Critical care

Inspiratory muscle training in adult intensive care units: A survey of UK physiotherapy practice

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Abstract

Introduction

Inspiratory muscle training (IMT) is a safe and feasible treatment modality for critically ill patients presenting with respiratory muscle weakness. IMT has been shown to increase respiratory muscle strength, accelerate weaning and reduce length of stay.

Objectives

To explore the clinical use of IMT by physiotherapists working in adult intensive care units (ICUs) in the United Kingdom (UK).

Methods

An online survey was developed and distributed to respiratory physiotherapists in the UK via the Association of Chartered Physiotherapists in Respiratory Care social media platform and the UK Respiratory Physiotherapy Leaders group. The survey was available for completion between November 2020 and January 2021.

Results

Eligible responses were received from 45 ICUs. Eleven ICUs (24%) used IMT, five (11%) were in the process of procurement and 29 (65%) did not use IMT.

There was variation between ICUs in the type of IMT device used and patient populations who received IMT. The most commonly reported clinical indications for IMT use were failure to wean (n=8; 73%) and prolonged mechanical ventilation of more than seven days (n=5; 45%).

The most commonly reported outcome measure used to guide treatment parameters and determine effectiveness of IMT was maximal inspiratory pressure (MIP) (n=8; 70%).

Conclusions

IMT is not a common treatment modality used by physiotherapists within UK adult ICUs. There is a need for increased education regarding IMT implementation and the development of an evidence based national guideline to enable a standardised approach to IMT delivery, and to promote its use within the UK.

INTRODUCTION

Respiratory muscle weakness is a well known complication of mechanical ventilation and is highly prevalent within the adult intensive care population.[1] The presence of respiratory muscle weakness, associated with prolonged periods of mechanical ventilation, can result in an increased intensive care unit (ICU) length of stay (LOS).[2] The development of diaphragm dysfunction has been shown to occur twice as frequently as ICU acquired weakness at the time of ventilator liberation.[3] Within the literature, significant reductions in diaphragm thickness have been observed within as little as 18 hours of mechanical ventilation, with reported reductions of up to 26% within the first 72 hours.[4] Reductions in inspiratory muscle endurance have also been observed in up to a third of patients mechanically ventilated for more than seven days.[5] Literature has shown that a reduction in respiratory muscle strength can result in a longer duration of mechanical ventilation and subsequent increased risk of secondary complications.[6] Physiotherapists commonly employ strategies to enable and accelerate weaning from mechanical ventilation. This may include the use of inspiratory muscle training (IMT).

IMT has been shown to be a feasible and well tolerated modality within the intensive care population.[7] A systematic review and meta-analysis demonstrated meaningful improvements in measures of inspiratory muscle strength in critically ill patients receiving IMT.[8] IMT has also been shown to reduce the duration of mechanical ventilation[9] and improve quality of life scores.[10]

Within the literature, both spring-loaded mechanical threshold devices and electronic tapered flow devices have been utilised within the ICU setting, both providing titratable resistance and adaptability for use with mechanically ventilated patients via an endotracheal tube and tracheostomy.[6] Mechanical threshold devices utilise a spring-loaded flow-independent one way valve, providing external loading to the respiratory muscles throughout inspiration. These single patient use devices can create a resistance of between 9-41 cmH_20. Comparably, electronic tapered flow resistive loading IMT devices provide a gradual decrease in load throughout inspiration, matching the decline in flow and volume of the patient effort.[6] Tapered flow devices offer a lower starting resistance of 0 cmH_20 and can feature in-built maximal inspiratory pressure (MIP) testing functions. In healthy individuals, performing IMT with a tapered flow device improved MIP and increased maximal inspiratory flow generating capacity compared to use with mechanical threshold devices.[8] In difficult to wean patients, tapered flow devices were also found to allow for increased lung volume expansion, higher inspiratory flows and better patient tolerance than mechanical threshold devices.[11] However, the comparable difference in MIP scores, respiratory weaning duration, ICU LOS and longer-term quality of life scores between devices are yet to be established within the ICU patient cohort.

In an international cross-sectional survey of physiotherapy practice, 63% (n=270) of respondents reported utilisation of IMT within their intensive care units.[12] In an earlier survey of French physiotherapists, IMT use was reported by just 36% (n=106) of the respondents, citing lack of knowledge regarding clinical procedures and limited resources as common barriers to IMT usage.[13] With a growing evidence base within the ICU population, it is important to understand the prevalence of IMT within UK adult intensive care units. This will also help establish current clinical practices and barriers to its implementation within the UK.

OBJECTIVES

The aim of this study was to explore the clinical use of IMT within UK adult ICUs.

METHODS

A survey was developed on an online platform (Survey Monkey) and informed by literature relating to IMT.[6,8,14] The survey comprised of seventeen questions specific to IMT, both open and multiple choice, pertaining to:

- Current use of IMT within intensive care
- Device selection
- Patient eligibility and exclusion criteria
- IMT training regimes and clinical procedures
- Patient related outcome measures
- Staff training and competency processes

The NHS Health Research Authority decision making tool[15] was utilised, and ethical approval was deemed not required for completion of this survey.

The survey was advertised via the Association of Chartered Physiotherapists in Respiratory Care social media platform and monthly newsletter. In addition, an invitation to take part in the survey was sent to members of the UK Respiratory Physiotherapy Leaders group via email. The survey was open for completion for a period of ten weeks (November 2020 - January 2021).

Survey results were extracted from the online platform and entered into an Excel database for analysis.

RESULTS

Responses were received from 48 ICUs. Two surveys were discounted due to incompletion and one discounted as it originated from outside the UK. The geographical location of respondent ICUs are shown in table 1.

Of the 45 respondents, 11 ICUs (24%) used IMT, five (11%) were in the process of procurement and the majority (n=29; 65%) did not use IMT. Lack of knowledge regarding IMT implementation and absence of funding were the most commonly reported reasons as to why IMT was not used.

Of the 11 ICUs using IMT and the five in the process of procurement, device selection varied. Ten respondents (63%) used mechanical threshold IMT devices. Five (32%) used tapered flow devices and two (13%) utilised inspiratory trigger adjustment on the ventilator as a means of delivering IMT. Five respondents utilised more than one modality. One ICU did not specify the type of modality used.

Within the 11 ICUs that used IMT, patient inclusion criteria varied (Table 2), with failure to wean (n=8; 73%) and prolonged mechanical ventilation of more than seven days (n=5; 45%) mentioned most frequently by survey respondents. Three respondents also outlined additional exclusion criteria for the use of IMT (Table 3). One survey respondent included extracorporeal membrane oxygenation (ECMO) and presence of severe bullae/pulmonary cavitations on CT as precautions to be considered prior to IMT use.

The most commonly utilised training regime, outlined by six respondents, was a set threshold of 50% MIP, five sets of six breaths daily with gradual incrementation of 1-2 cmH_20 every 1-2 days. The respondents all reported their regimes were informed by the same published literature.[14] Five respondents (45%) reported utilising IMT with ventilator dependent patients delivered via an endotracheal tube, nine (82%) utilised IMT on ventilator dependent patients with a tracheostomy and ten respondents (91%) used IMT on self-ventilating patients delivered via a facemask.

Table 1. Geographical location of respondent ICUs.

UK regions	total number of ICU responses (n=)	number of ICUs using IMT (n=)	number of ICUs in the process of procuring IMT (n=)	number of ICUs not using IMT (n=)
North West of England	7	1	0	6
North East of England	0	0	0	0
Yorkshire	4	0	0	4
East Midlands	5	0	0	5
West Midlands	4	0	0	4
East of England	3	1	0	2
South East of England	3	1	0	2
South West of England	5	2	1	2
London	10	3	4	3
Wales	2	1	0	1
Scotland	0	0	0	0
Northern Ireland	2	2	0	0
Total	45	11	5	29

ICU = intensive care unit, IMT = Inspiratory muscle training.

Table 2. Reported patient inclusion criteria for IMT use.

Inclusion criteria	number of respondents (n=)
Failure to wean	8
Mechanical ventilation >7 days	5
Alert, cooperative and able to follow commands	4
Able to trigger spontaneous breaths	3
Able to form a seal around a mouthpiece	3
FiO2 <60%	3
PEEP <10	3
RR <25	3
MIP <30 cmH_20	2
Diagnosis of critical illness myopathy	2
PIP <30	1
PS +PEEP combined <30	1
Failed SBTs	1
Cognitively intact	1

PEEP = Positive end expiratory pressure, FIO2 = Fraction of inspired oxygen, RR = Respiratory rate, MIP = Maximal inspiratory pressure, PIP = Peak Inspiratory pressure, PS = Pressure support, SBT = spontaneous breathing trial.

There was variability in the use of outcome measures used by respondents to guide IMT treatment parameters and determine effectiveness of the intervention (Table 4). The most commonly reported outcome measure was MIP (70%; n=8).

All survey respondents that were utilising IMT reported that it was a physiotherapist delivered treatment modality. One respondent also reported that alongside registered physiotherapists, therapy assistants were also involved in the delivery of IMT. One ICU reported that they had a formal competency process for IMT.

DISCUSSION AND CONCLUSIONS

The main finding from this study indicates that IMT is not a common treatment modality utilised within adult intensive care units in the UK.

Despite the growing evidence base for IMT within the intensive care population, just 24% (n=11) of respondents were identified as currently using IMT within their establishments. The most commonly reported reasons as to why IMT was not used centred around lack of knowledge regarding IMT use and lack of funding for device procurement. These results echo that of a previous survey of French physiotherapists[13] and an international survey of IMT use,[12]

Table 3. Reported exclusion criteria for IMT use.

Exclusion criteria	number of respondents (n=)
Mechanical ventilation of <7 days	1
PEEP of >10	2
PS + PEEP combined >30	1
High FiO2 requirements	2
Inability to follow commands	2
CAM-ICU positive	1
Patients undergoing nitric therapy	1
Prostacyclin/ilioprost nebs	1
High frequency oscillatory ventilation	1
Suspected or undrained pneumothorax	1
Intracranial pressure >20mmhg	1
Blocked/excessive extra ventricular drainage	1
Cardiovascular instability	1

PEEP = Positive end expiratory pressure, PS = Pressure support, CAM-ICU = Confusion assessment method for the intensive care unit.

Table 4. Outcome measures used by survey respondents

Outcome measure	number of respondents (n=)
MIP	8
Respiratory rate	3
Duration of weaning	3
Patient feedback	2
Negative inspiratory force test	2
SaO2	2
Sniff nasal inspiratory pressure test	1
Oxygen requirements	1
Maximal expiratory pressure score	1
Cardio pulmonary exercise test score	1
Borg scale	1

MIP = Maximal inspiratory pressure score, SaO2 = Oxygen saturation of arterial blood.

identifying commonalities in barriers to the implementation of IMT globally.

A high proportion of survey respondents reported delivering IMT to patients who were mechanically ventilated, both via tracheostomy and endotracheal tube. Within the literature, early commencement of IMT is championed by authors[6] and advocated for as a feasible and well tolerated modality for intensive care patients.[7] The most commonly utilised IMT training regime identified from our survey followed a high intensity, low repetition interval approach. Within the literature training regimes vary, adopting either an endurance based or a high intensity interval approach to application.[6,8,14,16,17] In a multi-disciplinary guide for clinicians,[14] the high intensity low repetition interval approach has been suggested as effective and well tolerated by ICU patients who often cannot sustain repeated resistance over a prolonged period of time. However, it is acknowledged within the wider literature that the optimal training approach for ICU patients is yet to be established.

Mechanical threshold devices were the most commonly utilised device amongst the survey respondents. One reason for this may be the lower cost of purchase for these devices. Additionally, as the tapered flow devices are newer to the market, many ICUs may have opted not to purchase these devices in addition to existing mechanical threshold devices. Within our data, IMT was also identified as a purely physiotherapist led modality. However, as the survey was circulated through social media platforms and email groups targeted only at physiotherapists, it is possible that some ICUs within the UK, where IMT is delivered by other members of the MDT, could have been excluded.

Although the highest number of survey respondents were located in London ICUs, there is good geographical spread observed across the survey respondents, representing a mix of large major trauma hospitals, specialist centres and district general hospitals from across the UK, with the exception of Scotland (Table 1). The increased number of ICU respondents from London (n=10) is likely due to the high prevalence of ICUs within the geographical region compared to other parts of the UK. However, it is recognised that due to the relatively small sample size it could be argued that the data may not be fully representative of UK wide physiotherapy practice. Measures to increase survey responses such as advertising via speciality specific networks and approaching specific ICUs were not undertaken and is a limitation to the study.

The variability of responses relating to IMT implementation from this survey demonstrates a lack of standardised physiotherapy practice across UK adult ICUs. This may be a reflection of the variation in the current literature regarding the optimal approach to IMT delivery in the ICU population. Due to the heterogeneous nature of ICU patients, further research would be beneficial, specifically regarding longer-term patient outcomes following use of IMT and optimal training parameters that can be generalised to the ICU population. In addition, creation of a national clinical guideline could help inform local business cases for procurement of devices, clinician training/competency requirements and standardising training regimes for delivery of IMT to a variety of ICU patient cohorts.

The authors acknowledge that since the dissemination of this survey the evidence base for IMT use within the intensive care environment has continued to grow. In view of this, a repeat survey may also be beneficial.

Key Points

- At the time of this survey IMT was not a common treatment modality utilised by UK adult ICUs.
- Mechanical threshold devices were the most commonly utilised device amongst physiotherapists working in UK adult ICUs.
- Further research exploring different training parameters specific to ICU patients could be beneficial.

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DECLARATION OF INTEREST

The authors have no declarations of interest.

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ETHICAL AND R&D APPROVAL

The NHS Health Research Authority decision making tool[15] was utilised and ethical approval was deemed not required for completion of this survey.

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REFERENCES

1. Goligher E, Dres M, Fan E, et al. Mechanical Ventilation-induced Diaphragm Atrophy Strongly Impacts Clinical Outcomes. *Am J Respir Crit Care Med*. 2018;197(2):204-213. doi:10.1164/rccm.201703-0536OC

2. Magalhães P, Camillo C, Langer D, et al. Weaning failure and respiratory muscle function: What has been done and what can be improved? *Respir Med*. 2018;134:54-61. doi:10.1016/j.rmed.2017.11.023

3. Dres M, Dubé B, Mayaux J, et al. Coexistence and Impact of Limb Muscle and Diaphragm Weakness at Time of Liberation from Mechanical Ventilation in Medical Intensive Care Unit Patients. *Am J Respir Crit Care Med*. 2017;195(1):57-66. doi:10.1164/rccm.201602-0367OC

4. Schepens T, Verbrugghe W, Dams K, et al. The course of diaphragm atrophy in ventilated patients assessed with ultrasound: a longitudinal cohort study. *Crit Care*. 2015;19:422. doi:10.1186/s13054-015-1141-0

5. Bissett B, Leditschke I, Neeman T, et al. Weaned but weary: one third of adult intensive care patients mechanically ventilated for 7 days or more have impaired inspiratory muscle endurance after successful weaning. *Heart Lung*. 2015;44(1):15-20. doi:10.1016/j.hrtlng.2014.10.001

6. Bissett B, Gosselink R, Van Haren F. Respiratory Muscle Rehabilitation in Patients with Prolonged Mechanical Ventilation: A Targeted Approach. *Crit Care*. 2020;24(1):103. doi:10.1186/s13054-020-2783-0

7. Nickels M, Erwin K, McMurray G, et al. Feasibility, safety, and patient acceptability of electronic inspiratory muscle training in patients who require prolonged mechanical ventilation in the intensive care unit: A dual-centre observational study. *Aust Crit Care*. Published online 2023. doi:10.1016/j.aucc.2023.04.008

8. Vorona S, Sabatini U, Al-Maqbali S, et al. Inspiratory Muscle Rehabilitation in Critically Ill Adults. A Systematic Review and Meta-Analysis. *Annals of the American Thoracic Society*. 2019;15(6):735-744. doi:10.1513/AnnalsATS.201712-961OC

9. Worraphan S, Thammata A, Chittawatanarat K, et al. Effects of Inspiratory Muscle Training and Early Mobilization on Weaning of Mechanical Ventilation: A Systematic Review and Network Meta-analysis. *Arch Phys Med Rehabil*. 2020;101(11):2002-2014. doi:10.1016/j.apmr.2020.07.004

10. Bissett B, Leditschke I, Neeman T, et al. Inspiratory muscle training to enhance recovery from mechanical ventilation: a randomised trial. *Thorax*. 2016;71(9):812-819. doi:10.1136/thoraxjnl-2016-208279

11. Van Hollebeke M, Pleysier S, Poddighe D, et al. Comparing two types of loading during inspiratory muscle training in patients with weaning difficulties: An exploratory study. *Aust Crit Care*. 2023;36(4):622-627. doi:10.1016/j.aucc.2022.07.001

12. Hearn E, Gosselink R, Freene N. Inspiratory muscle training in intensive care unit patients: An international cross-sectional survey of physiotherapist practice. *Australian Critical Care*. 2022;35(5):527-534. doi:10.1016/j.aucc.2021.08.002

13. Bonnevie T, Villiot-Danger J, Gravier F, et al. Inspiratory muscle training is used in some intensive care units, but many training methods have uncertain efficacy: a survey of French physiotherapists. *J Physiother*. 2015;61(4):204-209. doi:10.1016/j.jphys.2015.08.003

14. Bissett B, Leditschke I, Green M, et al. Inspiratory muscle training for intensive care patients: A multidisciplinary practical guide for clinicians. *Australian Critical Care*. 2019;32:249-255. doi:10.1016/j.aucc.2018.06.001

15. NHS Health Research Authority.org. October 2022. Accessed June 2024. https://www.hra-decisiontools.org.uk/research/

16. Moodie L, Reeve J, Elkins M. Inspiratory muscle training increases inspiratory muscle strength in patients weaning from mechanical ventilation: a systematic review. *J Physiother*. 2011;57(4):213-221. doi:10.1016/S1836-9553(11)70051-0

17. Bissett B, Leditschke I, Neeman T, et al. Does mechanical threshold inspiratory muscle training promote recovery and improve outcomes in patients who are ventilator-dependent in the intensive care unit? The IMPROVE randomised trial. *Australian Critical Care*. 2023;36(4):613-621. doi:10.1016/j.aucc.2022.07.002