Title: 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?

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Introduction

Severe community-acquired pneumonia (CAP) is a common cause of intensive care unit admission for intubation and mechanical ventilation (1), resulting in significant morbidity and mortality (2). Indigenous Australians (3), individuals over 65 years of age, and those with co-morbid disease are at greater risk of contracting CAP (4) and of having worse outcomes (2, 5, 6). Limited Australian data indicates that 10-35% of patients hospitalised with CAP require admission to an ICU due to respiratory failure and septic shock resulting from severe infection (1, 7) and mechanical ventilation is necessary in 73% of these cases (1). The mortality rate of patients admitted to ICU for CAP is 20-50% (1, 2, 8, 9) despite advances in medical science over the last four decades (1, 5, 7) and adequate initiation of antibiotic treatment (9, 10).

Pneumonia occurs from pulmonary infection and inflammation in response to proliferation of pathogenic microorganisms (4, 11). Exudation of fluid containing inflammatory mediators and blood cells into the alveolar spaces results in consolidation (4), leading to reduced compliance of the lung tissue (4, 12). This increases work of breathing and can lead to ventilatory failure from respiratory muscle fatigue (12, 13). Consolidation also impairs gas exchange as a result of ventilation-perfusion mismatching and shunt, which causes hypoxaemia to occur (12, 13). Purulent sputum develops as a result of leukocytes, macrophages and pathogenic

microorganisms in the airways (11), and can cause secondary obstruction if secretions are not adequately cleared (14), resulting in atelectasis of functional lung units, further impairing gas exchange and worsening hypoxaemia (12, 13, 15). Antibiotic therapy is the mainstay of treatment for pneumonia (16).

Additionally, physiotherapists working in the ICU are also involved in the management of patients with acute respiratory illness, such as CAP, with the aim of improving alveolar ventilation, lung compliance and oxygenation, clearing pulmonary secretions, and reducing the work of breathing (17 - 19). Restoration of volume loss caused by atelectasis is important in facilitating clearance of airway secretions by annular two-phase gas-liquid flow (20, 21) through the generation of a greater expiratory flow rate, which enables mucous plugs to be propelled towards the larger airways where they can be cleared (21). This in turn may reduce work of breathing (13, 15). Reversal of atelectasis also improves lung compliance (22), facilitates ventilation and perfusion matching (13, 15) and improves gas exchange (23).

The role of respiratory physiotherapy is limited for patients admitted to hospital with mild to moderate CAP who are; spontaneously breathing, do not require mechanical ventilation, can independently mobilise, and expectorate secretions, as supported by Grade B evidence (24, 25). However, this evidence cannot be applied to patients with severe CAP who are intubated and mechanically ventilated in the acute phase. In this cohort mucociliary clearance is impaired (17, 21) placing these patients at greater risk of sputum retention (26 - 28). This may lead to subsequent atelectasis and further infection (15, 29).

Despite a growing body of research in the area of critical care physiotherapy, significant gaps remain in the evidence base, particularly in the management of

specific pulmonary conditions (30, 31) such as CAP, leaving clinicians with limited guidance. This may contribute to the anecdotal variability witnessed in clinical practice.

The primary aims of this survey were to explore ICU senior physiotherapist perceptions of current physiotherapy practice for intubated adult patients with CAP within Australia, to identify the degree of variability in reported practice and explore factors that influenced physiotherapy treatment mode, duration and frequency in this patient cohort. The secondary aim was to use the results to inform a further planned review of evidence in this field and the development of clinical practice guidelines.

Methods

A cross-sectional online survey was conducted using SurveyMonkey® (Palo Alto: USA). The questionnaire consisted of 42 items over three domains: participant demographics, ICU and physiotherapy service delivery, and physiotherapy management and clinical reasoning for intubated and mechanically ventilated patients with CAP, defined as pneumonia of bacterial, viral or fungal aetiology which occurred in the community setting, or within 48 hours of admission to hospital. Categorical scales were used for survey items which measured demographic and service data and Likert scales were used for items which asked therapists to rate their preferences, beliefs and clinical reasoning regarding their management of the patient. Survey items which asked therapists to describe their clinical reasoning used open ended responses. The questionnaire was locally piloted by eight ICU senior physiotherapists for content validity, clarity and participant flow, and any ambiguous items were modified. After piloting, a link to the online survey was sent to 104 senior ICU physiotherapists across 88 Australian hospitals. Participants were recruited through direct contact with physiotherapy managers to gain endorsement. The email

contact details of the participants were obtained either from physiotherapy managers or though professional networks of the research team. Participants were included if they had a minimum of five years clinical experience and a minimum twelve months experience as a senior physiotherapist working in an adult ICU within the last five year period. Physiotherapists involved in the piloting process were precluded from participation in the finalised survey. Ethics approval was granted by the Human Research and Ethics Committee of The University of Notre Dame Australia (014126F), and from local hospital ethics committees. Participants gave informed consent before commencing the survey by selecting an online check box. Data collection was conducted over two three-week periods (22/10/2014 - 12/11/2014 and 22/04/2015 – 13/05/2015). A reminder email was send to participants after two weeks. Responses were de-linked from participant email addresses for anonymity, with the aim of maximising honesty and validity of responses.

Quantitative data were analysed using descriptive statistics and Chi-square with Fisher exact test using SPSS version 22 (IBM SPSS Statistics, IBM Corp, New York: USA). Qualitative data were thematically analysed (32), with data management conducted using NVivo 10 (QSR International, Melbourne: Australia), and by content analysis using SPSS.

Results

The survey response rate was 72% (n=75). The highest qualification of respondents was Bachelor degree 50% (n=24/48), Postgraduate Diploma 2% (n=1/48), Master's degree 24% (n=17/48), Doctor of Philosophy 10% (n=5/48) and Postdoctoral degree

2% (n=1/48). Full details of respondent and unit characteristics are presented in Table 1.

Table 1: Respondent Characteristics.

		n (%)
Respondent jurisdiction	NSW	16 (23.5)
	QLD	12 (17.6)
	VIC	23 (33.8)
	SA	8 (11.8)
	WA	7 (10.3)
	ACT/TAS/NT	2 (2.9)
Workplace	Public	54 (79.4)
	Private	19 (20.6)
ICU Casemix	Medical	3 (4.4)
	Surgical	8 (11.8)
	Mixed medical & surgical	57 (83.8)
Respondent ICU experience	0 - 5 years	18 (26.5)
	6 – 10 years	17 (25.0)
	11 – 15 years	17 (25.0)
	16 - 20 years	7 (10.3)
	21 - 25 years	6 (8.8)
	26 - 30 years	1 (1.5)
	>30 years	2 (2.9)

Respondent ICU bed numbers	0 – 10 beds	18 (26.5)
	11 – 20 beds	31 (45.6)
	21 - 30 beds	12 (17.6)
	> 30 beds	7 (10.3)
Respondent ICU staffing level	<1.0 FTE	4 (5.9)
	1.0 – 2.0 FTE	41 (60.3)
	>2.0 < 3.0 FTE	0 (0)
	3.0 – 4.0 FTE	22 (32.4)
	> 4.0 FTE	1 (1.5)

Abbreviations: FTE = Full time equivalent, NSW = New South Wales, QLD = Queensland, VIC = Victoria, SA = South Australia, WA = Western Australia, ACT = Australian Capital Territory, TAS = Tasmania, NT = Northern Territory

For results that are presented as percentages, numerators and denominators are provided to indicate the sample size from which the frequency was calculated, due to the presence of missing data, as respondents were not forced to complete each question in the survey.

Physiotherapists reported caring for patients with CAP requiring intubation and mechanical ventilation in ICU with varying frequency over the preceding twelve month period, with admissions reported to have occurred frequently (78% n=52/67), which was defined as "several times a month, allowing for seasonal variations", occasionally (19%, 13/67) "once every few months", or rarely (3%, 2/67) "once or twice a year". None of the respondents reported never having admissions for CAP in their ICU.

Rationale for respiratory physiotherapy treatment

The most frequent clinical reasoning rationale that respondents reported would inform their clinical decision as to whether to undertake respiratory physiotherapy treatment for intubated patients with CAP was facilitation of sputum clearance (98%, n = 60/61). Other rationales reported were improved ventilation, alveolar recruitment or lung compliance (74%, n = 45/61), improved gas exchange (33%, n = 20/61) and prevention of deconditioning or ICU acquired weakness (20%, n = 12/61). Facilitation of ventilator weaning was reported by 8% of respondents (n = 5/61).

Frequency and duration of respiratory physiotherapy treatment

Respondents were asked to rate how often they chose to use a range of respiratory techniques for CAP. Their self-reported clinical practice regarding frequency and duration of respiratory treatment for these patients is presented in Figures 1a and 1b.

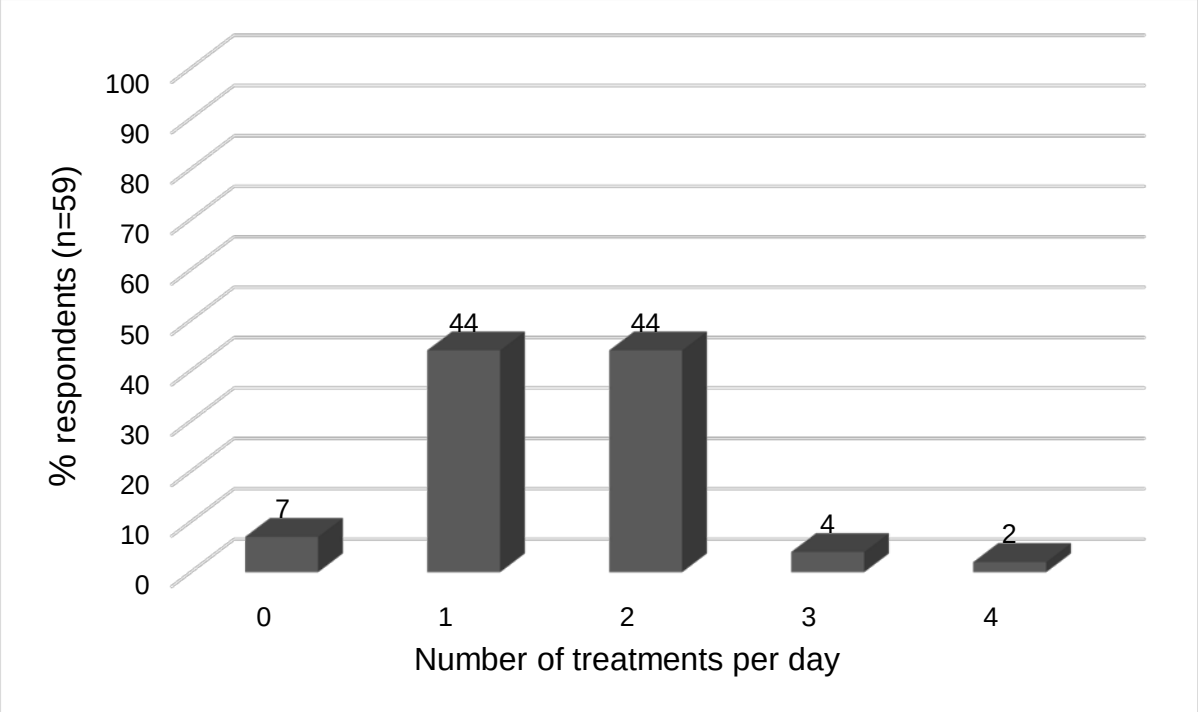

Figure 1a: Frequency of respiratory physiotherapy intervention for intubated adults with CAP.

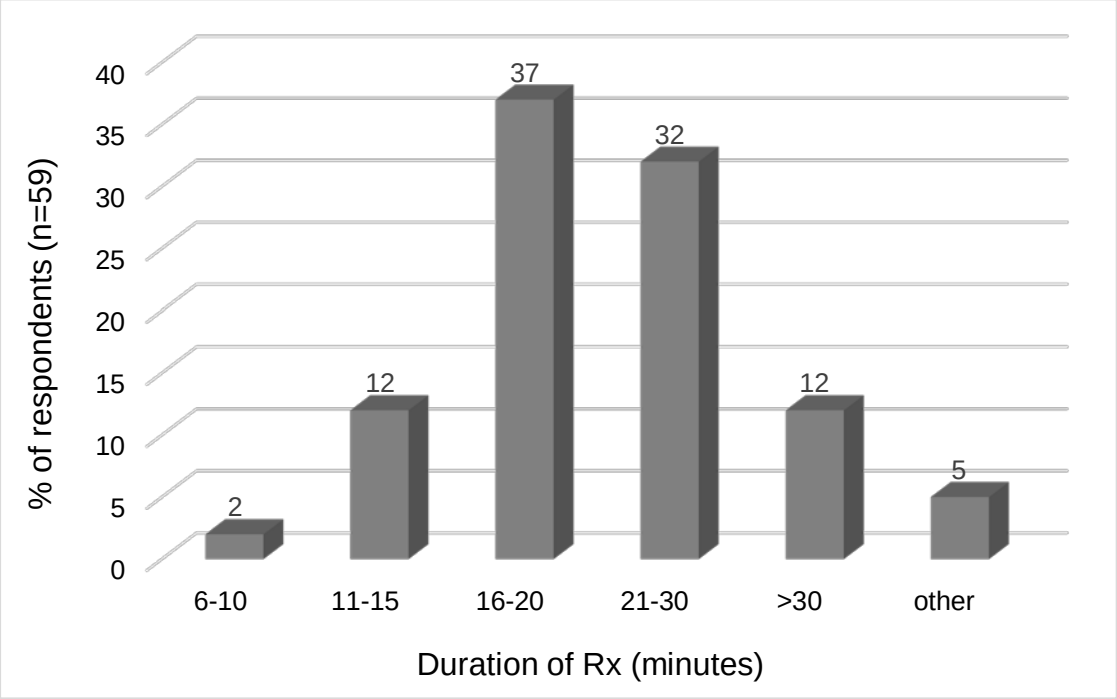

Figure 1b: Duration of physiotherapy intervention for intubated adults with CAP.

Based on the opinions of respondents, patients were significantly more likely to receive longer intervention in ICUs with higher physiotherapy staffing levels (p=0.03).

The self-reported factors which affect frequency and duration of respiratory intervention by physiotherapists for those intubated with CAP are presented in Figure 2a and 2b respectively.

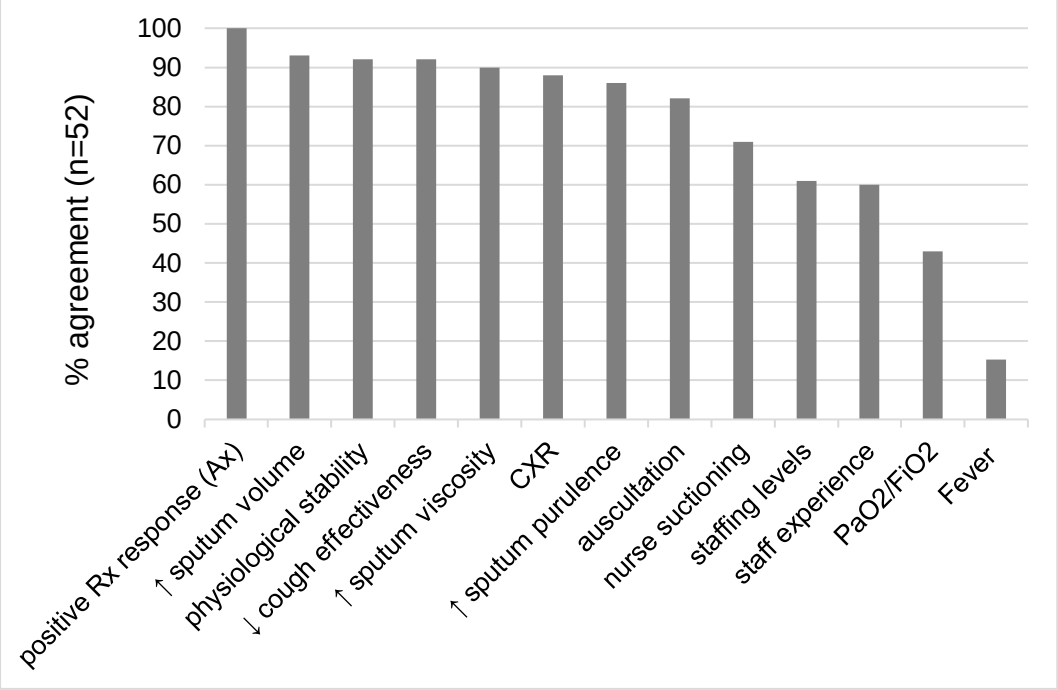

Figure 2a: The reported factors which affect frequency of respiratory physiotherapy for intubated adults with CAP.

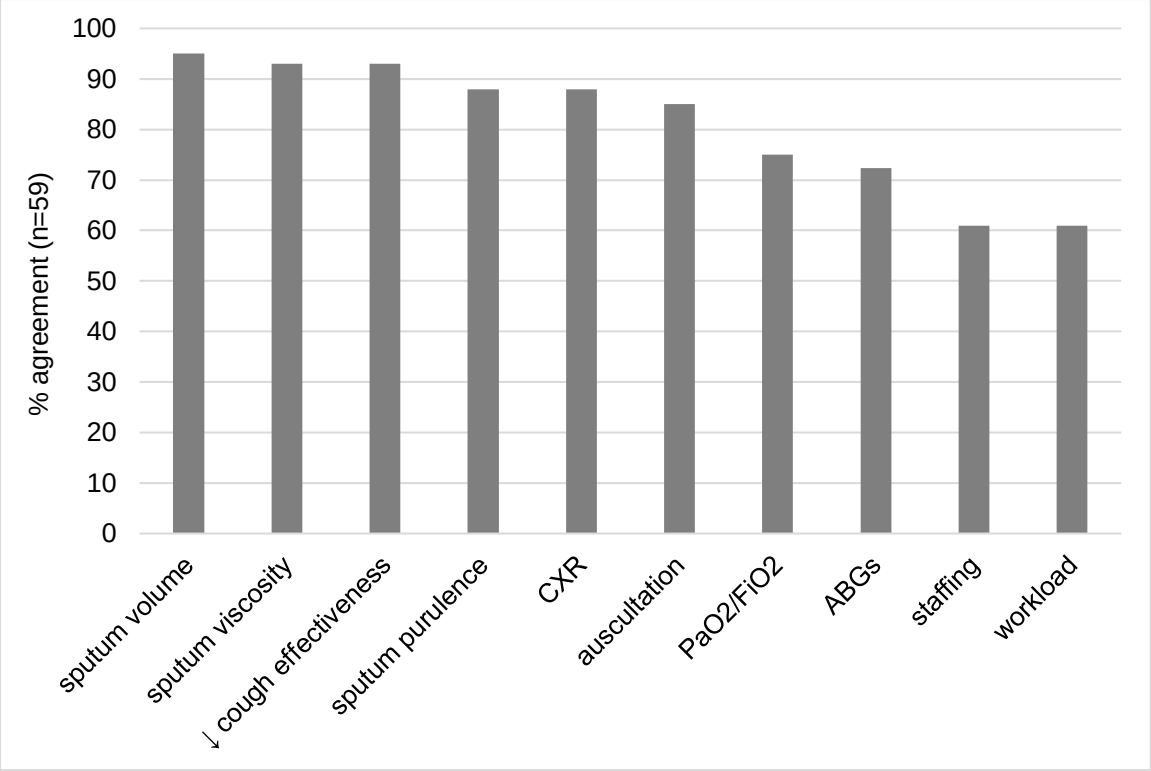

Figure 2b: The reported factors which affect duration of respiratory physiotherapy for intubated adults with CAP.

Chi square analysis indicated that there was no significant relationship between self-reported frequency ($p=0.16$) or duration ($p=0.23$) of respiratory physiotherapy treatment and the length of clinical ICU experience of respondents. Duration and frequency of treatment were both equally reported to be influenced by both staffing resources and workload by over 60% of respondents. This is presented in Table 2.

Table 2: Reported influence of staffing and workload on duration and frequency of physiotherapy intervention for intubated adults with CAP.

Sample size n= 59	Staffing, n (%)	Workload, n (%)
Treatment duration	36 (61)	36 (61)
Treatment frequency	36 (61)	37 (62)

Positioning patient for treatment

The treatment positions self-reported to be used by respondents were side-lying with the affected lung uppermost (83%, n = 53/64), alternate side-lying (81%, n = 52/64), supine with head elevated (61%, n = 39/64), head down tilt (11%, n = 7/64) and prone (5%, n = 3/64). Over 98% of respondents agreed that position was influenced by cardiovascular (n = 56/58) and respiratory (n = 58/59) stability, and auscultation findings (n = 57/58). Patient comfort was important for 96% of respondents (n = 52/54) and consciousness influenced positioning for 73% (n = 32/44), while "presence of attachments" and "turning routine" were both important factors for 64% of respondents, n = 25/39 and n = 27/42 respectively. For treatment of unilateral lung pathology, side-lying with the affected lung uppermost was most common (71%, n = 44/62), followed by high or upright sitting (26%, n = 16/62). For treatment of bilateral lung pathology, alternate side-lying (88%, n = 52/59) followed by high or upright sitting (32%, n = 19/59) and prone lying (19%, n = 11/59) were most reported.

Respiratory treatment techniques

Figure 3 outlines the choice of respiratory techniques by respondents.

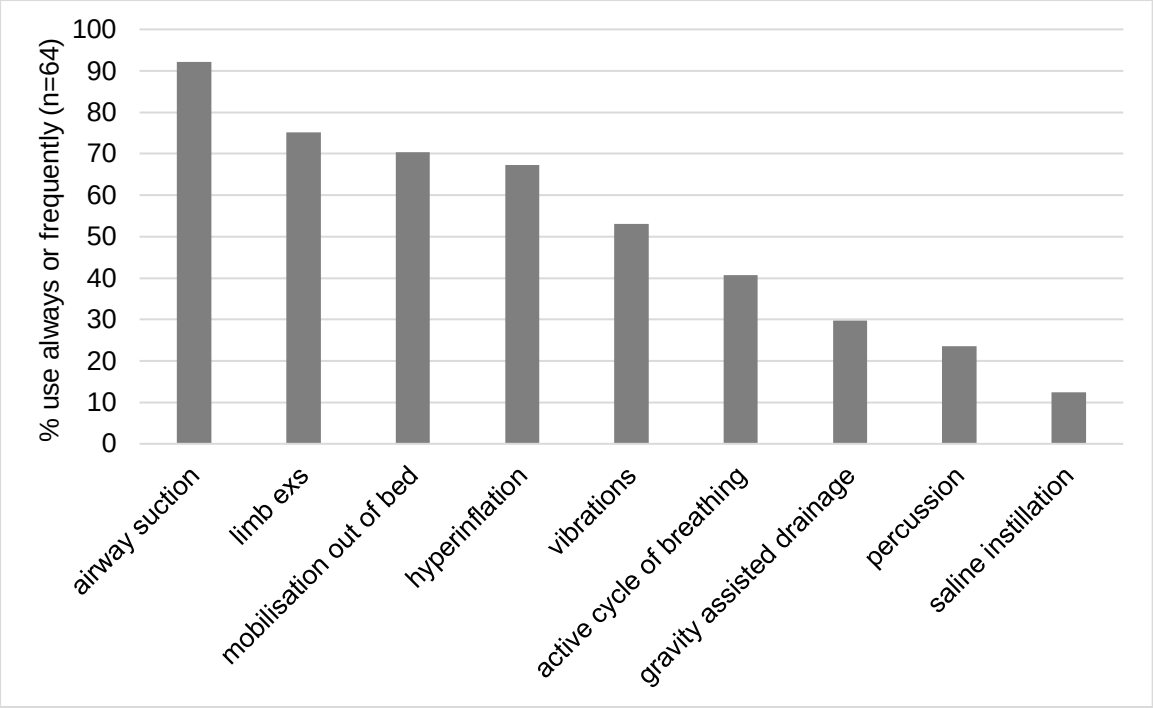

Figure 3: Use of respiratory physiotherapy techniques for intubated adults with CAP.

Of those respondents who self-reported using hyperinflation techniques as part of their clinical practice for intubated patients with CAP (81%, n=52/64), 26% (n=17/64) used only manual hyperinflation (MHI) and 14% (n=9/64) used only ventilator hyperinflation (VHI). Use of both methods of hyperinflation in clinical practice was reported by 38% of respondents (n=24/64), with 13% (n=3/24) indicating they chose to use MHI more often and 33% (n=8/24) indicating they used VHI more often. Both techniques were self-reported to be used equally by 54% of respondents (n=13/24).

Active modes of intervention were also chosen when the patient's level of consciousness and medical condition allowed. Mobilisation out of bed was self-reported to be used in clinical practice by 97% (n=62/64), thoracic expansion exercises by 84% (n=54/64) and limb exercises by 55% (n=35/64). There was wide

variability among respondents regarding the frequency of use of treatment modes, as illustrated in Figure 4.

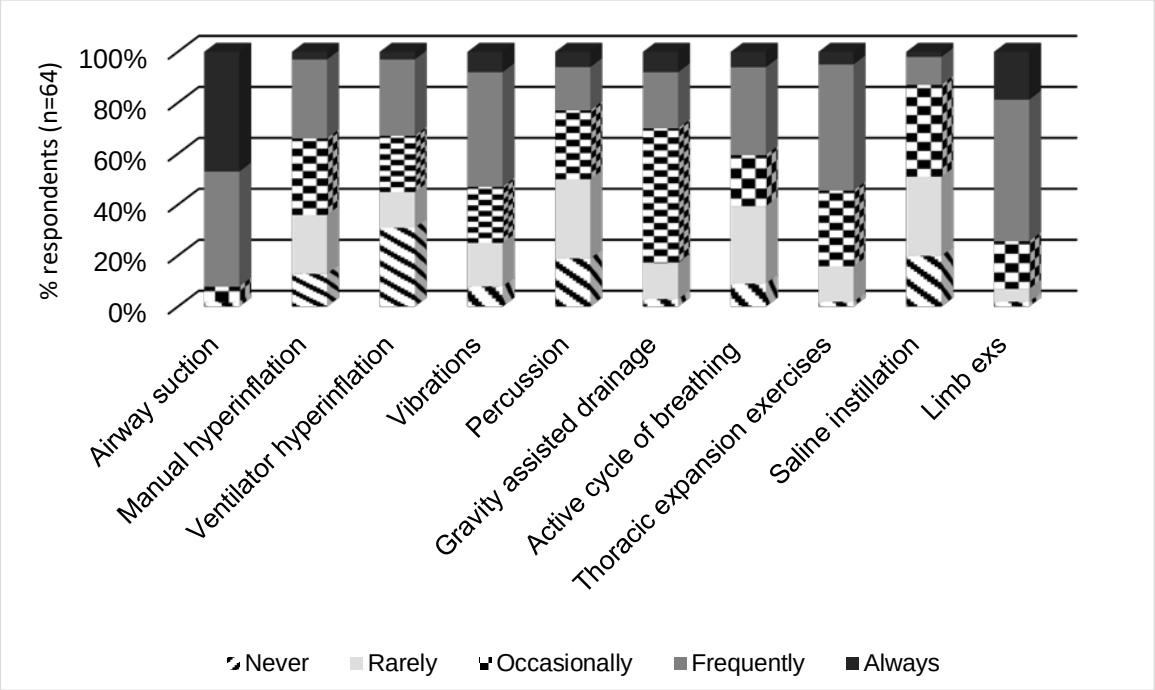

Figure 4: Variation of self-reported use of intervention modes by senior physiotherapists for intubated adults with CAP.

There was no significant relationship found between length of the respondents' ICU experience and use of treatment position or mode for intubated patients with CAP. There was a trend for physiotherapists with greater than ten years of ICU experience (39%, n=12/31) to report using MHI more frequently compared with those clinicians with less than 10 years of experience, however this was not statistically significant.

Hyperinflation techniques were grouped together for analysis as research has demonstrated no significant difference between MHI and VHI regarding improvements in secretion clearance and respiratory mechanics (33, 34).

Respondents reported that MHI was preferred when sputum load was high (29% of respondents, n= 14/49) due to specific benefits of the technique (20%, n=10/49):

Respondents conveyed the following sentiments regarding the use of MHI:

"it can allow more precise co-ordination with the patient's breathing pattern in patients who are awake and agitated or intolerant of ventilator hyperinflation"

"it provides better feedback regarding lung compliance and secretion load".

Manual hyperinflation was reported to be used most when the level of ventilatory support and positive end expiratory pressure (PEEP) was low (≤7.5-10cmH_2O), by 10% of respondents (n = 5/49).

The majority of respondents who reported using VHI always or frequently indicated selecting the technique when PEEP was greater than 10cmH_2O (61%, n = 28/46) or when recruitment was the main goal (20%, n = 9/46).

Respondents commonly commented:

"Generally (VHI is) the preferred mode of hyperinflation treatment because maintaining intact ventilation circuit provides maintenance of PEEP, presumed reduction of infection risks and more precise monitoring of tidal volume, flowrate, inspiratory time etc while producing comparable effects on lung compliance, oxygenation & probably airway clearance".

Chest wall vibrations (CWV) were reportedly used by 53% of respondents always or frequently (n = 34/64) and this increased to 75% (n=48/64) if occasional use was included. A small number of respondents (11%, n = 7/64) commented that they used CWV in conjunction with hyperinflation techniques, whereas none of the respondents who used percussion indicated combining the technique with hyperinflation.

Tenacious or highly viscous secretions or a high sputum load were the most common rationale reported. Percussion was always or frequently used by 24% of respondents (n = 15/64), with rationale being a high sputum load, thick and tenacious secretions unable to be cleared using other modalities, or underlying suppurative lung disease.

Discussion

Rationale for respiratory physiotherapy treatment

Respondents believed that a strong rationale exists for physiotherapists to provide respiratory physiotherapy which aims to facilitate sputum clearance and promote improved ventilation and alveolar recruitment for the patient cohort with CAP. However, the results of this survey indicate that significant variability in clinical reasoning and subsequent (self-reported) clinical practice for intubated and mechanically ventilated patients with CAP exists regarding how these treatment aims are achieved. This is likely to result in variability also in patient outcomes.

Frequency and duration of respiratory physiotherapy treatment

The results indicated that physiotherapists reported their clinical practice in ICU includes longer and more frequent delivery of treatments to intubated patients with CAP when there was a greater physiotherapy full time equivalent (FTE) to bed ratio. Over 60% of respondents agreed that staffing and workload affected the duration and frequency of treatment they would consider feasible to deliver. The variability in duration and frequency of intervention demonstrated in the survey results are most

likely related to the type of facility and physiotherapy FTE staffing available. Respondents indicated that sputum volume was a significant factor in deciding how long and how frequent respiratory intervention should be. This factor was perceived by respondents to be more important that sputum viscosity, however cough effectiveness was also strongly considered.

Positioning patient for treatment

When considering selection of patient position for respiratory intervention there was a strong trend to state that the choice for using side-lying with the affected lung uppermost was based on unilateral lung pathology, or a choice would be made to use alternate side-lying when there was bilateral lung pathology. These findings are consistent with previous research (22, 33 - 36). Despite evidence that head down tilt further enhanced sputum clearance when added to hyperinflation in side-lying (35), only 11% of respondents reported using this position often for treatment. Explanations for less use of head down positioning could be that standard ICU care advocates patients being positioned head up in the semi-recumbent position to reduce risk of developing ventilator associated pneumonia, which has shown to result from microaspiration of colonised oropharyngeal and gastric contents, particularly in the supine position when a nasogastric tube is in situ (37). In addition the use of the head down position has also been linked to increased incidence of gastro-oesophageal reflux (38), which may also increase risk of aspiration.

Respiratory treatment techniques

The frequent reported use of hyperinflation techniques resonates with physiotherapy literature indicating good evidence for enhanced sputum clearance and lung compliance (22, 33, 35, 39, 40), and reduced airways resistance (41). Suggesting that VHI would be a technique of choice within some Australian tertiary ICUs is supported by another study which found that use of VHI appears to have increased over the last decade (42). The reported use of VHI in this study (55%, n=35/64) is higher than the 39% reported by Dennis et al in 2010, and in this study was most commonly reported to be used in the state of Victoria, followed by New South Wales (p= 0.006) which is consistent with previous findings (42). Results of this study suggest that VHI may have replaced MHI in some facilities, with some respondents using VHI exclusively for hyperinflation, commenting that this was due to either personal preference or lack of equipment to perform MHI. Respondents also indicated that VHI may provide an added degree of confidence for the treating clinician as the patient's respiratory variables are displayed in real time throughout the intervention and VHI negates the need to disconnect the ventilator circuit, thereby preserving PEEP and minimising infection transmission risk.

However, evidence for use of other respiratory techniques for intubated patients with acute respiratory illness is limited or conflicting, and it is unknown which intervention mode, position or dosage is required to impact patient outcomes (31), including for patients with CAP. Respondents rated their use of CWV as a frequently used or always used technique in 53% of cases despite evidence from a number of animal and in vivo studies which indicated that addition of external rib cage compressions (ERCC), either in isolation, combined with or followed by hyperinflation did not provide any additional improvements in lung compliance (43-47), oxygenation (45-

47) or sputum clearance (43, 45-47). One of these studies (42) found that ERCC did increase peak expiratory flows and sputum volume compared with the control group, however the effect size was too small to be considered clinically significant in patients with pulmonary infection and sputum hypersecretion. Furthermore the authors concluded that application of ERCC to the ribcage on expiration may cause expiratory flow limitation in some patients due to dynamic compression of the airways during the technique, which may hinder secretion clearance and be detrimental to the patient (43).

Percussion was self-reported to be used less commonly, with 50% of respondents (n = 32/64) reporting that they rarely or never used percussion for patients with CAP, in contrast to only 25% of respondents (n = 16/64) reporting rarely or never using CWV. Consideration of using percussion as part of an intervention may be mediated by previous findings of adverse effects, such as arrhythmias being associated with its clinical application in the critically ill (48). However caution is required when interpreting the results. One study (49) reported that 36% of subjects developed arrhythmias from postural drainage in side-lying with a 10 degree head down tilt and percussion, however it was noted that none were life threatening. In addition, 90% (n=64) of subjects suffered from a cardiac condition and 28% (n=20) had an acute cardiac condition, which may increase the likelihood of arrhythmias occurring. Furthermore, the relationship between the different components of the intervention and arrhythmia development in this study is unclear.

Most respondents rated their use of active intervention modes, such as limb exercises and mobilisation out of bed “always” or “frequently” presumably once

patients were able to participate in such an active intervention, which reflects the large body of recent literature into the benefits of early mobilisation for critically ill patients (18, 50 - 52). Active breathing exercises such as thoracic expansion exercises and active cycle of breathing techniques were used, but less commonly, possibly due to a shift in focus away from respiratory intervention once the patient is awake and able to take part in rehabilitation.

Normal saline instillation appeared uncommon, with only 13% (n = 8/64) reported using the technique always or frequently, for very thick or tenacious secretions (62%, n = 37) that are difficult to suction (20%, n = 12), or when other techniques for clearing secretions from the upper airways had been unsuccessful (10%, n = 6). Over 50% of respondents (n = 33/64) indicated that they rarely or never used this technique, reflecting literature which does not recommend routine use (19, 53, 54).

This current study sampled a large cohort of senior physiotherapists from public, private, metropolitan and rural hospitals around Australia who had substantial ICU clinical experience, providing good external validity. Survey responses were anonymous to facilitate honest and candid answers regarding clinical practice. A limitation of the study was that the data was self-reported, so responses may reflect best practice clinical reasoning of the clinician, rather than their usual practice. Respondents' recall of the frequency of admission of patients with CAP to ICU was based on opinion as review of ICU diagnostic admission codes for each facility was not able to be conducted as part of this investigation. It would have been ideal to obtain a staff to bed ratio to compare across units but we were not able to obtain

these due to hospital concerns that this would identify the unit involved. Also not all respondents answered every question, resulting in some missing data. However, to conduct a multicentre audit of practice by an external third party to eliminate bias would be difficult and costly.

This study has surveyed current respiratory physiotherapy practice for critically ill adults with CAP who are intubated and mechanically ventilated, a common presentation to the ICU. There was wide variability of practice among senior ICU physiotherapists in Australia regarding mode and dosage, which was influenced by a variety of factors, including workforce issues. At present what constitutes best physiotherapy practice for this patient population is unclear. Further research should investigate the consensus for what interventions should be tested in this population. These interventions should then be evaluated in intubated patients with CAP through randomised, controlled trials to determine what best practice is for this patient population, and the efficacy and impact of respiratory physiotherapy intervention on patient outcomes.

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