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A retrospective study of physiotherapy management for patients with pneumonia requiring invasive ventilation in a single-center Australian ICU

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Background: Pneumonia is a frequent diagnosis for patients admitted to Australian intensive care units (ICUs) for invasive ventilation. Physiotherapists in ICU provide interventions to enhance respiratory function and physical recovery.
Objective: This retrospective cohort study aimed to describe physiotherapy management of adults with pneumonia who require invasive mechanical ventilation in a single Level 3 ICU in a quaternary teaching hospital.
Methods: All adults admitted with a medical diagnosis of pneumonia requiring invasive mechanical ventilation over a two-year period were included. Demographic and clinical data, including APACHE II score, ventilator-free days (VFDs) to day 28, ICU length of stay (LOS), and type and frequency of physiotherapy episodes of care delivered in ICU, were collected from electronic medical records. Correlations between VFDs to day 28 and the frequency of physiotherapy interventions delivered per subject were examined using Spearman's rho analysis.
Results: From 208 records screened, 66 subjects with an ICU admission diagnosis of pneumonia, who required invasive mechanical ventilation, were included. Median (IQR) ICU LOS was 10 (5–17) days, and mortality rate was 15.2% ($n = 10$). The cohort had a median of 20.5 (IQR 2–25) VFDs to day 28.

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Community-acquired pneumonia (66.7%, $n = 44$) was the most frequent type of pneumonia diagnosis. There were 1110 episodes of physiotherapy care, with patients receiving a median of 13.5 (IQR 6.8–21.3) episodes during their ICU stay, with a median rate of 1.2 (IQR 1.0–1.6) episodes per day. Over 96.7% of patients with pneumonia received physiotherapy treatment during their ICU stay. Overall, physiotherapy treatments consisting only of respiratory techniques were most commonly provided (55.1%, $n = 612$). Airway suctioning (92.4%, $n = 61$), patient positioning (72.7%, $n = 48$) or positioning advice to nurses (77.3%, $n = 51$), and hyperinflation techniques (63.6%, $n = 42$) were among the respiratory techniques most delivered.
Conclusion: This study described the current intensive care physiotherapy management in a single center for adults with pneumonia who required invasive mechanical ventilation, demonstrating that respiratory physiotherapy interventions are often provided for this ICU patient cohort. Further research is warranted to determine the efficacy of respiratory physiotherapy interventions to justify their use for ICU patients with pneumonia receiving invasive mechanical ventilation.

Keywords: Critical care; physiotherapy; pneumonia; respiratory.

Introduction

Pneumonia is a common respiratory condition that has caused a substantial burden for global healthcare systems.[1–4] Pneumonia and influenza were listed as the ninth leading cause of death in Australia in 2019.[5] Approximately a fifth of patients hospitalized with community-acquired pneumonia (CAP) will require treatment in an intensive care unit (ICU),[6] with approximately 70% requiring invasive mechanical ventilation.[7] Both CAP and hospital-acquired pneumonia (HAP) have a significant mortality rate, reported between 20–50%.[8,9] Severe pneumonia is a risk factor for the development of acute respiratory distress syndrome (ARDS), which is associated with higher morbidity and mortality.[10,11]

Clinical diagnosis of pneumonia is based on signs and symptoms which include fever, leucocytosis, cough, presence of sputum, hypoxemia, and reduced lung compliance.[12] Alteration in respiratory mechanics results in increased work of breathing, which if severe can lead to respiratory failure.[12,13] Physiotherapists working in ICU treat patients with CAP to improve secretion clearance, respiratory mechanics, and oxygenation, and commence rehabilitation to restore functional independence.[14–16]

A survey of clinical practice of senior physiotherapists working in Australian ICUs found that physiotherapists commonly provide respiratory physiotherapy interventions during daytime working hours for ventilated patients with CAP, comprising specific positioning to target the affected lung regions, hyperinflation techniques, manual chest wall techniques, and airway suctioning.[15,17] These interventions are aimed at improving alveolar ventilation and secretion clearance to optimize pulmonary function and physical recovery and enhance weaning from mechanical ventilation.[15] Despite being considered an essential component of usual care for this ICU patient cohort,[18,19] there is limited evidence regarding the efficacy of respiratory physiotherapy for patients who require invasive ventilation in ICU for pneumonia.[20] Minimum standards for physiotherapy management have been developed based on expert consensus[14] which can provide useful guidance regarding best physiotherapy practice.[18,19] However, no studies have been conducted that have evaluated what type of physiotherapy interventions are provided for ventilated patients in ICU with a diagnosis of pneumonia.

The aim of this study was to conduct a retrospective audit of physiotherapy delivered to patients with a medical diagnosis of pneumonia who were admitted to a Level 3 Australian ICU within a quaternary teaching hospital over a two-year period. The study included all physiotherapy interventions to provide a holistic perspective of care, but described respiratory physiotherapy interventions in further detail to ascertain the physiotherapy practice for improving respiratory function.

Methods

A single-center, retrospective cohort study was conducted over a 24-month period. The setting was a 30-bed, Level 3 ICU situated within a major

teaching hospital in Western Australia.[21] The ICU has access to a 24-h, 7-day a week physiotherapy service, with one physiotherapist located onsite after-hours to service the whole hospital, including the ICU, during the evening and overnight. Patients may be referred for after-hours physiotherapy by the daytime physiotherapists, or by medical and nursing staff. New patients admitted to ICU after-hours are screened by the onsite physiotherapist to determine whether physiotherapy clinical assessment is deemed to be indicated at that time. The sample included the digital medical records of all adult subjects over 18 years of age admitted to the ICU between November 2017 and November 2019, with a documented medical diagnosis of pneumonia, and who required a period of invasive mechanical ventilation. Cases were excluded where the diagnosis of pneumonia was unclear from the records, pneumonia was not the primary cause for ICU admission, death was imminent on ICU admission, or if the patient was normally ventilator-dependent at home.

Data collection

Data were collected from the medical records by a qualified physiotherapist (B. K.), who was provided with training by two senior ICU physiotherapists. Subjects meeting the inclusion criteria were identified from the electronic ICU Clinical Information System (CIS) (MetaVision, iMDsoft, Red Hill) using a keyword search by diagnosis for "pneumonia", "respiratory failure", "respiratory infection", and "aspiration". Identified case notes were screened for a documented diagnosis of pneumonia by a medical officer being the reason for admission to ICU. The pneumonia diagnosis was then categorized for each subject as being either community-acquired pneumonia (CAP) with onset in the community or within 48 h of hospital admission, or hospital-acquired pneumonia (HAP) with onset greater than 48 h after admission to hospital. Data pertaining to the ICU stay were retrieved from the ICU CIS and data pertaining to the hospital ward stay were retrieved using the digital medical record (BOSSnet, Core Medical Solutions, Adelaide). Data collected from the ICU CIS included: demographic information; type of pneumonia on ICU admission (CAP or HAP); sputum pathology results; presence of a documented medical diagnosis of ARDS; acute physiology and chronic health evaluation (APACHE) II score; duration of ventilation; ICU length of stay (LOS); ICU mortality; type and frequency of physiotherapy episodes delivered in ICU, categorized as assessment only or assessment and treatment; and types of physiotherapy treatments delivered, both within normal daytime working hours (0700–1630) and outside of daytime working hours (1630–0700); highest level of function at ICU discharge using the ICU mobility scale (IMS)[22]; and ICU mortality. Data regarding hospital mortality, hospital LOS, and hospital discharge destination were collected from the hospital digital medical record.

The median rate of daily physiotherapy episodes during the ICU stay was calculated by first calculating the average daily rate of physiotherapy episodes per patient by dividing the total number of physiotherapy episodes by ICU LOS for each case. These daily averages per patient were then used to calculate the median and interquartile range of physiotherapy episodes per day for the cohort. Ventilator-free days (VFDs) to day 28 were calculated from the collected mortality and ventilation duration data as a composite outcome measure.[23] The number of days spent on mechanical ventilation was deducted from 28 to obtain the VFDs to day 28, with the exception of any deceased subject automatically scoring 0. The calculation and reporting of VFDs to day 28 adhered to the published recommendations on VFD reporting.[23] The physiotherapy interventions delivered during each physiotherapy episode of care were categorized using a framework based on the study by Skinner *et al.*[19] as respiratory interventions, with the primary purpose of optimizing respiratory function; mobilization interventions[24] such as active or assisted exercise and/or functional mobilization activities, with the purpose of targeting impairments of reduced strength, functional mobility and/or exercise tolerance in the ICU environment; or a combination of respiratory and mobilization interventions. Respiratory interventions were further categorized according to the findings of a recent survey of clinical practice by van der Lee *et al.*[15] Due to the retrospective nature of this study, the categories by van der Lee *et al.*[15] were altered during data collection to account for other interventions which were used in the data extracted from the digital medical records. Although mobilization interventions were grouped separately from respiratory interventions, the authors acknowledge that mobilization

interventions have the potential to improve respiratory function. However, for the purpose of this study, the authors chose to discuss respiratory physiotherapy interventions that are primarily aimed at improving respiratory function and the usual practice regarding these interventions in an Australian tertiary-level ICU in further detail.

Data analysis

The retrieved data were entered into a database, de-identified, and coded for analysis manually by BK using Microsoft Excel. Cases, where eligibility against the inclusion and exclusion criteria was unclear, were independently reviewed by L. V. and M. E., both experienced senior ICU physiotherapists. Data were summarized using descriptive statistics, with mean and standard deviations for parametric data and median and interquartile ranges for non-parametric data. Associations between categorical and numerical variables of interest were performed using independent samples *t*-test and Mann–Whitney *U* test for parametric and non-parametric data, respectively. Relationships between numerical variables were examined by Spearman's rho analysis. Associations were tested between characteristics of age, ICU and hospital LOS, VFDs to day 28, and pneumonia classification, and variables of type and frequency of physiotherapy intervention.

Analysis was conducted using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY).[25] All hypothesis tests were two-sided and *p*-values of ≤ 0.05 were considered statistically significant. The assigned strength of the correlation coefficient was examined by *a priori* guidelines which stated that 0.1 to less than 0.3 was weak, 0.3 to less than 0.5 was moderate and greater than 0.5 was strong.[26]

Ethics approval

Ethical and governance approvals were granted for the study as a quality improvement project by the South Metropolitan Health Service Governance, Evidence, Knowledge and Outcomes (GEKO) system (approval number 34434).

Results

Records search via the ICU CIS identified 208 potential cases that were screened against the inclusion and exclusion criteria for eligibility into the study. This resulted in a sample of 66 cases for data extraction.

Subject characteristics

The average age of the cohort was 58.3 years (SD = 14.9) and n= 45 (68.2%) were male. Community-acquired pneumonia [66.7% ($n = 44$)] was the most common type of pneumonia classification. The ICU mortality rate was 15.2% ($n = 10$) and overall hospital mortality rate was 16.7% ($n = 11$). The median APACHE II score was 20 (IQR 15–26). There were seven subjects (10.6%) in the study cohort who had a medical diagnosis of ARDS documented by a medical professional. Pathogens causing pneumonia were identified from sputum specimens for 80.3% of subjects ($n = 53$), with more than one pathogen identified in 48.5% of subjects ($n = 32$). The common pathogens identified were *Pseudomonas aeruginosa* (26.4%, $n = 14$), *Candida albicans* (26.4%, $n = 14$), and *Streptococcus pneumoniae* (16.9%, $n = 9$) (Table 1). Subgroup analysis by pneumonia classification indicated that *Candida albicans* was the most common pathogen identified in both the CAP and HAP groups (24.3%, $n = 9$; 31.3%, $n = 5$).

The median VFDs to day 28 and duration of invasive mechanical ventilation were 20.5 days (IQR 2–25) and 5.5 days (IQR 2–11), respectively. There was a moderate, negative, significant association between APACHE II score and VFDs to day 28 in the overall cohort ($r = -0.366$, $p = 0.003$) and the CAP subgroup ($r = -0.427$, $p = 0.004$). The median ICU and hospital LOS were 10 days (IQR 5–17) and 19 days (IQR 12–37), respectively. The median highest level of function (IMS) at ICU discharge was 6 (marching at bedside) (IQR 3, sitting over edge of bed, to 7, walking with the assistance of two people) and at hospital discharge was 10 (walking independently without gait aid) (IQR 8, walking with the assistance of one person, to 10, walking independently without gait aid). Forty-three percent of subjects ($n = 23$) were able to ambulate with the assistance of two people or less at ICU discharge (IMS 7 or above). Sixty percent of subjects ($n = 33$) discharged from the hospital were able to ambulate independently with or without gait aids. Following hospital discharge, 40.9% of subjects ($n = 27$) required transfer to a rehabilitation facility, while 42.4% of subjects ($n = 28$) were discharged home.

Table 1. Pathogens[a] identified in sputum samples, *N* (%).

Pathogens	Total, $N = 53$	Community-acquired pneumonia, $N = 37$	Hospital-acquired pneumonia, $N = 16$
Candida albicans	14 (26.4)	9 (24.3)	5 (31.3)
Enterobacter cloacae complex	4 (7.5)	—	4 (25.0)
Pseudomonas aeruginosa	10 (18.9)	8 (21.6)	2 (12.5)
Staphylococcus aureus	8 (15.1)	4 (10.8)	4 (25.0)
Streptococcus pneumoniae	9 (17.0)	8 (21.6)	1 (6.3)
Other	36 (67.9)	27 (73.0)	9 (56.3)

Notes: [a]Top three pathogens identified within the whole cohort and each pneumonia classification subgroup were listed individually.

Characteristics of episodes of physiotherapy care

In total, 1110 physiotherapy episodes of care were received by subjects (Table 2). Overall, 96.7% ($n = 64$) of patients with pneumonia received physiotherapy treatment during their ICU stay. The median rate of daily physiotherapy episodes during ICU stay was 1.2 (IQR 1.0–1.6) in the overall cohort and for the CAP and HAP subgroups (CAP IQR 1.0–1.7; HAP IQR 1.0–1.5). The majority of physiotherapy episodes were provided during daytime working hours (72.8%, $n = 808$) and 27.2% ($n = 302$) were provided outside of daytime working hours. In total, the cohort received a median of 13.5 episodes (IQR 6.8–21.3) of physiotherapy care during their ICU stay, with a median of 2 (IQR 1–7) physiotherapy episodes provided outside of daytime working hours.

Physiotherapy episodes that consisted of assessment only occurred in 10.7% ($n = 119$) of overall episodes. Over half of total physiotherapy episodes included only respiratory interventions (55.1%, $n = 612$) and 27.5% ($n = 305$) comprised a combination of respiratory and mobilization interventions. Physiotherapy episodes that involved only mobilization intervention occurred in 6.7% of episodes ($n = 74$). Details of all respiratory interventions are presented in Table 2. A third of all physiotherapy episodes involved mobilization treatment, received by 84.8% of subjects.

Table 2. Types and frequencies of physiotherapy interventions received, *N* (%).

Types of physiotherapy interventions received	Number of patients receiving the intervention, $N = 66$[a]	Total episodes of the intervention in the cohort, $N = 1110$[a]
Saline instillation	1 (1.5)	1 (0.1)
Manual chest wall techniques (e.g., vibrations/percussion)	22 (33.3)	58 (5.2)
MHI	19 (28.8)	59 (5.3)
VHI	39 (59.1)	135 (12.2)
Hyperinflation techniques (MHI or VHI)[b]	42 (63.6)	187 (16.8)
Airway suctioning (via ETT/tracheostomy)	61 (92.4)	610 (55.0)
Positioning	48 (72.7)	244 (22.0)
DBE on ventilator	26 (39.4)	83 (7.5)
DBE post extubation	50 (75.8)	215 (19.4)
Mobilization	56 (84.8)	370 (33.3)
Positioning advice given to nursing staff	51 (77.3)	237 (21.4)
Patient/family education	36 (54.5)	105 (9.5)
Oxygen therapy titration	37 (56.1)	118 (10.6)
Mechanical insufflation–exsufflation	1 (1.5)	13 (1.2)

Notes: DBE = deep breathing exercises; ETT = endotracheal tube; MHI = manual hyperinflation; VHI = ventilator hyperinflation. [a]Percentage does not add up to 100% as subjects may have received more than one type of intervention during a single physiotherapy episode. [b]Combined to show the frequency of hyperinflation techniques as a standalone subgroup. In total, 16 out of 66 subjects received both MHI and VHI during their ICU stay, with both techniques utilized in the same physiotherapy episode in 7 out of 1110 occurrences.

Table 3. Correlation analysis[a,b] of ventilator-free days to day 28 and intensive care unit length of stay with the frequency of physiotherapy episodes.

	VFDs to day 28			ICU LOS		
	Overall cohort ($n = 66$)	CAP ($n = 44$)	HAP ($n = 22$)	Overall cohort	CAP	HAP
Overall episodes delivered per subject	−0.695	−0.298*	−0.660	0.860	0.860	0.866

Notes: CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; ICU = intensive care unit; LOS = length of stay; VFD = ventilator-free day. [a]According to the guidelines by Cohen,[26] the assigned strength of the correlation coefficient was that 0.1 to < 0.3 was weak, 0.3 to < 0.5 was moderate and > 0.5 was strong. [b]Correlation is significant at the $p < 0.01$ level (two-tailed), unless otherwise stated. *Correlation is significant at the $p < 0.05$ level (two-tailed).

There was a strong negative correlation between VFDs to day 28 and the frequency of physiotherapy interventions delivered per subject, both overall ($p < 0.001$) and HAP ($p < 0.001$), whereas the relationship was moderate in the CAP subgroup ($p < 0.05$) (Table 3). There was also a strong, positive, and significant correlation between the overall number of physiotherapy episodes received and the ICU length of stay, both for the cohort overall and diagnostic categories (Table 3).

There was no significant correlation between the type of pneumonia and ICU and hospital LOS, VFDs to day 28, or the number of ICU physiotherapy episodes (Table 4). There was also no significant correlation between age range (less or greater than and equal to 65 years) and ICU and hospital LOS, number of physiotherapy episodes, and VFDs to day 28 (Table 4). The mean age in the pneumonia classification subgroups did not differ significantly [CAP: 57.3 (SD 14.4); HAP: 60.3 (SD 15.9); $p > 0.05$].

Discussion

This retrospective study audited a cohort of adult patients admitted for pneumonia to a single-center ICU in Australia for invasive mechanical ventilation, to identify the types of pneumonia and physiotherapy treatments provided. All except two patients admitted to ICU with a diagnosis of pneumonia requiring invasive ventilation received physiotherapy treatment during the ICU stay, consistent with the findings of a recently conducted Australian survey of clinical practice.[15] A larger proportion of physiotherapy care episodes involved respiratory interventions compared to mobilization interventions, which is consistent with other Australian studies.[18,19]

Results of this study indicated that a large percentage of patients (63.6%) received lung hyperinflation techniques, which is consistent with the expert consensus statements and other studies,[14,18,19] and ventilator hyperinflation was delivered more frequently than manual hyperinflation, also consistent with a national survey of clinical practice.[15] Lung hyperinflation techniques have been found to be effective in clearing secretions in intubated and ventilated patients through increasing tidal volumes to generate an expiratory flow bias.[27–32] A recent systematic review and meta-analysis of 14 studies found that for

Table 4. Statistically non-significant results for Mann–Whitney U tests of association between clinical outcomes and subgroup characteristics of pneumonia type and age range of subjects.

	Type of pneumonia			Age of subjects		
	CAP, $n = 44$ Median (IQR)	HAP, $n = 22$ Median (IQR)	p-value	< 65 years, $n = 43$ Median (IQR)	≥ 65 years, $n = 23$ (Median, IQR)	p-value
Hospital LOS	16.0 (9.3–32.5)	25.0 (13.8–56.0)	0.09	21.0 (10.0–37.0)	16.0 (13.0–53.0)	0.89
ICU LOS	10.0 (5.0–17.5)	9.0 (4.8–16.2)	0.88	10.0 (5.0–23.0)	8.0 (5.0–12.0)	0.31
Total episodes of physiotherapy	12.5 (7.25–25.75)	14.0 (6.0–19.0)	0.97	13.0 (6.0–22.0)	14.0 (8.0–21.0)	0.94
VFDs to day 28	20.0 (1.2–25.8)	21.0 (3.0–25.0)	0.78	20.0 (4.0–26.0)	23.0 (0–25.0)	0.96

Notes: CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; ICU = intensive care unit; LOS = length of stay; VFD = ventilator-free day.

invasively ventilated adults with pneumonia, a statistically significant treatment benefit existed for improved secretion clearance and lung compliance for respiratory interventions which increased tidal volumes, such as hyperinflation techniques, and that these physiotherapy techniques are safe, with no adverse events reported.[20] Another systematic review has suggested that there is no significant difference in physiological outcomes between MHI and VHI, but these findings are limited by a small number of reviewed studies and an overall high risk of bias.[33]

In this study, manual chest wall techniques, such as chest wall vibrations and percussion, were found to be used with a third of patients. These findings are consistent with a recent Australian survey of clinical practice[15] and point prevalence study investigating techniques used in ICUs throughout Australia and New Zealand for sputum clearance[18] indicating that manual chest wall techniques continue to have a role in clinical practice despite limited and conflicting evidence for their use in the treatment of intubated ICU patients with respiratory illness, such as pneumonia.[14,15] Furthermore, studies[14,34] have indicated that the use of manual chest wall techniques is a controversial area of clinical practice due to clinical rationale and perceived clinical benefit for their use for secretion clearance despite a lack of research evidence of efficacy.[14] However, local ICU culture has been found to influence clinical practice, particularly in the context of limited or conflicting evidence,[34] which may explain the contrasting findings by Skinner *et al.*,[19] who reported no use of manual techniques for ICU patients.

The results of this study indicate that patients with pneumonia who have less VFD to day 28 and a longer ICU stay are likely to receive a greater number of episodes of respiratory physiotherapy, which is not unexpected. However, physiotherapy should be delivered based on clinical indications following a thorough assessment,[14] rather than provided routinely merely because the patient is still on a ventilator and in ICU. This correlation does not indicate the intensity of physiotherapy treatment, but rather suggests that physiotherapy was deemed to be required by the treating physiotherapist. It was outside of the study scope to determine the clinical reasoning behind the reason for treatment provision, which is impossible to determine accurately with a simple retrospective study design.

The association found between VFDs to day 28 and the number of physiotherapy episodes was stronger in the HAP subgroup of this cohort. This suggests that there may be HAP-specific factors warranting more episodes of respiratory physiotherapy intervention and after-hours treatment during the intubated phase in patients requiring a longer period of ventilation, such as different clinical presentations of higher secretion load related to the type of infecting micro-organisms. This would be worthwhile investigating in future studies to determine whether certain types of pneumonia respond better to respiratory physiotherapy treatment. Future research to determine whether clinical phenotypes exist which are more amenable or responsive to respiratory physiotherapy techniques would be an important next step in the planning of future clinical trials to investigate which type and intensity of respiratory physiotherapy treatment have the best efficacy for patients with pneumonia in the intubated period.

With 84.5% of the cohort receiving mobilization treatment at some point during the ICU stay, most subjects were able to stand and march by the bedside at ICU discharge and 60% of subjects were able to ambulate independently at hospital discharge. These findings are supported by previous research that found active mobilization in ICU was able to prevent ICU-acquired weakness and improve muscle strength at ICU discharge and enhance ambulation ability at hospital discharge.[35,36] Further research is required to establish the effect of mobilization interventions on patient-centered outcomes in adult patients with pneumonia admitted for invasive mechanical ventilation.

Strength of this study is that it reports the usual physiotherapy practice for invasively ventilated adults with pneumonia that were admitted to a large Australian ICU over a two-year period. Previous research has indicated that considerable variability was found in physiotherapy clinical practice for patients in this cohort.[15] This is the first study to the authors' knowledge that has audited and quantified physiotherapy practice in this manner in a Level 3 ICU in a quaternary teaching hospital. Researchers have also found that local ICU culture has influenced on clinical practice[34]; therefore, caution is warranted when generalizing the findings of this study to that of other ICUs, in other Australian states or internationally. Due to the limited number of subjects with ARDS, subgroup analysis was not conducted. However, the

results from this study have established a baseline that would allow comparison in future research.

Due to the retrospective cohort study design, we are unable to draw conclusions regarding associations between the type, mode, or frequency of physiotherapy interventions delivered and patient outcomes such as VFDs to day 28, ICU length of stay, or functional recovery. Furthermore, clinical reasoning related to indications for providing respiratory physiotherapy treatment, selection of treatment mode or referral for treatment after-hours was unable to be determined using a retrospective design and would be worthwhile investigating prospectively in future studies. The lack of standardized diagnostic criteria for pneumonia limits the comparability of the results of this study. However, retrospective studies can provide useful information to inform local practice and develop larger-scale studies in the future.[37] We also identified that the types, modes, and frequency of physiotherapy interventions were not standardized limiting the generalizability of the results. This provides an opportunity for improvement in standardization of treatment approaches for future prospective studies in the ICU setting. This study was also subjected to the general limitations of the retrospective methodology involving medical record review, including inaccurate, incomplete, or missing documentation. For pragmatic reasons, the researchers (B. K., L. V., M. E.) were not able to be blinded to the purpose of the study. Further research using a prospective design is required to investigate whether a relationship between type, mode, and dosage of physiotherapy and patient outcomes of ventilator-free days to day 28, length of stay, and functional recovery exists. Subjects remained in ICU for a median of 13 days, and in hospital for 31 days. At a cost of AUD $4875 per day in ICU and $800 per day on the wards, this represents a significant economic burden to the health system.[38,39] Future research is necessary to determine whether respiratory physiotherapy intervention for ICU patients with pneumonia has any impact on ICU and hospital length of stay, as well as patient-centered outcomes such as functional recovery, quality of life, and mortality.

In conclusion, this study describes usual physiotherapy practice for adult patients with pneumonia who require invasive mechanical ventilation in a single Level 3 Australian ICU in a quaternary teaching hospital. Greater focus was placed on physiotherapy treatment for respiratory care compared to mobilization during the ICU stay. Further research is warranted to determine the impact of respiratory physiotherapy interventions to justify their provision for those admitted to ICU with pneumonia.

Conflict of Interest

The authors declare that they have no competing interests relevant to this paper.

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Author Contributions

Baldwin Pok Man Kwan: Investigation, Formal Analysis, Writing — Original Draft, Editing, and Manuscript Revisions. Anne-Marie Hill: Conceptualization, Methodology, Writing — Review, Editing, and Manuscript Revisions. Mercedes Elliott: Methodology and Editing. Lisa van der Lee: Conceptualization, Methodology, Investigation, Formal analysis, Writing — Review, Editing, and Manuscript Revisions.

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References

1. Monge V, San-Martin VM, Gonzalez A. The burden of community-acquired pneumonia in Spain. Eur J Public Health 2001; 11(4):362–4, doi: 10.1093/eurpub/11.4.362.
2. Morimoto K, Suzuki M, Ishifuji T, et al. The burden and etiology of community-onset pneumonia in the aging Japanese population: A multicenter prospective study. PLoS One 2015; 10(3):e0122247, doi: 10.1371/journal.pone.0122247.
3. Jackson ML, Neuzil KM, Thompson WW, et al. The burden of community-acquired pneumonia in seniors: Results of a population-based study. Clin Infect Dis 2004; 39(11):1642–50, doi: 10.1086/425615.

4. Earle K, Williams S. Burden of pneumococcal disease in adults aged 65 years and older: An Australian perspective. Pneumonia (Nathan) 2016; 8:9, doi: 10.1186/s41479-016-0008-8.
5. Australian Bureau of Statistics. Causes of Death, Australia, 2019 [Internet]. Canberra (Australia): Australian Bureau of Statistics, 2020 (cited Apr 2, 2021). Available at https://www.abs.gov.au/statistics/health/causes-death/causes-death-australia/2019#articles.
6. Storms AD, Chen J, Jackson LA, et al. Rates and risk factors associated with hospitalization for pneumonia with ICU admission among adults. BMC Pulm Med 2017; 17(1):208, doi: 10.1186/s12890-017-0552-x.
7. Wilson PA, Ferguson J. Severe community-acquired pneumonia: An Australian perspective. Intern Med J 2005; 35(12):699–705, doi: 10.1111/j.1445-5994.2005.00962.x.
8. Ewig S, Ruiz M, Mensa J, et al. Severe community-acquired pneumonia. Assessment of severity criteria. Am J Respir Crit Care Med 1998; 158(4):1102–8, doi: 10.1164/ajrccm.158.4.9803114.
9. Heyland DK, Cook DJ, Griffith L, Keenan SP, Brun-Buisson C, Canadian Critical Care Trials Group. The attributable morbidity and mortality of ventilator-associated pneumonia in the critically ill patient. Am J Respir Crit Care Med 1999; 159(4Pt 1):1249–56, doi: 10.1164/ajrccm.159.4.9807050.
10. Lee KY. Pneumonia, acute respiratory distress syndrome, and early immune-modulator therapy. Int J Mol Sci 2017; 18(2):388, doi: 10.3390/ijms18020388.
11. Ranieri VM, Rubenfeld GD, Thompson BT, et al. Acute respiratory distress syndrome: The Berlin definition. JAMA 2012; 307(23):2526–33, doi: 10.1001/jama.2012.5669.
12. Loscalzo J, ed. Harrison's Pulmonary and Critical Care Medicine. 3rd ed. New York: McGraw-Hill Medical, 2016.
13. Bersten A, Handy J, eds. Oh's intensive care manual. 8th ed. London: Elsevier Health Sciences, 2019.
14. van der Lee L, Hill AM, Patman S. Expert consensus for respiratory physiotherapy management of mechanically ventilated adults with community-acquired pneumonia: A Delphi study. J Eval Clin Pract 2019; 25(2):230–43, doi: 10.1111/jep.13077.
15. van der Lee L, Hill AM, Patman S. A survey of clinicians regarding respiratory physiotherapy intervention for intubated and mechanically ventilated patients with community-acquired pneumonia. What is current practice in Australian ICUs? J Eval Clin Pract 2017; 23(4):812–20, doi: 10.1111/jep.12722.
16. Hanekom S, Berney S, Morrow B, et al. The validation of a clinical algorithm for the prevention and management of pulmonary dysfunction in intubated adults a synthesis of evidence and expert opinion. J Eval Clin Pract 2011; 17(4):801–10, doi: 10.1111/j.1365-2753.2010.01480.x.
17. van der Lee L, Hill AM, Patman S. After-hours respiratory physiotherapy for intubated and mechanically ventilated patients with community-acquired pneumonia: An Australian perspective. Aust Crit Care 2018; 31(6):349–54, doi: 10.1016/j.aucc.2017.10.001.
18. Ntoumenopoulos G, Hammond N, Watts NR, et al. Secretion clearance strategies in Australian and New Zealand Intensive Care Units. Aust Crit Care 2018; 31(4):191–6, doi: 10.1016/j.aucc.2017.06.002.
19. Skinner EH, Haines KJ, Berney S, Warrillow S, Harrold M, Denehy L. Usual care physiotherapy during acute hospitalization in subjects admitted to the ICU: An observational cohort study. Respir Care 2015; 60(10):1476–85, doi: 10.4187/respcare.04064.
20. van der Lee L, Hill A-M, Jacques A, Patman S. Efficacy of respiratory physiotherapy interventions for intubated and mechanically ventilated adults with pneumonia: A systematic review and meta-analysis. Physiother Can 2021; 73(1):6–18, doi: 10.3138/ptc-2019-0025.
21. College of Intensive Care Medicine of Australia and New Zealand. Minimum standards for intensive care units [Internet]. Prahran (Australia): College of Intensive Care Medicine of Australia and New Zealand, 2011 (cited November 21, 2021). Available at https://www.cicm.org.au/CICM_Media/CICMSite/CICM-Website/Resources/Professional%20Documents/IC-1-Minimum-Standards-for-Intensive-Care-Units.pdf.
22. Tipping CJ, Holland AE, Harrold M, Crawford T, Halliburton N, Hodgson CL. The minimal important difference of the ICU mobility scale. Heart Lung 2018; 47(5):497–501, doi: 10.1016/j.hrtlng.2018.07.009.
23. Yehya N, Harhay MO, Curley MAQ, Schoenfeld DA, Reeder RW. Reappraisal of Ventilator-Free Days in Critical Care Research. Am J Respir Crit Care Med 2019; 200(7):828–36, doi: 10.1164/rccm.201810-2050CP.
24. The Team Study Investigators. Early mobilization and recovery in mechanically ventilated patients in the ICU: A bi-national, multi-centre, prospective cohort study. Crit Care 2015; 19:81, doi: 10.1186/s13054-015-0765-4.
25. IBM Corp. Released 2018. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.
26. Cohen J. Statistical Power Analysis for the Behavioral Sciences. 2nd ed. New York: Psychology Press, 1988.
27. Dennis D, Jacob W, Budgeon C. Ventilator versus manual hyperinflation in clearing sputum in

ventilated intensive care unit patients. Anaesth Intensive Care 2012; 40(1):142–9, doi: 10.1177/0310057X1204000117.
28. Lemes DA, Zin WA, Guimarães FS. Hyperinflation using pressure support ventilation improves secretion clearance and respiratory mechanics in ventilated patients with pulmonary infection: A randomised crossover trial. Aust J Physiother 2009; 55(4):249–54, doi: 10.1016/s0004-9514(09)70004-2.
29. Berney S, Denehy L, Pretto J. Head-down tilt and manual hyperinflation enhance sputum clearance in patients who are intubated and ventilated. Aust J Physiother 2004; 50(1):9–14, doi: 10.1016/s0004-9514(14)60243-9.
30. Berney S, Denehy L. A comparison of the effects of manual and ventilator hyperinflation on static lung compliance and sputum production in intubated and ventilated intensive care patients. Physiother Res Int 2002; 7(2):100–8, doi: 10.1002/pri.246.
31. Hodgson C, Denehy L, Ntoumenopoulos G, Santamaria J, Carroll S. An investigation of the early effects of manual lung hyperinflation in critically ill patients. Anaesth Intensive Care 2000; 28(3):255–61, doi: 10.1177/0310057X0002800302.
32. Maxwell L, Ellis E. Secretion clearance by manual hyperinflation: Possible mechanisms. Physiother Theory Pract 1998; 14(4):189–197, doi: 10.3109/09593989809057165.
33. Anderson A, Alexanders J, Sinani C, Hayes S, Fogarty M. Effects of ventilator vs manual hyperinflation in adults receiving mechanical ventilation: A systematic review of randomised clinical trials. Physiotherapy 2015; 101(2):103–10, doi: 10.1016/j.physio.2014.07.006.
34. van der Lee L, Hill AM, Patman S. Clinical validation of expert consensus statements for respiratory physiotherapy management of invasively ventilated adults with community-acquired pneumonia: A qualitative study. Intensive Crit Care Nurs 2020; 60:102854, doi: 10.1016/j.iccn.2020.102854.
35. Tipping CJ, Harrold M, Holland A, Romero L, Nisbet T, Hodgson CL. The effects of active mobilisation and rehabilitation in ICU on mortality and function: A systematic review. Intensive Care Med 2017; 43(2):171–83, doi: 10.1007/s00134-016-4612-0.
36. Zang K, Chen B, Wang M, et al. The effect of early mobilization in critically ill patients: A meta-analysis. Nurs Crit Care 2020; 25(6):360–7, doi: 10.1111/nicc.12455.
37. Sedgwick P. Retrospective cohort studies: Advantages and disadvantages. BMJ 2014; 348:g1072, doi: 10.1136/bmj.g1072.
38. Hicks P, Huckson S, Fenney E, Leggett I, Pilcher D, Litton E. The financial cost of intensive care in Australia: A multicentre registry study. Med J Aust 2019; 211(7):324–5, doi: 10.5694/mja2.50309.
39. Page K, Barnett AG, Graves N. What is a hospital bed day worth? A contingent valuation study of hospital Chief Executive Officers. BMC Health Serv Res 2017; 17(1):137, doi: 10.1186/s12913-017-2079-5.