes were variable and often secondary to descriptions of service models. Some papers reported positive clinical impacts associated with models of care, including reductions in ICU length of stay and ventilation duration, often associated with intensive or out-of-hours physiotherapy provision.[16,23] Babu *et al*[15] reported improvements in respiratory measures, including peak expiratory flow rate and six-minute walk distance, linked to out-of-hours physiotherapy. Shannon *et al*[14] found that specialist respiratory physiotherapists more frequently applied effective techniques such as combined chest wall vibration and suction, alongside greater improvements in compliance and tidal volumes, and fewer adverse events (4.8% vs 12.7%) compared to non-respiratory physiotherapists .[2]

Service level outcomes included quantifying treatments delivered out-of-hours,[17] reduced out-of-hours burden and cost savings associated with extended hours models.[5] The RRT model highlighted challenges in overnight acute care delivery, reporting higher mortality associated with nighttime activations.[6] Overall, while some papers demonstrated positive impacts, formal evaluations of effectiveness, patient centred outcomes, and long-term recovery were limited.

BARRIERS AND FACILITATORS

All included papers reported barriers and facilitators to implementing and delivering out-of-hours care for acutely deteriorating respiratory patients (Table 2). Two papers noted the difficulty of maintaining staff competence and confidence, particularly where non-respiratory physiotherapists were involved.[1,14] Staffing limitations were reported as a barrier in both research design[15] and service delivery,[5,21] contributing to concerns about consistency of service delivery and patient safety. Financial and organisational challenges were also identified, highlighting issues related to cost effectiveness and staffing sustainability.[5,17] Brusco *et al*[23] highlighted barriers, including heterogeneity of study designs and low to medium study quality, which limited conclusions about best practice models.

Facilitators of out-of-hours models of care included formal training, access to senior staff, clear protocols, adequate staffing, and organisational commitment to service quality. (Table 2). The ACPRC[1] and the UK audit by Dixon

Table 2. Barriers and Facilitators

Author	Year	Barriers	Facilitators
ACPRC[1]	2017	Challenges to maintain competency in non-specialist physiotherapists; managing fatigue, securing funding, and ensuring service robustness.	Advocates for minimum standards; structured training; clear policies; appropriate staffing and promoting service value.
Babu *et al*[15]	2010	Staffing limitations.	Use of CSP/ACPRC guidelines for referrals.
Berney *et al*[16]	2002	Lack of standardisation of clinical decision making.	Dedicated ICU physiotherapy staffing model.
Brusco *et al*[22]	2006	Study heterogeneity, low-moderate quality.	Demonstrated feasibility in some critical care subgroups (Acute spinal cord injury and high-risk elderly surgical ICU patients).
Devroey *et al*[17]	2016	Unable to assess cost effectiveness due to lack of baseline data and ethical constraints.	Dedicated ICU physiotherapy team; institutional support and positive staff perception of value.
Dixon and Reeve[18]	2003	Inconsistent adherence to protocols.	Clear protocols, training, and support from senior respiratory physiotherapists.
Fernando *et al*[6]	2018	Night-time service challenges; delays in activation, reduced staff experience, shift patterns at risk of impacting cognitive performance.	24/7 multidisciplinary team and defined activation criteria.
Gustafson and Grant[5]	2017	Staffing challenges, burnout risk.	Extended hours reduced on-call burden, organisational support
Lim *et al*[19]	2008	No evaluation of long-term outcomes or cost effectiveness.	Structured after-hours service.
Shannon *et al*[2]	2015a	Skill level having potential impact on patient outcomes.	Use of force-sensing technology for training feedback; potential for targeted education.
Shannon *et al*[14]	2015	Confidence gaps between specialist and non-specialist.	Highlighted need for targeted training.
Thomas *et al*[20]	2023	Lower staffing linked to dissatisfaction, variability in access to senior staff.	Access to senior staff. Integrated orientation and educated processes.
Van Der Lee *et al*[21]	2018	Staffing limitations, reliance on other health professionals to provide respiratory care.	Larger ICUs, more availability for on-call staff.

Abbreviations: ACPRC: Association of Chartered Physiotherapists in Respiratory Care; CSP: Chartered Society of Physiotherapy; ICU: Intensive Care Unit

and Reeve[18] highlighted the role of structured training programmes and clear policy frameworks in supporting staff competence and service delivery. Thomas *et al*[21] similarly identified access to senior ICU physiotherapists support as key enablers of safe and effective service delivery. Van der Lee *et al*[21] reported that larger ICUs with higher physiotherapy staffing levels facilitated after-hours service provision. Dedicated ICU physiotherapy teams with institutional support were identified as facilitators[5,17] alongside the use of national or professional guidelines to further support service quality.[1,15,18]

DISCUSSION

This scoping review highlights considerable variation in how out-of-hours respiratory care is structured and delivered across international healthcare systems. Models ranged from traditional out-of-hours services such as from 16:00-8:00 seven days a week, to extended working hours and 24/7 multidisciplinary teams, with operational hours, staffing configurations, and referral processes differing significantly between settings. Importantly, these models were implemented across a diverse range of hospital types, from specialist ICUs to general wards each with distinct clinical demands and workforce capabilities.

Variability is important to note and highlights the challenge of prescribing a single "ideal" model for out-of-hours respiratory care. Rather than advocating for a one-size-fits-all approach, our findings support the need for scalable and contextually adaptable service models that can evolve in response to local population needs, organisational resources, and existing workforce capacity. Future guidance may be more effectively framed around a set of core principles or standards, such as those outlined in the CSP Toolkit[8] which define the function and responsiveness of out-of-hours care, allowing for localised implementation within a flexible framework.

Barriers identified suggest a potential need for deliberate and system-level planning in designing sustainable out-of-hours respiratory services. Workforce limitations and inconsistent staff competence, particularly among non-specialist physiotherapists, raise important questions about how services can safely scale or operate in resource-constrained environments. These challenges are unlikely to be addressed through training alone and demand integrated approaches that include role clarity, protected time for skill maintenance, and flexible models of care. Applying imple-

mentation science frameworks such as the Consolidated Framework for Implementation Research (CFIR)[23] and Expert Recommendations for Implementing Change (ERIC)[24] may help organisations systematically identify and address context-specific barriers and facilitators to service implementation.

Financial and organisational barriers may also suggest that commissioning out-of-hours services should go beyond workforce inputs and consider broader questions of service value, outcome measurement, and long-term sustainability through appropriate data collection and analysis. Health economic evaluation was largely absent in the current literature and could play a critical role in informing decisions around resource allocation and service design.

A notable observation across papers was the diversity of professionals delivering out-of-hours respiratory interventions. While physiotherapists were the primary providers, responsibility for managing acute deterioration was sometimes shared with, or transferred to other health professionals, including nurses and medical staff, particularly in RRT models of multidisciplinary nature. These arrangements raise important questions about professional boundaries, role clarity, and the competencies required to deliver safe and effective respiratory care out-of-hours. Rather than focussing on the role of respiratory physiotherapy, it may be more productive to consider who is best equipped to respond to acute respiratory deterioration and under what conditions. Re-framing the issue shifts the lens from profession-specific tasks to the broader issue of system responsiveness, interdisciplinary capability and sustainability, and patient safety.

Finally, facilitators such as structured training, senior mentorship, clear protocols, and institutional support offer valuable direction for service development. However, ensuring consistent access to these enablers across diverse settings remains a challenge, particularly where staffing and financial constraints exist. Alignment of governance structures, education pathways, and quality monitoring may help promote consistent, high-quality care delivery.

CONCLUSION

This scoping review identified wide variation in out-of-hours respiratory care models internationally, reflecting differences in context, resource availability, and workforce. A single standardised model is unlikely to address the diverse needs and contextual challenges identified across settings. Future research should focus on identifying core components of safe and effective care - including staff competence, timely access, and referral clarity - and on adapting these through flexible, context-sensitive implementation. Collaboration between professional bodies, policymakers, and service leaders- including those in strategic physiotherapy roles, will be critical to enable the development of models that are evidence-informed, equitable, and sustainable in real-world practice.

Submitted: August 22, 2025 GMT. Accepted: October 30, 2025 GMT. Published: November 24, 2025 GMT.

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SUPPLEMENTARY MATERIALS

Appendix

Download: https://acprcjournal.scholasticahq.com/article/146483-out-of-hours-service-models-for-acutely-deteriorating-respiratory-patients-a-scoping-review/attachment/308303.docx?auth_token=1Lw2j13HQB7slGpNgIJM

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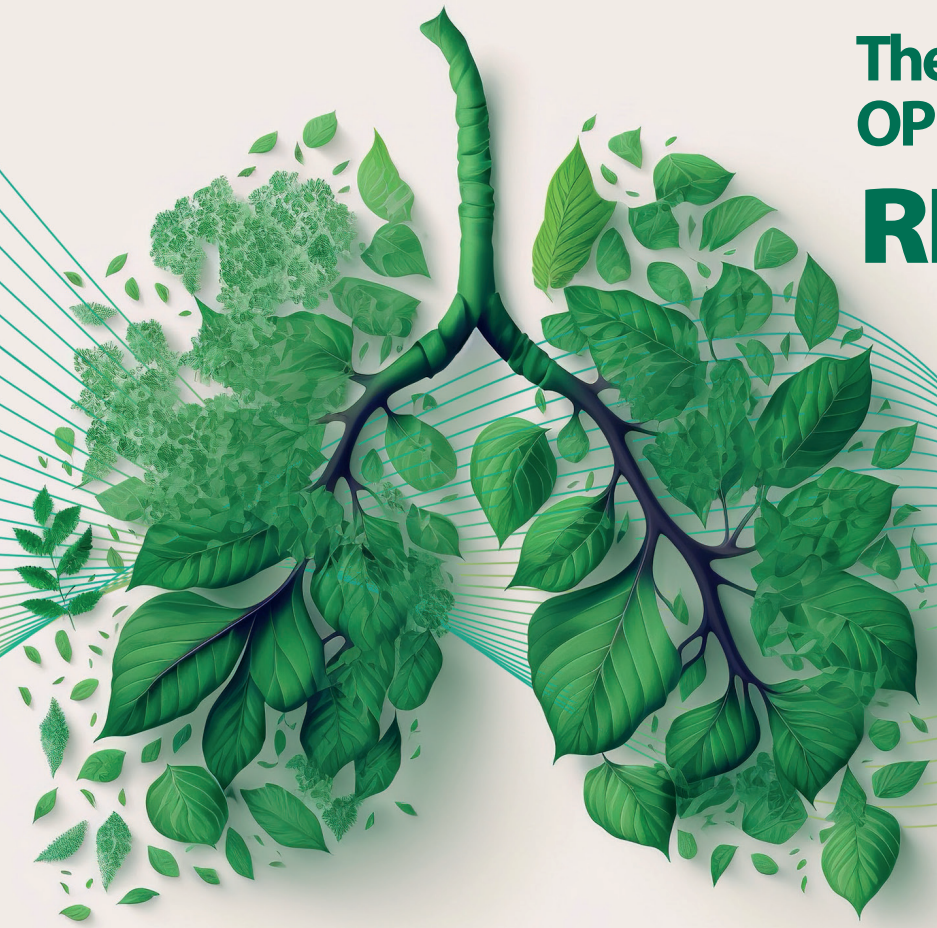

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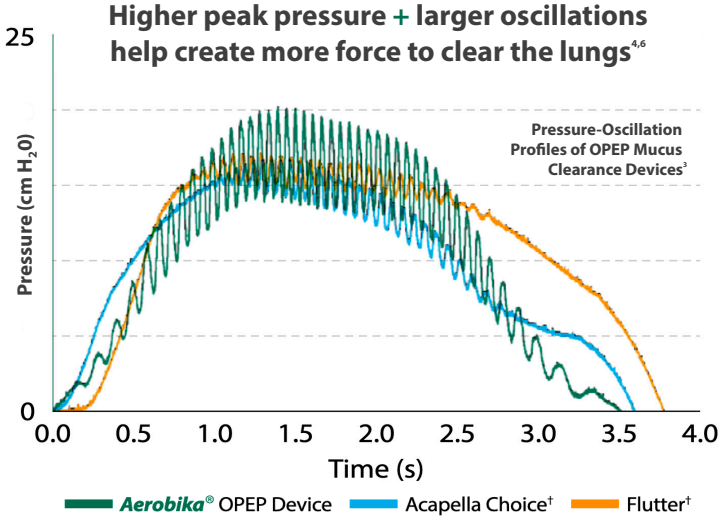

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† In vivo data, compared to Acapella and Flutter ‡ greater pressure amplitude is related to therapeutic effectiveness

1 GpRx Primary Care Data [Feb 2024]. **2** GOLD 2023 Report. **3** Hill AT *et al.*, British Thoracic Society Guideline for bronchiectasis. **4** Van Fleet H, *et al.* Respiratory Care 2017;62(4):451-458. **5** Suggett, J. *et al.* CHEST 2017.**6** Coppolo, *et al.* Pulmonary Therapy (2021)..

Butler K, Patel J, Hodson J, Weblin J. Can the one-minute sit-to-stand test predict the development of post-operative hospital-acquired pneumonia in patients undergoing oesophagectomy: a service evaluation. *ACPRC Journal*. 2025;57(2):44-52. doi:10.56792/ARXF8356

Surgery

Can the one-minute sit-to-stand test predict the development of post-operative hospital-acquired pneumonia in patients undergoing oesophagectomy: a service evaluation

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Keywords: one minute sit to stand, risk stratification, oesophagectomy, post-operative outcomes, pneumonia

https://doi.org/10.56792/ARXF8356

Journal of the Association of Chartered Physiotherapists in Respiratory Care

Vol. 57, Issue 2, 2025

Abstract

Introduction

Oesophagectomy remains the only potentially curative treatment strategy for patients with oesophageal cancer. However, it is associated with high rates of post-operative pulmonary complications, including hospital acquired pneumonia (HAP), negatively impacting patient recovery and survival. Poor pre-operative functional status has been linked with increased post-operative morbidity and mortality. Validated pre-operative risk stratification assessments (e.g. the incremental shuttle walk test) are available to assess pre-operative fitness. However, many of these need to be performed in-person, or require equipment or adequate space. Restrictions during the COVID-19 pandemic meant that alternative assessment strategies needed to be used, with our institution selecting the one-minute sit-to-stand test (STS).

Aim

To assess the predictive accuracy of the STS at our institution, with respect to the primary outcome of HAP and secondary outcomes including hospital length of stay (LOS).

Method

A retrospective service evaluation was performed for patients undergoing pre-operative STS assessment prior to elective oesophagectomy for oesophageal cancer. The evaluation covered two periods when the STS was being used at our institution: July - December 2020 and April 2022 - May 2023. Predictive accuracy was quantified by the area under the receiver operating characteristic curve (AUROC) for the outcome of HAP, and Spearman's rho for LOS.

Results

The 55 patients achieved a mean (± standard deviation) pre-operative STS of 27 ± 9, and 13 (24%) developed HAP. STS was not found to be significantly predictive of HAP (AUROC: 0.48, 95% CI: 0.31-0.64, p=0.796). However, a significant association between STS and LOS was observed (rho: -0.37, p=0.005), with LOS reducing by 16% (95% CI: 2-28%) per five-point increase in the STS score.

Conclusion

The STS did not have clinical utility in identifying patients at risk of HAP after elective oesophagectomy at our institution. However, it may be useful in identifying patients who are likely to have an extended post-operative LOS. Further investigation of the STS is warranted, to validate these findings at other institutions, and identify the effectiveness of the STS in predicting other outcomes, particularly patient-centred outcome measures such as functional recovery and quality of life.

INTRODUCTION

Oesophageal cancer is the fourteenth most common type of cancer in England and Wales, with around 9,400 people diagnosed annually, and 3,733 patients undergoing potentially-curative oesophagectomy between 2019 and 2022.[1] Despite the implementation of Enhanced Recovery After Surgery (ERAS) protocols and advancements in surgical techniques, patients undergoing oesophagectomy for oesophageal cancer still experience high rates of post-operative morbidity and mortality,[2] with 24-40% of patients experiencing pulmonary complications such as hospital-acquired pneumonia (HAP), respiratory failure, or acute respiratory distress syndrome.[3-6] Post-operative complications after oesophagectomy, including HAP, have been shown to have a significant detrimental impact on longer-term patient survival.[2] In an attempt to improve these outcomes, there is an increasing focus on the assessment of patients' pre-operative functional capacity. The pre-operative functional status of patients can be used to guide the consent process and shared decision making; avoid decisional regret having undergone surgery[7]; plan best and individualised post-operative care; and to understand outcomes allowing for risk adjustment. Pre-operative risk stratification has also been utilised to guide prehabilitation requirements.[8]

The incremental shuttle walk test (ISWT) is an objective measure of functional capacity and physiological reserve.[9] Studies have suggested that a pre-operative mobilisation of <350m is indicative of a higher-risk patient, and is associated with significantly higher rates of post-operative complications and 30-day and three-year mortality in patients undergoing oesophagectomy.[10-12] However, the ISWT requires a face-to-face clinician/patient appointment, and adequate space to be performed. This caused challenges during the COVID-19 pandemic, due to many hospitals repurposing physiotherapy and rehabilitation space, and the need to move to virtual pre-assessment clinic appointments to adhere to social distancing guidelines.[13] As a result, alternative field tests to assess functional capacity were utilised, including the one-minute sit-to-stand test (STS). This has the benefits of needing minimal space and no equipment, other than a chair; and that it can be explained, administered and witnessed over a videocall, allowing for the test to be used in virtual clinic appointments.[14] Despite restoration of normal services post-pandemic, the STS continues to be widely used by clinicians as a measure of an individual's functional capacity, with outcomes of the STS contributing to multidisciplinary team (MDT) decision making relating to fitness for surgery.[15] However, whilst the STS is widely used in cardiothoracic pre-assessment, there is currently a lack of published research assessing its utility in predicting the risk of pulmonary complications in patients undergoing oesophagectomy.[16]

AIM

This service evaluation aimed to assess the clinical utility of performing the STS at the pre-operative assessment at our institution. Specifically, the primary aim was to assess the ability of the STS to predict the development of HAP after oesophagectomy. The secondary aims were to compare the performance of the STS to other risk assessment tools, and to assess associations with secondary outcomes, including length of stay and 90-day mortality.

METHODS

DESIGN

This was a single-centre service evaluation conducted in a large tertiary-level acute care hospital. This service evaluation was registered as an audit on the Clinical Audit Registration and Management System (CARMS) at University Hospitals Birmingham NHS Foundation Trust (UHB; audit ID: CARMS-19300).

SETTING

The Queen Elizabeth Hospital Birmingham (QEHB), UK, covers a population of 1.7 million. As a major tertiary upper gastrointestinal unit, it treats local and regional patients undergoing curative treatment for oesophageal cancer. Prior to oesophagectomy surgery, all patients attended a pre-assessment clinic, during which they were reviewed by a physiotherapist. However, due to funding limitations, during periods of annual leave and sickness, a physiotherapist was unable to join pre-assessment clinics to perform this review. Prior to the COVID-19 pandemic, an ISWT was performed during the clinic to quantify functional capacity and physiological reserve. However, due to social distancing requirements, this was substituted for the STS between July 2020 and December 2020. Due to re-deployment of physiotherapy staff during the COVID-19 pandemic, there was a hiatus in physiotherapy attendance at pre-assessment clinic subsequently. When staff returned to their previous duties in May 2021, the STS was replaced with the ISWT. However, the STS then was reimplemented for a second period between April 2022 and May 2023, due to a repurposing of therapy space, which left insufficient room for the ISWT to be performed.

PARTICIPANTS

The service evaluation included a convenience sample of consecutive patients attending pre-assessment clinics between the two periods when STS was being used (July 2020 - December 2020 and April 2022 - May 2023). Patients were included if they had been listed for an elective oesophagectomy for oesophageal cancer, and completed the STS as part of pre-assessment within 90 days prior to surgery. Patients were excluded if they did not complete the STS or did not proceed to surgery.

PROCEDURE

Since the first period of the service evaluation commenced during the COVID-19 pandemic, patients either attended in-person clinics, or were assessed in virtual clinics using videocalls, depending on the prevailing social distancing guidelines. For patients reviewed by a physiotherapist during their pre-assessment clinic, the STS was completed according to a standardised protocol, which involved patients completing as many sit to stands from a chair as possible within one minute.[17] The STS was then repeated after a 15-minute break, with the second result recorded, to negate the learning effect.[18] After performing the STS, patients were asked to rate their perceived level of exertion on the Borg scale, giving a score in the range of 6-20.[19] Observations performed at the pre-operative assessment, along with the details of the planned operative approach were then used to calculate the ARISCAT score.[20] The ARISCAT is validated risk tool for prediction of perioperative pulmonary complications devised from a heterogeneous surgical cohort.[21] The clinician additionally recorded the Eastern Cooperative Oncology Group (ECOG) performance status for each patient.[22]

Post-operatively, all patients received standard care as normally provided in our institution. This consisted of an ERAS pathway, including daily reviews by a physiotherapist for the provision of respiratory care and progression of mobility. The level of mobility at each of these reviews was quantified using the Manchester Mobility Scale (MMS).[23]

OUTCOMES

The primary outcome was diagnosis of HAP from any cause, including ventilator-acquired pneumonia, as defined by the US Centres for Disease Control.[24(pp327-330)] Specifically, this included the presence of a chest radiograph (or two in patients with underlying pulmonary or cardiac disease), with at least one of the following:

1. New or progressive and persistent infiltrates;
2. Consolidation;
3. Cavitation ***AND*** symptoms of HAP

For the final point, symptoms of HAP were defined as the combination of at least one of the following:

Fever (>38ºC) with no other recognised cause; leucopoenia (white cell count $<4x10^9 litre^{-1}$); leucocytosis (white cell count $>12x10^9 litre^{-1}$); ***OR*** altered mental status with no other recognised cause (for adults >70 years old);

AND at least two of the following

1. New-onset of purulent sputum or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements;
2. New-onset or worsening cough, or dyspnoea, or tachypnoea;
3. Rales or bronchial breath sounds;
4. Worsening gas exchange (hypoxaemia, increased oxygen requirement, or increased ventilator demand).

HAP diagnoses were made by retrospective review of patient notes on the electronic health record (EHR) system by the study authors.

Secondary outcome measures included the number of days from surgery to achieving an MMS score of seven (MMS7; defined as mobilising ⩾30m), as well as the lengths of stay in the ICU and hospital, and 90-day mortality.

DATA COLLECTION

Clinically-relevant variables relating to patient characteristics, treatment and outcomes were chosen *a priori*, and retrospectively extracted from the EHR. Specifically, these comprised patient demographics, pre-operative assessments of functional capacity, use of neoadjuvant chemotherapy, surgical approach, post-operative analgesia modality, and post-operative MMS assessments. Dates of admission, discharge, and death were additionally extracted, and used to calculate lengths of stay and survival times.

STATISTICAL METHODS

Association between patient characteristics and HAP were performed using Mann-Whitney U tests for ordinal or continuous variables, or Fisher's exact tests for nominal variables. The predictive accuracy of the STS with respect to HAP at our institution was then assessed using a receiver operating characteristic (ROC) curve, which was quantified using the area under the ROC curve (AUROC). This analysis was also performed for the other risk stratification tools and assessments of functional capacity. The association between the STS and HAP rates was further assessed using a univariable binary logistic regression model, with the STS as a continuous covariate.

The relationships between the STS and other outcomes were then analysed, with the associations initially being quantified using Spearman's rank correlation coefficients (rho). Univariable regression models were then produced, with the STS a covariate, and the outcome of interest as the dependent variable. Outcomes were $\log_2$-transformed prior to analysis, to reduce the level of skew in the distribution and improve model fit. The coefficients from the resulting models were then anti-logged and converted into percentage changes per five-point increase in the STS, for ease of interpretation.

All analyses were performed using IBM SPSS v29 (IBM Corp. Armonk, NY), with $p<0.05$ deemed to be indicative of statistical significance throughout. Continuous variables are reported as *mean* ± *standard deviation*, where approximately normally distributed, or as *median (interquartile range; IQR)* otherwise. Cases with missing data were excluded from the analysis of the affected variable.

SAMPLE SIZE CALCULATION

Since the service evaluation was based on a retrospective convenience sample of patients, it was based on a fixed sample size. As such, rather than performing a sample size calculation *a priori* to determine the required sample size,

a *post hoc* power calculation was instead used, to assess the feasibility of performing the service evaluation with the available sample size. Based on the included sample size (N=55) and HAP prevalence (24%), a *post hoc* power calculation for the primary aim of assessing the ability of the STS to predict the development of HAP returned a minimal detectable AUROC of 0.75 at 80% power and 5% alpha. Whilst this represented a relatively large effect size, this was within the range of AUROC values deemed by Hosmer et al. to be indicative of "acceptable" discriminative accuracy (i.e. an AUROC of 0.70-0.79).[25] As such, it was concluded that, whilst the service evaluation would be underpowered to detect small-to-moderate effect sizes, such effects would likely represent insufficient predictive accuracy for the STS to be deemed to have clinical utility. As such, the sample size was deemed sufficient to achieve the primary aim of the service evaluation.

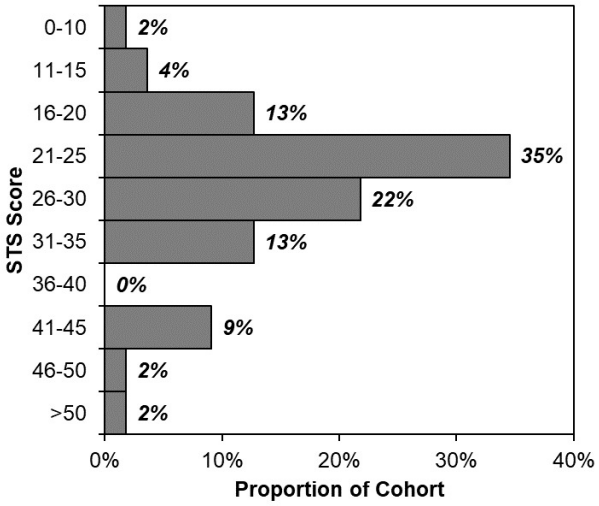

Figure 1. Distribution of pre-operative STS scores

STS: One-minute sit-to-stand test.

RESULTS

COHORT CHARACTERISTICS

In total, 87 patients underwent oesophagectomy surgery during the service evaluation periods, of whom 32 (37%) did not complete the STS at the pre-assessment, due to the absence of a physiotherapist at the clinic. This was largely a consequence of staffing limitations, either due to insufficient clinical capacity or redeployment due to the COVID-19 pandemic. The 55 who completed the STS and were included in the service evaluation had a mean age of 64±8 years and 71% were male. A total of 13 (24%) of these patients developed HAP; comparisons between these cases and the remainder of the cohort found no significant differences in demographic- or treatment-related factors (***Table 1***). Development of HAP was not found to be significantly associated with the MMS scores on post-operative day one (p=0.802). However, there was a non-significant tendency for patients developing HAP to have a lower MMS score on post-operative day two (p=0.053) and to take longer to achieve an MMS score of seven (median: 6 vs. 4 days p=0.057). HAP was associated with significantly longer lengths of stay in ITU (median: 7 vs. 3 days, p=0.022) and hospital (median: 20 vs. 13 days, p=0.022).

ASSOCIATION BETWEEN STS AND HAP

At the pre-operative assessment, a median of 11 days (IQR: 7-25; maximum: 87) prior to surgery, patients achieved a mean STS score of 27 ± 9, with scores ranging from 10 to 53 (***Figure 1***). The STS score was not found to be significantly predictive of HAP (p=0.796), with an AUROC of 0.48 (95% CI: 0.31-0.64; ***Table 2***, ***Figure 2***). The fact that this was <0.5 implies that the direction of the effect was the opposite to what was anticipated *a priori* (i.e. higher STS scores were associated with marginally higher risk of HAP).

ASSOCIATION BETWEEN OTHER ASSESSMENTS AND HAP

The other risk stratification tools or assessments of functional capacity considered had similarly poor performance to that of the STS, with none found to be significantly predictive of HAP (i.e. Borg score, ARISCAT score or ECOG performance status; **Table 2**). Again, all scores had AUROC values that were <0.5, implying that any trends for these scores were in the opposite direction to what was anticipated *a priori* (i.e. higher scores were associated with lower risk of HAP).

ASSOCIATIONS BETWEEN STS AND SECONDARY OUTCOMES

Significant negative correlations were observed between the STS and the time from surgery to achieving an MMS of seven (rho: -0.48, p<0.001), ICU length of stay (rho: -0.28, p=0.041) and hospital length of stay (rho: -0.37, p=0.005). Regression modelling estimated an increase of five points on the STS to be associated with a 23% (95% CI: 11-34%) reduction in the time from surgery to achieving an MMS of seven, a 16% (95% CI: 2-28%) reduction in the ICU length of stay, and an 11% (95% CI: 0-20%) reduction in the hospital length of stay (**Figure 3**). Analysis of 90-day mortality was not performed, due to the low event rate (4%; n=2).

DISCUSSION

This single-centre service evaluation found the STS to have no clinical utility for predicting the development of HAP in patients undergoing elective oesophagectomy at our institution. Other measures of functional capacity, such as the ISWT, have previously been shown to offer better predictive accuracy for post-operative outcomes in this patient cohort.[10-12] Unlike the ISWT, the STS is dependent on participant motivation, due to a lack of external pacing.[26] The STS also lacks specificity to assess cardiovascular fitness, with performance potentially limited by lower limb muscle weakness rather than aerobic capacity.[27] However, it was not possible to assess the ISWT in the present evaluation,

Table 1. Cohort characteristics

	Whole Cohort (N=55)	Hospital-Acquired Pneumonia		p-Value
		No (N=42)	*Yes (N=13)*	
Age (Years)	64 ± 8	64 ± 7	65 ± 11	0.481
Male Gender	39 (71%)	28 (67%)	11 (85%)	0.304
BMI (kg/m^2)	25.8 (23.2-30.0)	25.9 (23.9-30.1)	25.6 (23.0-28.3)	0.692
Smoking History				0.192
Never	16 (29%)	14 (33%)	2 (15%)	
Previous	21 (38%)	17 (40%)	4 (31%)	
Current	18 (33%)	11 (26%)	7 (54%)	
Neoadjuvant Chemotherapy	47 (85%)	34 (81%)	13 (100%)	0.176
Type of Procedure				0.423
Open	11 (20%)	7 (17%)	4 (31%)	
Hybrid	40 (73%)	31 (74%)	9 (69%)	
Minimally invasive	4 (7%)	4 (10%)	0 (0%)	
Post-operative Analgesia				0.110
Epidural	25 (45%)	22 (52%)	3 (23%)	
Block	30 (55%)	20 (48%)	10 (77%)	
MMS on Post-operative Day 1				0.802 [a]
1-3	18 (33%)	14 (33%)	4 (31%)	
4-5	31 (56%)	23 (55%)	8 (62%)	
6-7	6 (11%)	5 (12%)	1 (8%)	
MMS on Post-operative Day 2				0.053 [a]
1-3	16 (29%)	12 (29%)	4 (31%)	
4-5	28 (51%)	19 (45%)	9 (69%)	
6-7	11 (20%)	11 (26%)	0 (0%)	
Surgery to Achieving MMS 7 (Days) [b]	4 (3-8)	4 (2-8)	6 (5-19)	0.057
ITU Length of Stay (Days)	4 (2-8)	3 (2-6)	7 (5-15)	**0.022**
Hospital Length of Stay (Days) [c]	14 (11-28)	13 (10-21)	20 (13-62)	**0.022**
90-Day Mortality	2 (4%)	1 (2%)	1 (8%)	0.420

Continuous variables are reported as "mean ± standard deviation" or "median (interquartile range)", with p-values from Mann-Whitney U tests. Categorical variables are reported as "N (column %)", with p-values from Fisher's exact tests, unless stated otherwise. Bold p-values are significant at p<0.05. [a] p-Value from a Mann-Whitney U test on the ungrouped MMS data, as the factor is ordinal. [b] One patient was discharged on post-operative day 62 without achieving MMS7; a value of 99 days was assumed for analysis. [c] One patient died in hospital on post-operative day 109; hence, this was used as their length of stay. ITU: Intensive treatment unit, MMS: Manchester Mobility Score.

since the patients in this cohort did not undergo this assessment.

To our knowledge, this is the first published service evaluation to examine the use of the STS as a predictor of HAP in patients undergoing oesophagectomy. Notably, smaller studies within the thoracic surgery population, including those involving minimally invasive approaches, have indicated that completing ⩽20–22 repetitions in the STS test may be associated with a higher incidence of post-operative complications.[16] Direct comparison between patients undergoing thoracic surgery and those receiving oesophagectomies is inherently limited. Unlike standard thoracic procedures, oesophagectomies involve dual cavity access and significantly prolonged anaesthesia durations, both of which contribute to a heightened vulnerability to post-operative complications, including HAP.[3-6]

Analysis of the secondary outcomes found the STS to be significantly associated with the time taken to achieve MMS 7 (i.e., mobilising ⩾30m) post-operatively, as well as the ICU and hospital length of stay. Therefore, the STS may have some utility in targeting finite physiotherapy resources to patients who may see the greatest benefit, both with respect to prehabilitation and in the post-operative period. The STS may be particularly useful in situations where space or resources are limited, or where in-person clinic appointments are challenging or impossible for patients to attend, given that it can be performed during a virtual appointment and only requires a chair.[14]

Our service evaluation also highlights the likely frailty of the patients undergoing oesophagectomy at our institution. With a mean age of 65 years, the mean STS of 27 was considerably lower than the average age-matched healthy individual, which has been reported as 35 in males and 33 in females.[28] This could be contributing to the high rates of post-operative morbidity observed, specifically the HAP rate of 24%, although this is similar to other studies reporting pneumonia rates of ~22%.[29]

Table 2. Associations between pre-operative assessments of functional capacity and hospital-acquired pneumonia

		Hospital-Acquired Pneumonia			
	Whole Cohort (N=55)	***No (N=42)***	***Yes (N=13)***	**AUROC (95% CI)**	**p-Value**
Pre-op. Assessment to Surgery (Days)	11 (7-25)	11 (7-18)	16 (7-30)	-	0.585
STS	27 ± 9	27 ± 9	27 ± 7	0.48 (0.31-0.64)	0.796
Borg Score	13 ± 3	13 ± 3	12 ± 3	0.45 (0.27-0.63)	0.596
ARISCAT Score				0.44 (0.25-0.62)	0.302
47	4 (7%)	2 (5%)	2 (15%)		
50	45 (82%)	35 (83%)	10 (77%)		
58	3 (5%)	3 (7%)	0 (0%)		
61	3 (5%)	2 (5%)	1 (8%)		
ECOG Performance Status				0.41 (0.24-0.59)	0.310
0	24 (44%)	17 (40%)	7 (54%)		
1	21 (38%)	16 (38%)	5 (38%)		
2	7 (13%)	7 (17%)	0 (0%)		
3	3 (5%)	2 (5%)	1 (8%)		

Data are reported as "mean ± standard deviation", "median (interquartile range)", or "N (column %)", as appropriate, with p-values from Mann-Whitney U tests; bold p-values are significant at p<0.05. AUROCs are reported anticipating that a higher score would be associated with a higher risk of HAP for all assessments, except for STS, where lower scores were anticipated to be associated with a higher risk of HAP. As such, AUROCs <0.5 indicate that the association between the assessment is in the opposite direction to what was anticipated a priori. AUROC: area under the receiver operating characteristic curve, Pre-op.: Pre-operative, STS: One-minute sit-to-stand test.

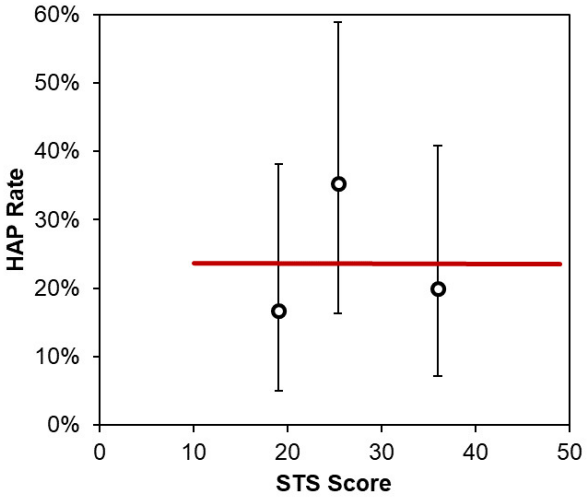

Figure 2. Association between pre-operative STS score and hospital-acquired pneumonia

Points represent the observed HAP rates within subgroups of patients defined by the tertiles of STS scores (<23, 23-28 and >28), and are plotted at the mean of the interval; whiskers represent 95% confidence intervals. The trend line is from a binary logistic regression model on the patient-level data, with the STS score as a continuous covariate. HAP: Hospital-acquired pneumonia, STS: One-minute sit-to-stand test.

LIMITATIONS

The primary limitation of this service evaluation was the small sample size, particularly in the HAP group, which will have resulted in low statistical power. The *post hoc* power calculation for the primary outcome of HAP returned a minimal detectable AUROC of 0.75 at 80% power and 5% alpha, which was within the range deemed by Hosmer et al.[25] to be indicative of "acceptable" accuracy (i.e. 0.70-0.79). As such, this service evaluation is likely underpowered to identify pre-operative assessments that had small-to-moderate accuracy in identifying patients at risk of developing HAP. Consequently, the findings need to be interpreted in the light of the increased risk of false-negatives. The second limitation was that this is a single-centre service evaluation; hence, the results are not necessarily generalisable to other centres. However, an evidenced-based ERAS pathway was used throughout the period of the evaluation to standardise post-operative care; hence, the findings should be consistent with other centres that use a similar approach. Finally, the pre-operative assessments included a mixture of virtual and face-to-face appointments, which may have introduced some heterogeneity when performing the physical assessments. However, a standardised methodology was used, regardless of the type of appointment, which should have minimised the level of such heterogeneity.

CONCLUSION

In the drive to identify novel, alternative and cost-effective pre-assessment tools to risk stratify oesophagectomy patients for post-operative HAP, our single-centre service evaluation has added to the void of evidence. The STS was a poor predictor of post-operative HAP at our institution; however, it was found to have some utility in identifying patients at risk of extended post-operative hospital stays. Further research is required to identify the clinical utility of the STS in oesophagectomy, ideally with a larger sample size, comparisons to other similar assessments of physical

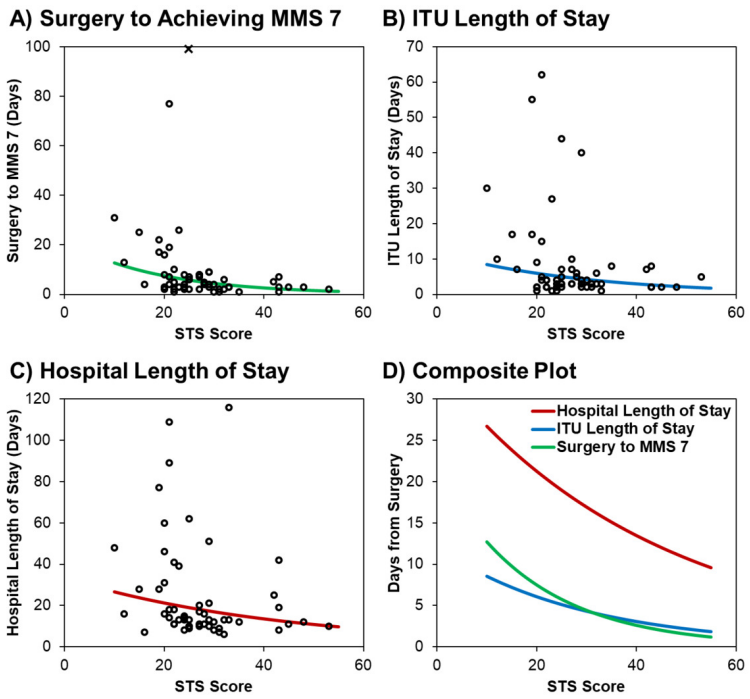

Figure 3. Associations between pre-operative STS score and other outcomes

Points represent individual patients, and plots are based on N=55. Trend lines are from regression models, with the STS score as a covariate, and the $\log_2$-transformed number of days as the dependent variable. All three models are then plotted together in Figure D, to illustrate the trends more clearly. In Figure A, the point indicated by crosses represents a patient who had not achieved MMS 7 at hospital discharge; this is plotted at 99 days, on the assumption that this patient would have the longest time to MMS 7 in the cohort. ITU: Intensive treatment unit, MMS: Manchester Mobility Scale, STS: One-minute sit-to-stand test.

function (e.g., the ISWT), and assessing a broader range of outcomes, particularly patient-centred outcome measures, such as functional recovery and quality of life.

Key Points

- The one-minute sit-to-stand test was not found to be predictive of the development of post-operative hospital acquired pneumonia in patients undergoing an oesophagectomy at out centre.
- However, it may have some utility in predicting time to mobilise, ICU and hospital length of stay.

CONFLICTS OF INTEREST/COMPETING INTERESTS

The authors have no conflicts of interest to declare

FUNDING

No additional funding was received to complete this project

Submitted: February 03, 2025 GMT. Accepted: September 18, 2025 GMT. Published: November 01, 2025 GMT.

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Yadav D, Kaur M, Parween A. A Pilot Quasi-Experimental Study to Evaluate the Effectiveness of the ELTGOL Technique with Conventional Chest Physiotherapy on Respiratory Function and Postoperative Pulmonary Complications in CABG Patients. *ACPRC Journal*. 2025;57(2):53-60. doi:10.56792/BHHH1758

Research methods

A Pilot Quasi-Experimental Study to Evaluate the Effectiveness of the ELTGOL Technique with Conventional Chest Physiotherapy on Respiratory Function and Postoperative Pulmonary Complications in CABG Patients

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Keywords: Eltgol, Coronary Artery Bypass Graft, CABG, Chest Physiotherapy

https://doi.org/10.56792/BHHH1758

Journal of the Association of Chartered Physiotherapists in Respiratory Care

Vol. 57, Issue 2, 2025

Abstract

Background

Patients undergoing coronary artery bypass grafting are at risk of pulmonary complications due to anesthesia, reduced lung function, and altered respiratory mechanics that leads to mucus retention. In physical therapy, Airway Clearance Techniques are used postoperatively to clear mucus from the lungs, aiming to improve lung function and reduce pulmonary complications in the early recovery period.

Objective

This study aimed to determine the effect of the ELTGOL technique combined with conventional chest physiotherapy on respiratory function and the prevention of postoperative pulmonary complications in patients following CABG surgery.

Methods

Fifty-seven patients (ages 45-80) of both sexes who underwent CABG and were in phase 1 of cardiac rehabilitation participated in this pilot randomized control trial (32 in the control group, 32 in the experimental group). Interventions started on POD 2 and continued until discharge (POD 5). The control group received conventional physiotherapy, including breathing exercises, incentive spirometry, and early mobilization, while the experimental group received the ELTGOL technique in addition to these treatments. Outcome measures included chest X-ray improvements, spirometric values, PF ratio, oxygen saturation, chest expansion, and RPE scale.

Results

The data collected on post-extubation day & the POD 5 revealed statistically significant improvement in the scores of inspiratory spirometery reading ($p<0.01$), chest x-ray ($p<0.01$), chest expansion ($p<0.01$) and Borg scale scores ($p<0.01$) for both the groups. However, on POD 5 statistically significant difference was observed in the scores of chest x-ray ($p=0.022$) and Borg scale scores ($p=0.043$) in experimental group.

Conclusion

The addition of the ELTGOL technique to conventional physiotherapy improved respiratory function and reduced postoperative pulmonary complications in the early recovery period in CABG patients.

INTRODUCTION

Cardiovascular diseases (CVD) are the leading cause of death globally,[1] affecting the cardiac muscle and the vascular systems supplying the heart, brain, and other vital organs.[2,3] In India, the age-standardized CVD death rate is 272 per 100,000 population, surpassing the global average of 235 per 100,000, according to the Global Burden of Disease study.[4,5]

Coronary Artery Bypass Grafting (CABG) is the gold standard for Triple Vessel Diseases (TVD), with approximately 1 million procedures performed annually world-

wide.[5] It significantly improves life expectancy for patients with left main coronary artery disease when compared to Percutaneous Coronary Intervention (PCI).[6,7] Various arterial and venous conduits are employed to restore vascularization and enhance long-term outcomes after CABG.[8]

Post-operative pulmonary complications (PPCs) are common in patients undergoing open thoracic surgeries like CABG and the prevalence is between 30% and 60%.[5, 9] Anesthesia, intubation, and surgical trauma can reduce Functional Residual Capacity (FRC) and alter surfactant production.[10] PPCs can lead to ineffective airway clearance (IAC), if left unrecognized and untreated, may lead to significant pulmonary sequestration such as atelectasis, disrupting ventilation-perfusion, affecting blood oxygenation, or may even lead to death in serious complications.[5,11]

This complication can lead to ineffective airway clearance (IAC), a common nursing diagnosis observed in patients' post-CABG. Unrecognized and untreated, IAC may progress to significant pulmonary sequestration or even death.

Chest physiotherapy is crucial in postoperative CABG cases to prevent atelectasis and limit lung volume reduction.[12] Physiotherapists guide patients in breathing exercises, Active Cycle of Breathing Techniques (ACBT), early mobilization, and inspiratory muscle training to enhance oxygenation after open-heart surgery.[13] These techniques are typically combined, especially for patients with impaired cough, muscle weakness, or reduced mucociliary clearance.[14]

ELTGOL (L'Expiration Lente Totale Glotte Ouverte en décubitus Latéral), which was first described by POSTIAUX et al. in 1987 is a less well-known airway clearing technique but increasingly getting popular.[15,16] It is performed in the lateral decubitus position and involves slow expiration with an open glottis, moving air from Functional Residual Volume (FRC) to Residual Capacity (RC).[15,16] This mucus-clearing technique increases airflow resistance and narrows the diameter of the peripheral airways in the inferolateral lung, enhancing the airflow-mucus interface.[17-19]

This technique is indicated for patients with pulmonary secretions such as Chronic Bronchitis[15] and Bronchiectasis.[19] However, evidence of its efficacy in postoperative CABG patients and its impact on open thoracic surgeries is lacking. This study aims to evaluate the effectiveness of the ELTGOL technique combined with conventional chest physiotherapy on respiratory function and the prevention of postoperative pulmonary complications in postoperative CABG patients.

METHODOLOGY

Sample: A total 64 subjects were selected for the study on the basis of inclusion and exclusion criteria. The sample size of 64 was based on feasibility, availability of eligible post-operative CABG patients during the study period, and consistency with similar studies. Although formal power analysis was limited by preliminary data, the number was adequate to observe meaningful trends in clinical outcomes.

Source of subjects: Fortis Hospital, Shalimar Bagh, Delhi and Institute of Heart Lungs Diseases Research Centre, PSRI Hospital, Delhi.

Method of sampling: All the subjects were selected using sample of convenience.

Research design: Quasi-Experimental Pilot Study

Method of selecting subjects: Selection of the subjects was done on the basis of inclusion and exclusion criteria.

INCLUSION CRITERIA

- Both male and female
- Age 45-80 (The most common age group undergoing CABG is between 50–80 years, as supported by epidemiological studies and cardiac surgery registries).
- Recent CABG patients
- Patient with CAD without any comorbidity (COPD, Cystic fibrosis)

EXCLUSION CRITERIA

- Patients on Intra-Aortic Balloon Pump (IABP) support
- Patients on Extracorporeal Membrane Oxygenation (ECMO) support
- Patients on either Temporary Pace maker (TPI) or Permanent Pace maker (PPI)
- Hemodynamically unstable
- Patients with delayed postoperative discharge beyond POD-5
- Patients previously underwent Valvular Heart surgeries
- Uncooperative patients
- Psychiatric disorders affecting participation

ASSIGNMENTS OF SUBJECTS TO GROUPS

Although randomization was initially planned, logistical challenges and clinical considerations during the study period led to a non-randomized assignment of participants to groups based on availability and clinical criteria Subjects selected based on inclusion and exclusion criteria were randomly assigned to two groups: the control group (Group A) and the experimental group (Group B).

INSTRUMENTATION

- Spirometer
- Mechanical Chest Vibrator
- Measuring tape
- Chest binder
- RPE scale (Rate of Perceived Exertion for dyspnea)

VARIABLES

Independent variables: Conventional Chest Physiotherapy and ELTGOL Technique

Dependent variables: Post-operative CABG patients

OUTCOME MEASURES

- Improvement in Chest X-ray
- Spirometric values
- PF Ratio
- Oxygen saturation level
- Chest Expansion
- RPE scale

Although sputum volume is the gold standard for directly assessing airway clearance, it is not always a feasible or reliable measure in post-operative CABG patients, particularly within the early recovery period. The selected outcome measures, including spirometry, chest X-ray, chest expansion, and ABG analysis, are well-established clinically relevant indicators of respiratory function and indirect markers of airway clearance. These measures have been widely used in studies assessing pulmonary rehabilitation and post-operative care in cardiac patients.

Intervention Delivery and Blinding: The ELTGOL technique and conventional chest physiotherapy were delivered by a heart-lung transplant physical therapist with specialized expertise in post-operative pulmonary rehabilitation. Blinding was not possible due to the distinct nature of the interventions. Both participants and clinicians were aware of the assigned treatment. To minimize bias, objective measures (spirometry, chest X-ray, and ABG analysis) were used, following standardized procedures for reliable outcome assessment.

PROCEDURE

Based on the inclusion and exclusion criteria, 64 subjects were selected and divided into two groups: Group A (Control) and Group B (Experimental). Seven out of the 64 patients opted out of participating in the study and 7 patients who had complications after the surgery and could not get discharge on POD 5 (Post-operative day 5) were also eliminated.

The study received Ethical Committee approval. Patients were informed about the objectives through video explanations and provided written consent. The control group received conventional therapy, while the intervention group received ELTGOL. A subgroup was monitored until discharge (POD 5) to assess mucus clearance effects.

After extubation, postoperative CABG patients were assessed on POD 1 (Post-operative day 1) before physiotherapy, with key data collected in semi-Fowler's position. Conventional chest physiotherapy continued until mediastinal or pleural drains were removed, followed by thoracic expansion exercises with a chest binder. Once inotropes were tapered, patients sat in a chair in the CTVS ICU and ambulated around the bed. From POD 3 (Post-operative day 3), they moved to the ward, maintaining treatment and ambulating within the room. The next day, hallway walks began with monitoring. On POD 5 (Post-operative day 5), isometric lower limb exercises, dynamic quads, stair training, and discharge instructions for home exercises were provided.

INTERVENTION

PROTOCOL FOR GROUP "A" (CONTROL GROUP)

Each exercise session lasted 15-20 minutes, starting with 10 deep breaths in three sets, with 30-60 second pauses in between.[20] Spirometry exercises involved 10 repetitions in 2 sets for both inspiration and expiration, sometimes tilted for inadequate effort.[21] ACBT was routinely included,[22] along with gentle range of motion exercises,[23] where patients relaxed and performed 10 repetitions per joint in two sets. A final assessment measured PF ratio in ABG readings, peripheral oxygen saturation, chest X-ray improvement (Grade 0: No improvement in Chest X-ray on POD 5; Grade 0.5: Partial Improvement in Chest X-ray on POD 5 and Grade 1: Complete improvement in Chest X-ray on POD 5), Chest Expansion and Borg scale scores, comparing these with previous readings taken on POD 1 after extubation.

PROTOCOL FOR GROUP "B" (EXPERIMENTAL GROUP)

Starting on **postoperative day 2 (POD-2)**, the ELTGOL technique was performed three times daily for 10 minutes per session, alongside conventional chest physiotherapy, until patient discharge. Sessions were spaced at six-hour intervals to balance effective airway clearance with patient comfort and tolerance. The first treatment session could not be performed on POD-0 (Day of surgery) or POD-1 (Post-operative day 1), as many patients remained intubated and mechanically ventilated. The treatment dose and frequency were based on clinical guidelines and prior research recommending early and frequent respiratory interventions to prevent postoperative pulmonary complications, particularly in cardiac surgery patients.

ELTGOL is an active-passive airway clearance technique performed with the patient in a **lateral decubitus position (left side up)**. The physiotherapist stands behind the patient, instructing them to inhale and exhale slowly through an **open glottis**, while applying infra-lateral abdominal and thoracic compression. Pillows are positioned behind the right knee and on the abdomen for support. A spirometer mouthpiece may be used to help maintain the glottis in the open position during the maneuver.

This approach combines physiological principles of ELTGOL — slow expiratory airflow from Functional Residual Capacity to Residual Capacity, increased peripheral airway resistance, and enhanced airflow–mucus interface — with practical clinical application, allowing effective and safe implementation in postoperative CABG patients.

STATISTICAL ANALYSIS

Data were collected on the post-extubation day and the 5th postoperative day, processed with IBM SPSS Statistics 23, and analyzed descriptively. Independent sample t-tests compared scores between groups, while paired sample t-tests assessed scores within groups. A master chart analyzed 50 subjects, including demographic characteristics (age, weight, height, BMI), with statistical significance set at $p < 0.05$ and a 95% confidence level.

Table 1. Comparison of Baseline and Post-operative Parameters Between Groups

Outcome Measure	Group 1 – Control (Mean ± SD)	Group 2 – Experimental (Mean ± SD)
Age (years)	7 ± 7.66	61.84 ± 7.49
Height (cm)	164.12 ± 8.36	164.05 ± 10.55
Weight (kg)	66.35 ± 8.86	68.2 ± 11.77
BMI	24.66 ± 3.19	25.43 ± 4.06
Post-Extubation – Inspiratory Spirometer (ml)	0.32 ± 0.48	0.36 ± 0.57
Post-Extubation – Expiratory Spirometer (ml)	1.24 ± 0.44	1.08 ± 0.28
Post-Extubation – CXR	0	0
Post-Extubation – Oxygen Saturation (%)	98.64 ± 1.75	98.56 ± 1.83
Post-Extubation – PF Ratio	333.92 ± 64.39	317.56 ± 90.98
Post-Extubation – Chest Expansion (cm)	1.40 ± 0.50	1.62 ± 0.61
Post-Extubation – Borg Score	6.56 ± 1.89	6.56 ± 1.58
POD 5 – Inspiratory Spirometer (ml)	1.48 ± 0.50	1.40 ± 0.65
POD 5 – Expiratory Spirometer (ml)	1.24 ± 0.44	1.16 ± 0.37
POD 5 – CXR	0.7 ± 0.25	0.86 ± 0.23
POD 5 – Oxygen Saturation (%)	97.08 ± 1.75	97.24 ± 2.07
POD 5 – PF Ratio	372.24 ± 126.17	406.6 ± 104.17
POD 5 – Chest Expansion (cm)	3.12 ± 1.07	3.66 ± 1.09
POD 5 – Borg Score	4.20 ± 2.65	2.84 ± 1.93

RESULTS

Descriptive analysis showed that the average age of participants was 57 ± 7.66 years in the control group and 61.84 ± 7.49 years in the experimental group. Details of each outcome measure are presented in Table 1.

WITHIN GROUP COMPARISON

A comparison between the data collected post-extubation and on the 5th postoperative day showed significant improvements in inspiratory spirometry ($p<0.01$), chest X-ray ($p<0.01$), oxygen saturation ($p<0.01$), chest expansion ($p<0.01$), and Borg scale scores ($p<0.01$) for the control group. These within-group findings are summarised in Table 2. However, there was no significant change in the PF ratio, and the expiratory spirometry t-value for the control group was not calculated due to a standard error of 0.

In the experimental group, significant improvements were noted in inspiratory spirometry ($p<0.01$), chest X-ray ($p<0.01$), oxygen saturation ($p=0.015$), PF ratio ($p<0.01$), chest expansion ($p<0.01$), and Borg scale scores ($p<0.01$) on the 5th postoperative day. No significant change was observed in expiratory spirometry.

BETWEEN GROUPS COMPARISON

The comparison between the control and experimental groups revealed no significant differences on the post-extubation day. These between-group results are summarised in Table 3. However, by the 5th postoperative day, significant differences were found in chest X-ray scores ($p=0.022$) and Borg scale scores ($p=0.043$). Improvements in spirometer readings, oxygen saturation, PF ratio, and chest expansion were observed in both groups, but these were statistically comparable with no significant difference.

DISCUSSION

This study found that conventional physiotherapy (Group A) significantly improved spirometry, chest X-ray scores, oxygen saturation, chest expansion, and Borg scale scores in CABG patients from post-extubation to day 5 postoperatively. Similarly, the ELTGOL technique (Group B) led to significant improvements in spirometry, chest X-ray scores, oxygen saturation, PF ratio, chest expansion, and Borg scale scores by day 5. However, expiratory spirometry readings showed no significant change in either group.

While both interventions showed benefits, the lack of a statistically significant difference in airway clearance measures (e.g., expiratory spirometry and PF ratio) between the two groups suggests that the ELTGOL technique may offer similar advantages to routine physiotherapy in improving respiratory function after CABG. This aligns with previous studies such as Savci et al., who found comparable effects of ACBT and incentive spirometry on respiratory outcomes in CABG patients.[24]

Furthermore, the clinical significance of these improvements, particularly in terms of lung volumes and ventilation-perfusion ratio, supports the use of the ELTGOL technique in improving quality of life through airway clearance, although further research is needed to assess its specific advantages over conventional physiotherapy. ELTGOL enhances lung volumes from Functional Residual Capacity (FRC) to Residual Volume (RV) through slow expiration with an open glottis, improving the ventilation-perfusion ratio and preventing lung damage.[15] Conducted in the lateral de-

Table 2. Comparison of Outcome Measures Within the Groups (Paired Sample t-test)

Group	Outcome Measure	t-value	Significance
Control Group	Inspiratory Spirometer (ml)	-12.27	<0.01*
	Expiratory Spirometer (ml)	-	-
	CXR	-14	<0.01*
	Oxygen Saturation	4.07	<0.01*
	PF Ratio	-1.809	0.083
	Chest Expansion (cm)	-9.49	<0.01*
	Borg Score	7.13	<0.01*
Experimental Group	Inspiratory Spirometer (ml)	-9.66	<0.01*
	Expiratory Spirometer (ml)	-1.45	0.161
	CXR	-18.77	<0.01*
	Oxygen Saturation	2.61	0.015*
	PF Ratio	-4.72	<0.01*
	Chest Expansion (cm)	-8.21	<0.01*
	Borg Score	12.07	<0.01*

Table 3. Comparison of the Scores Between the Groups (Independent Sample t-test)

Outcome Measure	Post-Extubation t-value	Post-Extubation Significance	POD 5 t-value	POD 5 Significance
Inspiratory Spirometer (ml)	-0.27	0.79	0.49	0.62
Expiratory Spirometer (ml)	1.55	0.13	0.70	0.49
CXR	-	-	-2.36	0.022*
Oxygen Saturation	0.16	0.88	-0.29	0.77
PF Ratio	0.73	0.47	-1.05	0.29
Chest Expansion (cm)	-1.32	0.19	-1.73	0.09
Borg Score	0.005	1	2.08	0.043*

cubitus position, it effectively clears secretions from the inferolateral lung, while Forced Expiratory Technique (FET) helps move secretions proximally.[25,26] Coughing then clears these secretions from the mouth, improving overall respiratory function. Given the limitations of this study (e.g., lack of a primary outcome measure focused specifically on airway clearance), future studies with more robust designs and larger sample sizes are needed to confirm these findings.[27,28]

CONCLUSION

This quasi-experimental study suggests that the ELTGOL technique, when combined with conventional chest physiotherapy, may contribute to improved chest X-ray scores and reduced Borg scale ratings in postoperative CABG patients, indicating potential benefits in mucus clearance during the early recovery period.

LIMITATIONS AND FUTURE SCOPES

The study's limitations include a small sample size and no long-term effect evaluation. As this pilot study focused on short-term effects of ELTGOL in postoperative CABG patients, we recommend its routine use for airway clearance. However, further research is needed to assess long-term outcomes, including quality of life and functional capacity.

Submitted: July 16, 2024 GMT. Accepted: November 19, 2025 GMT.

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SUPPLEMENTARY MATERIALS

Treatment Protocol for Group A and Group B

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Graphs

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