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Expert consensus for respiratory physiotherapy management of mechanically ventilated adults with community-acquired pneumonia: A Delphi study

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Expert consensus for respiratory physiotherapy management of mechanically ventilated adults with community acquired pneumonia: A Delphi study.

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Abstract

Rationale and Aims

Patients with community acquired pneumonia (CAP) are frequently admitted to an intensive care unit (ICU) for invasive mechanical ventilation. Physiotherapy treatment may be provided to optimise respiratory function, however there is significant variability in clinical practice and limited research guidance directing best practice for this cohort.

This study aimed to determine expert consensus for best physiotherapy practice for intubated and mechanically ventilated adults with CAP.

Method

A modified Delphi Technique involved three rounds of an online questionnaire administered to an international expert panel. The initial questionnaire of 35 statements covered seven domains of physiotherapy assessment and treatment of mechanically ventilated patients, based on a systematic literature review and survey of current clinical practice. Quantitative data using Likert scales determined level of agreement, with qualitative data collected through open-ended responses. Threshold for achieving consensus was set *a priori* at 70%. Items not achieving consensus were modified and new items added based on themes from qualitative data. Quantitative data were analysed with descriptive statistics and measures of central tendency, with thematic analysis used on qualitative data.

Results

The panel comprised of 29 international clinical and academic experts in critical care physiotherapy. Response rate was over 95% for each round. Outcome achieved was 38 expert consensus statements covering assessment and treatment, with 28 statements (74%) providing consensus on recommended clinical practice, 2 consensus disagreement statements (7%) for what practice is not recommended, and 8 statements (21%) indicating which treatments may be beneficial. Consensus could not be reached for 3 items relating to manual chest wall techniques and one item relating to normal saline lavage.

Conclusion

Expert consensus regarding physiotherapy for intubated adults with CAP patients provides an evidence-based approach to guide clinical practice. The consensus statements can also be used to guide research evaluating ICU physiotherapy interventions for CAP patients.

Introduction

Community acquired pneumonia (CAP) is a common respiratory diagnosis for patients admitted to the intensive care unit (ICU) for mechanical ventilation [1] and results in high morbidity and mortality [2].

Randomised trials investigating physiotherapy for invasively ventilated adult subjects with CAP are sparse. Respiratory physiotherapy comprised of techniques to increase tidal volume for secretion clearance compared with control has been found to increase sputum clearance [3-5]. Two other studies have found that hyperinflation techniques result in better lung compliance in small samples of mechanically ventilated adults with mixed diagnoses which included pneumonia [6, 7]. However the clinical significance of these benefits is unclear.

Despite a lack of evidence to guide clinical practice, a recent survey found that senior physiotherapists working in Australian ICUs do provide respiratory interventions for intubated and mechanically ventilated patients with CAP as part of usual care. Treatment is particularly directed towards reducing atelectasis and secretion retention; however significant clinical variability exists regarding the mode, duration and frequency of interventions used to address these clinical problems [8, 9].

While limited evidence suggests that there may be short term physiological benefits for undertaking respiratory interventions, the clinical significance, if any, is unclear given that minimal important clinical difference for changes in these outcomes is unknown. Further large, multi-centred, randomised controlled trials are necessary to evaluate the efficacy of respiratory physiotherapy in this critical care population. However, in the interim it is important to have guidelines for best practice, based on the best available evidence, in order to provide clinicians with a framework for making informed clinical decisions, thereby facilitating optimisation of patient care [10].

The Delphi technique has been widely used in medicine as a method of obtaining expert consensus for areas of practice where there is limited empirical evidence [14]. In particular researchers in critical care physiotherapy have conducted Delphi studies for this purpose in order to guide clinical practice [11-13]. The aim of this study was to determine expert consensus for respiratory physiotherapy management of intubated and mechanically ventlated adults with CAP which could subsequently inform development of guidelines for clinical practice.

Methods

The study used a modified Delphi Technique to achieve expert consensus based on an integration of current clinical practice [8, 9] and synthesis of the evidence from published literature. The Delphi Technique is a series of questionnaire rounds provided to a panel of experts to ascertain their agreement and opinions about a range of statements based on evidence related to a particular area of clinical practice. The statements are modified after each round based on panel responses, thereby enabling a consensus to be reached [14]. The methodology has been previously validated in a broad

range of clinical care areas [15-18], in addition to critical care physiotherapy, as a method for informing clinical practice [11, 12]. Ethics approval for the study was provided by the Human Research and Ethics Committee of The University of Notre Dame Australia (014126F). All participants provided written, informed consent prior to completing the survey.

Participants

In order to provide relevant perspectives and a range of expertise regarding the specialty area under investigation [14] a purposeful, heterogeneous sample of individuals "highly trained and competent within the specialised area of knowledge related to the target issue" [19] were required to participate in the expert panel. Therefore, physiotherapists with academic and/or clinical expertise in critical care physiotherapy were targeted for recruitment. An international panel of experts in critical care physiotherapy was convened. Prominent clinicians and academics within the field nationally and internationally were identified through literature review and via national and international networks of professional societies related to critical care physiotherapy, such as the International Confederation of Cardiorespiratory Physical Therapists. These individuals were directly emailed and invited to participate and snowballing was encouraged from within professional networks of the target participants. Participants of the preceding national survey of clinical practice who had already expressed interest in participating were also considered for eligibility [8, 9].

Sample size

There are no prescriptive guidelines regarding the ideal number of experts to be recruited for a Delphi study [19]. The sample size is dependent on the nature of the topic [19], with selection only of the most highly qualified and knowledgeable individuals from within the field critical to achieving the most valid outcomes [19]. A sample size of 25-40 was targeted for this study to allow for representation of a majority of Australian states as well as international representation, and inclusion of different sized ICUs. Both clinicians and academic experts were invited with the aim of providing both practical, research, and theoretical perspectives on clinical practice.

Inclusion criteria

Inclusion criteria determined *a priori* were a minimum of five years as a qualified physiotherapist and a minimum of three years of experience in critical care, and either a) met the standards for qualification of "specialist" in cardiorespiratory physiotherapy within the Australian Physiotherapy Association [22], or b) had minimum two years of experience working in a senior position within critical care, or a minimum of five publications pertaining to critical care physiotherapy (including co-author) [23]. Individuals who expressed interest in participating by reply email were asked to complete an online screening survey using SurveyMonkey (Palo Alto, USA) to identify whether they met the inclusion criteria. The chief investigator (LV) reviewed the screening surveys, and a link to Round 1 was emailed to all participants who met the eligibility criteria, making up the expert panel.

Development and piloting of initial questionnaire for Round 1

A structured, iterative process was undertaken to develop the questionnaire which was informed by a combination of literature synthesis and the results of a preceding national survey of clinical practice regarding physiotherapy management of invasively ventilated adults with CAP [8, 9]. The questionnaire comprised 35 statements (see Appendix 1), with 37% (n=13) related to physiotherapy assessment and 63% (n=22) to physiotherapy treatment. The scope of this study excluded patients with severe CAP progressing to adult respiratory distress syndrome, because the presence of different pathophysiology would require different treatment priorities. This was clearly outlined to participants at the outset of the questionnaire.

The statements were categorised into seven domains; assessment, patient selection and prioritisation, positioning, hyperinflation techniques, manual chest wall techniques, normal saline instillation, active treatment and mobilisation. Participants were asked to rank their level of agreement with each statement quantitatively on a five point Likert scale [14], based on their opinion and experience as a clinical or academic expert within the field [19]. The five points on the Likert scale provided to

participants for ranking were; strongly disagree, disagree, neutral, agree, strongly agree. Qualitative data was also collected for each item as open-ended responses. The questionnaire was piloted locally by four senior ICU physiotherapists, who were not members of the expert panel, to ensure content and face validity [14], time commitments to complete, and good respondent flow through the electronic questionnaire. Any ambiguous items were modified based on feedback provided during the pilot process.

Delphi procedure

Following the pilot process this Delphi Technique was undertaken between December 2016 and March 2017. Interested experts were sent information prior to the study and indicated their consent by selecting an online consent check box prior to commencing Round 1. Participants were required to complete three 'rounds' of online questionnaires approximately four weeks apart using SurveyMonkey. Each round was open for three weeks and a reminder email was sent to those who had not completed after two weeks for each round to optimise response rate.

The identity of panel members and their individual results for each round was known to the primary researcher (LV) only, and remained anonymous to other panel members, in accordance with Delphi Technique for maximising effective consensus by reducing the influence of dominant individuals within the group [14]. Following data collation and analysis after each round, the primary researcher (LV) provided each of the panel members with an individualised report outlining the collective group response in relation to their own response and summary of the qualitative data for each of the items which did not reach consensus within the preceding round. This was an essential part of the Delphi Technique, which allowed an individual panel member insight into where their own responses ranked in relation to the collective group response and facilitated convergence towards consensus in subsequent rounds by informing the opinions of participants and potentially influencing their point of view in light of the collective group response and other participants' anonymous individual comments [14, 19].

Panel members were asked to rank statements of each questionnaire and provide open ended comments for each according to their expert opinion on the subject. Statements failing to achieve consensus were modified and new statements were added to the second and third rounds based on themes generated by panel members through their open-ended responses. The Delphi Technique was ceased after the third questionnaire round as determined *a priori.*

Statistical analysis and determining consensus

The definition of consensus and how best to achieve this using a Delphi study is unclear in the literature, with the most common methods used being percentage of agreement above a certain threshold ranging from 50-97%, or a proportion of ratings within a particular range [20, 21]. In this study the threshold level for achieving consensus for each item was decided *a priori* at 70% as this is reported to be the minimum rate for maintaining rigor [14].

Previous Delphi studies have used Likert scales ranging from 3 to 9 points [21], with a greater number of points requiring more complex analysis of quantitative data. For this study a five point Likert scale was chosen with the descriptors: 1 = strongly disagree = 1, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. This scale provided sufficient range of responses in order to facilitate convergence towards consensus with each round, whist maintaining ease of analysis to reduce time for turn-around in between rounds, thus minimising participant attrition rate [14]. The quantitative data were analysed between each round using Microsoft Excel to calculate percentages of scores for each item. For each item measures of central tendency using median score and interquartile range for non-parametric categorical data was calculated using SPSS version 23 (IBM SPSS Statistics, IBM Corp, New York: USA) to indicate dispersion [20]. Qualitative data for each item were analysed after each round using thematic analysis [24] to identify common themes voiced by individual panel members. The analysis took a deductive approach where responses were analysed within the framework of the questionnaire domains [24], with two researchers (LV and SP) independently reading and coding the responses then comparing their analysis. A third independent researcher (AMH) was asked to view

both analyses for discrepancies, and then all three researchers met and discussed the responses until consensus was achieved. Where the three researchers agreed that a strong new theme was present in the open-ended comments from several experts, a summary of quotes were then assigned to each domain and presented alongside the quantitative results within participant feedback report provided to participants prior to the next round, and a new item was added in the subsequent round to explore the theme further with the whole expert panel.

Results

Recruitment of expert panel

The initial email invitation was sent to 48 potential target participants with a link to complete the eligibility screen. The screening survey was completed by 35 (73%) critical care physiotherapists who expressed interest in participating, and 29 (83%) met the criteria for inclusion into the expert panel and were recruited to the study. There was an excellent retention rate of over 96%. Characteristics of the expert panel members are presented in Table 1.

Table 1: Characteristics of expert panel (n=29)

Abbreviations: APA, Australian Physiotherapy Association

Gender	**n**	**%**
Female	20	69
Nationality	**n**	**%**
Australia	19	66
Belgium	2	7
Netherlands	1	3
New Zealand	1	3
South Africa	2	7
Sweden	1	3
United Kingdom	3	10
Role		
Clinical	17	59
Academic	9	31
Clinical & Academic	3	10
Specialists (APA)	3	10
Specialists (other countries)	4	14
Publications (including co-author)		
0	7	24
1-10	8	28
11-20	6	21
21-30	2	7
31-40	0	0
41-50	3	10
>50	3	10
Highest Qualification		
Graduate diploma/certificate	2	7
Bachelors	2	7
Masters	10	34
PhD	15	52
Years of ICU experience		
5-10	6	21
11-20	15	52
21-30	5	17
>30	3	10
Years of physiotherapy experience		
5-10	3	10
11-20	10	34
21-30	10	34
>30	6	21

Definitions: Clinician = Employed by a health care facility in a clinical role;

Academic = Employed by a university in an academic or research role

Achievement of consensus

Quantitative data analysis following the first round revealed a bimodal distribution of Likert responses resulting in grouping of categories 1 and 2 for disagreement and 4 and 5 for agreement to facilitate achievement of consensus above the 70% threshold within the predetermined 3 rounds, as agreement or disagreement with the statement by participants was felt to be of greater importance than the strength of agreement or disagreement. Definition of consensus according to a proportion of responses within a particular range above a certain threshold has been used a number of times in the literature [20]. Neutral response was maintained at a score of 3.

The final 38 expert consensus statements covered physiotherapy assessment and treatment, with 28 statements (74%) affirming what should be done, 2 statements (7%) affirming what should not be done, and 8 statements (21%) indicating which treatments may be beneficial. The flow of rounds to achieve consensus is shown in Figure 1. The final consensus statement is presented in Appendix 1.

Details of the statements that achieved consensus for each round, including modified and new statements, median and interquartile ranges are presented in Table 2, with those statements which did not reach consensus for each round, including modified and new statements, median and interquartile ranges presented in Table 3.

Table 2: Delphi Statements that achieved consensus

Item	Round achieving consensus[$]	Statement	% consensus	Median	25-75th percentile scores	IQR
Physiotherapy Assessment						
1	1	Respiratory physiotherapy assessment is a high priority during the acute intubated phase, when the patient is unconscious.	93.1	5.0	4 - 5	1
2	1	These patients should receive a respiratory physiotherapy assessment within 24 hours of intubation.	89.7	5.0	4 - 5	1
3	1	These patients should receive a respiratory physiotherapy assessment daily while in ICU.	89.7	5.0	4 - 5	1
4a*	2	These patients should receive a respiratory physiotherapy assessment more than once a day while in ICU when indicated by assessment or treatment findings.	85.7	4.0	4 - 4	0
5	1	Respiratory physiotherapy assessment should include ventilation support settings.	89.6	5.0	5 - 5	0
6	1	Respiratory physiotherapy assessment should include signs of impaired gas exchange e.g. ABG, FiO_2, SpO_2.	100	5.0	5 - 5	0
7	1	Respiratory physiotherapy assessment should include signs of increased work of breathing e.g. minute ventilation, respiratory rate, respiratory pattern, ventilator synchrony.	96.5	5.0	4.5 - 5	0.5
8	1	Respiratory physiotherapy assessment should include signs of atelectasis e.g. CXR interpretation, auscultation, chest expansion.	100	5.0	5 - 5	0
9	1	Respiratory physiotherapy assessment should include signs of secretion retention e.g. CXR interpretation, auscultation, fremitus, inspiratory strength and cough effectiveness.	96.5	5.0	5 - 5	0
10	1	Physiotherapy assessment should include pre-morbid respiratory disease, functional ability and smoking history.	100	5.0	4 - 5	1
11	1	Respiratory physiotherapy assessment should include signs of cardiovascular instability e.g. arterial BP, MAP, HR and rhythm, rate and dosage of vasoactive and inotropic medications.	100	5.0	5 - 5	0
12	1	Physiotherapy assessment should include current neurological function.	93.1	5.0	4 - 5	1
13	1	Physiotherapy assessment should include current musculoskeletal function.	82.8	4.0	4 - 5	1

Item	Round[$]	Statement	% consensus	Median	25-75th percentile scores	IQR
Physiotherapy Treatment						
Patient selection and prioritisation						
14	1	Respiratory physiotherapy treatment is a high priority during the acute intubated phase, when the patient is unconscious.	79.3	4.0	4 – 5	1
15	1	Respiratory physiotherapy treatment is important during the acute intubated phase, even if the patient is conscious but unable to actively participate due to neurological dysfunction or weakness of respiratory muscles.	93.1	5.0	4 - 5	1
16a*	2	Regular airway suctioning by the nursing staff should not be considered a substitute for respiratory physiotherapy treatment.	96.43	4.5	4 - 5	1
17	1	Assuming haemodynamic stability, patients who have evidence of secretion retention and/or high sputum load and/or impaired gas exchange would benefit from frequent respiratory physiotherapy assessment and treatment.	89.6	5.0	4 - 5	1
Positioning						
18	1	When the lung pathology is unilateral, the patient should be positioned in side-lying with the affected lung uppermost for respiratory physiotherapy treatment.	72.4	4.0	3 - 5	2
19a*	2	When the pathology is bilateral, and alveolar recruitment or secretion clearance is the goal of treatment, the patient should be treated in multiple positions with the target area for treatment uppermost, not just in the upright position.	92.9	4.0	4 - 5	1
20	1	When the lung pathology is bilateral, the patient should be positioned in alternate side-lying for respiratory physiotherapy treatment.	75.8	4.0	3.5 - 4	0.5
21a	2	Positioning the patients with head down tilt is beneficial to target drainage of the lower lobes as long as there are no contraindications and the patient is stable enough to tolerate this position.	75.0	4.0	3 - 5	2

Item	Round[$]	Statement	% consensus	Median	25-75[th] percentile scores	IQR
Hyperinflation techniques						
22	1	Patients with reduced consciousness should receive physiotherapy treatment with lung hyperinflation techniques when there is increased sputum volume.	72.4	4.0	3 - 4	1
23a*	2	Intubated patients with reduced consciousness and high sputum viscosity may also benefit from hyperinflation techniques in conjunction with measures to increase airway humidification.	96.4	4.0	4 - 5	1
24	1	Patients should receive physiotherapy treatment with lung hyperinflation techniques to improve alveolar recruitment when signs of atelectasis are present on CXR or auscultation.	79.3	4.0	4 - 5	1
Manual chest wall techniques						
25a*	2	Intubated patients with large volumes of sputum may benefit from manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) to assist secretion clearance.	75.0	4.0	3.25 - 5	1.75
26a*	2	Intubated patients with high sputum viscosity may benefit from manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) in conjunction with measures to increase airway humidification.	71.4	4.0	3 - 5	2
26b*	3	Intubated patients with high sputum viscosity may benefit from combination of hyperinflation and manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) in conjunction with measures to increase airway humidification.	85.2	4.0	4 - 5	1
27b*	3	When hyperinflation techniques cannot be used or tolerated, manual chest wall techniques (such as percussion, chest wall vibrations/expiratory rib cage compressions) may be beneficial in assisting secretion clearance in combination with positioning, provided they are not also contraindicated.	74.1	4.0	3 - 5	2
Normal Saline Instillation						
28	1	When performing respiratory physiotherapy treatment, normal saline should be routinely instilled in the airway prior to airway suctioning.	79.3[#]	2.0	1 - 2	1
29	1	When performing respiratory treatment, normal saline should be instilled in the airway prior to endotracheal suctioning only when the secretions are very tenacious and unable to be cleared using other techniques.	72.4	4.0	3 - 4	1

Item	Round[$]	Statement	% consensus	Median	25-75th percentile scores	IQR
Active treatment and mobilisation						
31	1	Respiratory physiotherapy treatment is important during the acute intubated phase, even if the patient is conscious and is able to participate actively with intervention.	82.8	4.0	4 - 5	1
32	1	Once the patient is conscious and able to participate in treatment, active modes of respiratory treatment should be used (e.g. deep breathing exercises, active cycle of breathing techniques, forced expiratory technique) rather than passive treatment modes such as hyperinflation and/or manual chest wall techniques.	89.7	4.0	4 - 5	1
33	1	The patient should be mobilised out of bed as soon as they are conscious and haemodynamically stable.	100	5.0	5 - 5	0
34	1	Respiratory physiotherapy treatment is no longer important once the patient is able to participate in active mobilisation.	79.2[#]	2.0	2 - 2	0
35a	2	Once the patient is conscious and medically stable, early mobilisation does not replace respiratory physiotherapy treatment but is complementary to it.	96.4	4.0	4 - 5	1
New items generated from comments of expert panel (Table 4)						
36a	3	If the head down tilt position is used, to minimise risk of aspiration of gastric contents into the lungs it is ideal to either stop enteral feeds for at least 30 minutes prior to treatment and/or ensure stomach is emptied by aspirating the nasogastric tube.	74.1	4.0	3 – 4	1
37	2	Intubated patients with high sputum viscosity would benefit from measures to increase airway humidification, such as use of heated humidifiers, regular saline nebs and fluid optimisation.	92.9	4.0	4 – 5	1
38	3	Intubated patients with high sputum viscosity may benefit from combination of hyperinflation and manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) in conjunction with measures to increase airway humidification.	85.2	4.0	4 – 5	1
43	2	Respiratory physiotherapy techniques should be continued to be used after mobilisation of the patient commences, until the patent is able to achieve sufficient alveolar recruitment and/or airway clearance with mobilisation alone.	89.3	4.0	4 - 5	1

Abbreviations: ABG, arterial blood gas; BP, blood pressure, CAP, community acquired pneumonia; CXR, chest xray; FiO_2, fraction of inspired oxygen; HR, heart rate; ICU, intensive care unit; IQR, interquartile range; MAP, mean arterial pressure; SpO_2, pulse oxygen saturation;

$ = Round in which consensus was achieved.

* = Item modified based on comments of expert panel.

= consensus achieved for disagreement with the statement.

Table 3: Delphi statements not achieving ≥ 70% consensus for each round

Item	Round	Statement	% consensus	Median	25-75th percentile scores	IQR
Physiotherapy Assessment						
4	1	These patients should receive a respiratory physiotherapy assessment more than once a day while in ICU.	41.3[#]	3.0	2 - 4	2
Physiotherapy Treatment						
Patient selection and prioritisation						
16	1	Respiratory physiotherapy treatment is not necessary when sputum can be regularly cleared by nursing staff via airway suctioning.	55.1[#]	2.0	2 - 3.5	1.5
Positioning						
19	1	When the lung pathology is bilateral, the patient should be positioned supine with the head of the bed elevated (sitting upright) for respiratory physiotherapy treatment.	48.3[#]	3.0	2 - 3.5	1.5
21	1	Positioning the patient with head down tilt is beneficial to target the lower lobes.	55.2	4.0	2.5 - 4	1.5
Hyperinflation techniques						
23	1	Patients with reduced consciousness should receive physiotherapy treatment with lung hyperinflation techniques when there is increased sputum viscosity.	58.6	4.0	3 - 4	1
Manual chest wall techniques						
25	1	Patients should receive physiotherapy treatment using manual chest wall techniques such as percussion or chest wall vibrations/expiratory rib cage compressions.	41.4	3.0	2.5 - 4	1.5
26	1	Patients should receive physiotherapy treatment using manual chest wall techniques such as percussion or chest wall vibrations/expiratory rib cage compressions, in conjunction with hyperinflation techniques, when sputum volume or viscosity are high.	69.0	4.0	3 - 5	2
27	1	Patients should receive physiotherapy treatment using manual chest wall techniques such as percussion or chest wall vibrations/expiratory rib cage compressions when hyperinflation techniques are contraindicated (e.g. pneumothorax, low mean arterial pressure) to facilitate secretion clearance.	55.1	4.0	2 - 4	2
27a*	2	Manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) are beneficial in assisting secretion clearance when hyperinflation techniques cannot be used or tolerated.	67.8	4.0	3 - 4.75	1.75

Item	Round	Statement	% consensus	Median	25-75th percentile scores	IQR
Normal Saline Instillation						
30	1	When performing respiratory physiotherapy treatment, it is beneficial for normal saline to be instilled via the airway prior to hyperinflation to lavage the lung.	51.7#	2.0	1 - 3	2
30a*	2	When performing respiratory physiotherapy treatment, if secretions are tenacious it is beneficial for normal saline to be instilled to the airway to lavage the lung prior to hyperinflation.	35.7#	3.0	2 - 4	2
30b*	3	Instillation of normal saline via the airway prior to hyperinflation to lavage the lung is not recommended as part of respiratory physiotherapy for ventilated patients with CAP.	44.4	3	2 - 4	2
Active treatment and mobilisation						
35	1	Early mobilisation is an adequate substitute for respiratory physiotherapy treatment once the patient is conscious and medically stable.	68.9#	2.0	2 - 3	1
New items generated from comments of expert panel						
Item	Round	Statement	% consensus	Median	25-75th percentile scores	IQR
36	2	If the head down tilt position is used, enteral feeds must be stopped for at least 30 minutes prior.	64.3	4.0	3 – 4	1
38	2	Intubated patients with high sputum viscosity would benefit from combination of hyperinflation and manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) in conjunction with measures to increase airway humidification.	67.8	4.0	3 - 5	2
39	2	Manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) should not be used routinely due to a lack of evidence that these techniques are effective in assisting with secretion clearance.	60.7	4.0	2 - 4	2
39a	3	Use of chest wall vibrations is not recommended for intubated and ventilated patients with CAP.	55.5#	2	2 - 3	1
39b	3	Use of expiratory rib cage compressions/rib springing is not recommended for intubated and ventilated patients with CAP.	55.5#	2	2 - 3	1
39c	3	Use of percussion is not recommended for intubated and ventilated patients with CAP.	44.44##	3	2 - 4	2

= agreement and disagreement with the statement was equivocal.

Other abbreviations and key as per Table 2

Consensus per domain

Domain 1 - Physiotherapy assessment

All but one statement related to assessment achieved consensus in the first round (92%, n=12) as experts agreed on the importance of thorough multisystem assessment with a focus on the respiratory system. One expert reported "*ventilator assessment is important as it provides information about both a patient's pathology and stability, and the level of support required to manage that. As well as providing information difficult to ascertain elsewhere eg compliance, it can corroborate other assessment modalities such as auscultation & CXR review."* (P19, Clinician, Grad Dip) Regarding secretions one expert commented "*I think CXR is important but I think the volume and colour of suctioned secretions over the day is more important to assess than auscultation signs." (*P26, Academic, PhD) Others commented that "*cardiovascular stability will affect decision on physiotherapy treatments that can be provided therefore is a requirement of the full systematic assessment that should occur for every ICU patient"* (P5, Clinician, Masters) because *"a number of the respiratory physiotherapy techniques can potentially compromise a patient's cardiovascular stability. As such, it is important to have a baseline understanding of the patient's cardiovascular status and stability, as well as clear limits / boundaries in mind before commencing treatment."* (P19, Clinician, Grad Dip)

The one statement that did not reach consensus in Round 1 was related to recommended frequency of assessment, which the expert panel agreed could not be recommended based on routine, but rather should be informed by assessment and/or treatment findings that highlight indications for or benefit from physiotherapy intervention.

> *"Frequency of assessment will depend on the previous findings, sputum load, response to treatment, mode of ventilation". (P12, Clinician, Bachelors)*

> *"Formal assessment once a day to determine likelihood of needing / being suitable for PT interventions. Further assessment may occur during the day e.g. looking for changes" (P4, Clinician, PhD)*

Themes from qualitative data indicated that early and regular physiotherapy assessment is important to determine whether the patient will benefit from physiotherapy intervention and allows early detection of changes in condition which may trigger need for, or escalation of, physiotherapy input. When modified for Round 2 to reflect this rationale, the item achieved consensus over 85%.

> *"If a patient's respiratory status changes, or their respiratory disease is significant enough to warrant multiple physiotherapy reviews (assessment +/- treatment) in one day, then this should be done if possible." (P19, Clinician, Grad Dip)*

Domain 2 – Patient selection and prioritisation

Only one statement in this domain did not reach consensus in Round 1. This related to regular suctioning by the nursing staff being an adequate substitute for respiratory physiotherapy intervention, which achieved consensus disagreement when the statement was presented again in the affirmative during Round 2. The key theme identified was that physiotherapist skill in mobilising and clearing secretions from deeper within the lungs was important, through use of a variety of treatment modalities in addition to suction, which "*results in greater sputum than just suction alone performed by nurses*." (P4, Clinician, PhD). *"Suctioning only clears the proximal airways, and is not without risk. In patients with secretion retention, there are physiotherapy techniques which can assist with sputum transport from the distal to proximal airways, and may make suctioning more effective and also techniques which can limit or reverse some of the detrimental effects of suctioning*" (P19, Clinician, Grad Dip). This theme was further reflected by another clinician:

> *"(Physiotherapy) treatment is not just aimed at suctioning & I believe that physiotherapists suction differently to nursing staff; that is we attempt to clear secretions further down the bronchial tree than just a quick suction to clear secretions in the endotracheal/trachy tube" (P12, Clinician, Bachelors)*

Another theme identified was *"aims and potential outcomes of respiratory physiotherapy treatment extend beyond simply clearing excess secretions from the upper airway, which is the main aim/outcome of suction in isolation…." (P13, Clinician, Masters)*

The theme from the open responses was that if secretions are "*minimal, loose and easily cleared*" and "*no other respiratory problems amenable to respiratory physiotherapy exist*", then "it may be appropriate for secretions to be managed solely by nursing staff".

> *"…..if scant, clear- white, watery thin secretions yes nursing can manage, for more copious, green/yellow secretions although can be cleared by nurses, needs to have physiotherapy intervention…more frequently" (P18, Clinician, Grad Cert)*

Domain 3 - Positioning

Consensus was achieved in Round 1 for items recommending use of side lying position with the affected lung uppermost for intervention. The strong theme identified for this domain was that use of the side lying position was preferable compared to upright when the pathology was basal. For example one academic stated *"if the pathology is in the bases, sitting up right will not assist." (P21, Academic, PhD)*

It was also acknowledged that positioning was sometimes influenced by logistics.

> *"….if I only have time to treat the patient once per day, or for a shorter treatment session, (upright) might be my preferred position. I would be less likely to use a head-up position if the pathology was basal" (P19, Clinician, Grad Dip)*

Consensus recommended either alternate side lying or the use of multiple positions to target the affected areas when lung pathology is bilateral, ensuring the affected area is uppermost.

> *"Positioning for treatment should depend on (patient) condition, clinical signs at time of treatment, and in the presence of bilateral lung pathology would ideally involve a variety of*

positions…including alternate side lying, supine +/- head-up tilt, and possibly also sitting upright during a course of treatment" (P13, Clinician, Masters)

Consensus was not achieved for the use of head down tilt position until Round 2, when the statement was modified according to themes regarding cardiovascular stability and presence of contraindications, such as gastro-oesophageal reflux disorder (GORD) which was believed to "*have greater risk in the head down position*" and may be "*present without diagnosis*" (*P8, Clinician, Masters).* The panel appeared divided regarding use of head down tilt to target basal regions in Round 1 (55% agreed), with a statement that "*there is a theoretical benefit of this practice, supported by research findings of increased sputum yields (but) clinical significance is unclear*" (P19, Clinician, Grad Dip). Another stated that it was uncommon "*to find a patient with CAP, mechanically ventilated (and) well enough to tolerate head down tilt without compromising recruitment*" (P12, Clinician, Bachelors). The theme of stopping enteral feeds before and during head down tilt also occurred in Round 1, together with strong concern regarding risk of aspiration of gastric contents in this position.

"*I would only perform head down tilt during physiotherapy treatment and not as a positioning strategy for nursing staff, and only if there were no other indications that would put the patient at risk, such as gastro-oesophageal reflux disorder. Feeds would be stopped during this time as well*." (*P5, Clinician, Masters)*

Open responses to this item resulted in the addition of a new item for Round 2 to recommend that feeds be stopped for a minimum of 30 minutes prior to head down positioning. This item failed to reach consensus. Following this, a strong theme identified in the open-ended responses was that the panel recommended that the nasogastric tube be aspirated to minimise any risk of aspiration of gastric contents into the lungs.

"Ideally we would stop enteral feeds, but this is not a must. If the feeds are not stopped before head down tilt, we would ask nursing staff to aspirate the nasogastric tube before head down positioning." (P6, Clinician, PhD)

> *"Why not just aspirate the nasogastric tube prior to intervention to minimise any risk of aspiration?" (P22, Academic, PhD)*

Some panel members stated that "*there is not enough evidence to make recommendations regarding this practice*" of stopping enteral feeds and aspirating the nasogastric tube to minimise risk (P16, Academic/Clinician, PhD). Despite this, the modified statement recommending the feed be stopped and/or nasogastric tube be aspirated for head down positioning reached consensus in Round 3. This indicated conflicting views regarding this issue among the expert panel.

Domain 4 - Hyperinflation techniques

Consensus was achieved in Round 1 for items regarding use of lung hyperinflation techniques when sputum volume is increased or when improved alveolar recruitment is the goal of treatment. Use of hyperinflation techniques for increased sputum viscosity did not achieve consensus until Round 2 when the use of humidification was added to the statement.

> *"In appropriate patients, (hyperinflation) tends to be my first choice of treatment; also combined with other management strategies such as regular side-side repositioning by nursing staff, ensuring appropriate humidification." (P19, Clinician, Grad Dip)*

Domain 5 - Manual chest wall techniques

None of the items related to use of manual chest wall techniques (MCWT), such as percussion, vibrations and external/expiratory ribcage compressions, achieved consensus until Round 2. In Round 1 there appeared to be disparity among the panel with 41% agreeing with use of MCWT, 24% disagreeing and 35% neutral, which increased in Round 2 to 69% agreeing, 18% disagreeing and 14% neutral when the statement was modified to combine MCWT use with hyperinflation. The panel was able to achieve consensus in Round 2 on items stating that MCWT *may be beneficial* in conjunction

with humidification when sputum viscosity is high or when sputum volume is increased. Use of MCWT and hyperinflation reached consensus in Round 3 with addition of humidification.

The evidence statements for this domain also appeared to divide the expert panel. Two contrasting themes were: a lack of proven evidence and a rationale existed for secretion retention or when sputum was thick or tenacious.

> *"…there is little evidence to guide the usefulness of manual chest wall techniques in mechanically ventilated patients" (P16, Academic/Clinician, PhD)*

> "*Despite lack of research evidence for manual techniques, clinically I find that chest wall vibrations assist to move secretions from peripheral airways to proximal airways where they can then be suctioned. I have observed this visually when done in combination with a bronchoscopy procedure. This will always be very difficult to clinically research due to changes in patients sputum load from day to day. I believe this is where clinical reasoning trumps clinical research" (P8, Clinician, Masters)*

> *"Vibrations can be a useful technique to mobilise secretions in patients where other techniques cannot be implemented" (P5, Clinician, Masters)*

Domain 6 - Normal saline instillation

The panel achieved consensus disagreement in Round 1 for the routine use of normal saline instillation (NSI) prior to airway suction, however consensus agreement was achieved that NSI could be used when "secretions are very tenacious and unable to be cleared using other techniques". Consensus was not able to be achieved over the three rounds regarding the use of NSI prior to use of hyperinflation techniques to lavage the lung.

> *"Saline lavage should be used cautiously as current evidence does not support its use. I would use a lavage prior to suction only when tenacious secretions that aren't clearing but can be heard, and not prior to a hyperinflation" (P5, Clinician, Masters)*

Domain 7 - Active exercise and mobilisation

In Round 1 the expert panel unanimously agreed that mobilisation out of bed should occur as soon as the patient is conscious and haemodynamically stable, however disagreed that respiratory physiotherapy is no longer important once the patient is able to participate in active mobilisation. "*Sometimes they both need to go hand in hand. Many patients can become fatigued before they have done sufficient mobilisation treatment to address their respiratory problem*" (P7, Academic/Clinician, PhD). There was strong consensus that active modes of respiratory physiotherapy, such as active breathing techniques, should be used once the patient is conscious and able to participate effectively. In Round 2 strong consensus was achieved which supported the statement that "mobilisation does not replace respiratory physiotherapy treatment but is complementary to it". Also in Round 2 consensus was achieved for the statement, "respiratory physiotherapy techniques should be continued after active mobilisation has commenced until the patent is able to achieve sufficient alveolar recruitment and/or airway clearance with mobilisation alone".

Discussion

This Delphi study resulted in 38 expert consensus statements covering 7 key domains for the ICU physiotherapy management of intubated adults with CAP.

The high proportion of items related to physiotherapy assessment, based on a systems approach, which achieved consensus in Round 1 indicates that there is strong international agreement regarding what constitutes a thorough physiotherapy assessment for intubated adults with CAP. This finding is consistent with published minimum standards for physiotherapists working in ICU, highlighting the importance of strong clinical assessment skills [23, 25, 27].

The much lower proportion of items related to physiotherapy treatment that achieved consensus reflects the variability in clinical practice for this population [8, 9].

Expert consensus recommends use of the side lying position for treatment of invasively ventilated adults with CAP, which is reflective of the broader literature demonstrating improved secretion clearance and lung compliance for ventilated patients treated in this position [5, 28].

The need to stop supplemental enteral feeds prior to positioning the patient in the head down position was controversial among the expert panel. There is no documented evidence in the literature regarding the need for, and optimal duration for withholding enteral feeds prior to physiotherapy intervention to guide this practice. Two studies [28, 29] both utilised head down tilt of 35-45 degrees in the side-lying position for a duration of 20 minutes during intervention involving hyperinflation techniques and nil adverse events were reported affecting haemodynamic or oxygen saturation. However neither of these studies made mention of enteral feed management prior to or during time of head down positioning.

Consensus for the use of lung hyperinflation techniques in patients with CAP when sputum volume is increased or when improved alveolar recruitment is the goal is reflective of the wider literature indicating improved secretion clearance and lung compliance with use in ventilated patients [3, 28, 30, 31].

The use of MCWT, such as percussion, vibrations and external/expiratory ribcage compressions in clinical practice also generated conflicting views among the expert panel, which is reflective of the limited and conflicting research evidence available for the efficacy of these techniques for ventilated patients. There were two strong opposing themes regarding treatment based on research evidence versus clinical reasoning and utility of MCWT, which over half of international experts believe do have a beneficial role in clinical practice. These views are consistent with findings of a previous survey of Australian clinical practice [9].

The consensus findings that NSI should not be used routinely prior to airway suction but could be used when secretions are very tenacious and unable to be cleared using other techniques is consistent with a previous Delphi conducted in 2009 in the United Kingdom [32]. In contrast, a systematic review regarding safety and efficacy of NSI found no evidence of harm and suggested there may be

some weak evidence of efficacy for clearance of secretions, however the studies had poor methodological quality [33].

Strong expert consensus for commencement of early active mobilisation is reflective of the large body of evidence highlighting benefits of early mobilisation for intensive care patients [34]. In this study it has also been recognised that early mobilisation should not replace respiratory physiotherapy treatment for patients with CAP who demonstrate problems of secretion retention and/or atelectasis, but rather respiratory care and rehabilitation are complimentary to one another, with each playing a different role at varying time points within a patient's clinical journey. Improving respiratory function through intervention targeted at reducing respiratory impairments of atelectasis, secretion retention and gas exchange in conjunction with patient mobilisation may result in improved rehabilitation outcomes, however this remains an area requiring research to confirm.

This Delphi study was successful in recruiting a purposive sample of international experts in critical care physiotherapy from eight countries who met pre-defined eligibility criteria for participation in the expert panel. The expert panel members had a high level of expertise in critical care physiotherapy, as indicated by years of physiotherapy and ICU experience (Table 1). The number of participants in this study is similar to other Delphi studies conducted within this specialised field of physiotherapy, aimed at providing guidance on aspects of clinical practice [11-13]. Furthermore, application of a bootstrap sampling technique by Atkins et al to responses generated by a Delphi panel of 23 participants from a defined field of knowledge found that responses to the Delphi surveys were stable, indicating good reliability of results [35]. It was also found that three rounds appeared to confirm themes, with saturation demonstrated and no new themes identified in the data.

Conducting this Delphi Technique had the benefit of allowing a large number of experts from multiple ICUs and universities across different countries to provide their opinions on this topic in a

quasi-anonymous manner, as the panel of participants were unknown to each other throughout the process [14, 19, 36]. This prevented dominant individuals from influencing the process and allowed the opinions of all group members to be equally heard [19, 36]. This provides rigor to the study and allows good generalisability of the consensus statements internationally.

Additional strengths which provided rigor to this study included a predefined methodology and threshold for determining consensus, and a predetermined number of rounds [20]. Very low attrition rates between each of the survey rounds increased stability of responses and also provided rigor by reducing bias, thereby enhancing validity of findings [14].

This study has provided valid expert opinion for the physiotherapy management of intubated and mechanically ventilated adults with CAP. Further research is necessary to clinically validate these consensus statements to ensure relevance and practicality within the multidisciplinary ICU setting.

A limitation of this study was the majority of panel participants were Australian (66%) which reduces strength of international applicability of the consensus statements. Another limitation is the absence of a domain for outcome assessment. This theme was not specifically added into the framework separate from the assessment domain. However the last item in each of the three rounds was a text box encouraging participants to include any further information which they felt was pertinent and had not yet been included. None of the participants raised comments related to outcome assessment. In hindsight it would have been beneficial to gain expert opinion regarding which clinical outcome measures are most important in this patient cohort to guide planning of future research. This could be an area for further research.

Conclusion

These expert consensus statements provide an evidence-based guide for the physiotherapy management of intubated and mechanically ventilated adults with CAP. The statements lay the

foundation for the development of formal clinical guidelines and provide a framework for further research in this area to improve patient outcomes.

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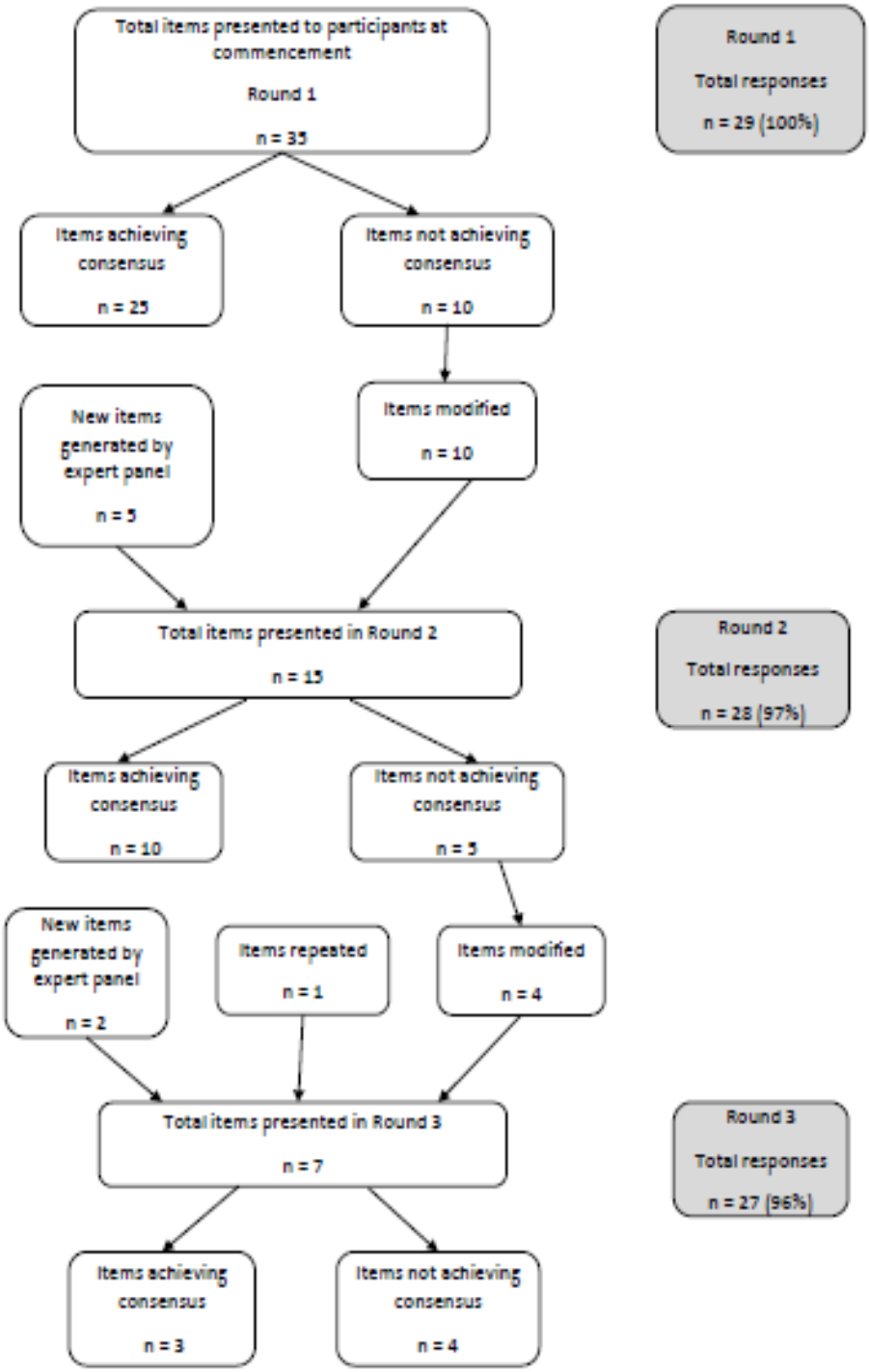
Figure Legends

Figure 1 Delphi Procedure – flow of consensus

Figure 1


Total items presented to participants at commencement
Round 1
n = 35
Round 1
Total responses
n = 29 (100%)
Items achieving consensus
n = 25
Items not achieving consensus
n = 10
New items generated by expert panel
n = 5
Items modified
n = 10
Total items presented in Round 2
n = 15
Round 2
Total responses
n = 28 (97%)
Items achieving consensus
n = 10
Items not achieving consensus
n = 5
New items generated by expert panel
n = 2
Items repeated
n = 1
Items modified
n = 4
Total items presented in Round 3
n = 7
Round 3
Total responses
n = 27 (96%)
Items achieving consensus
n = 3
Items not achieving consensus
n = 4

Appendix 1: Final Consensus Statements

Physiotherapy Assessment	
1	Respiratory physiotherapy assessment is a high priority during the acute intubated phase, when the patient is unconscious.
2	These patients should receive a respiratory physiotherapy assessment within 24 hours of intubation.
3	These patients should receive a respiratory physiotherapy assessment daily while in ICU.
4	These patients should receive a respiratory physiotherapy assessment more than once a day while in ICU when indicated by assessment or treatment findings.
5	Respiratory physiotherapy assessment should include ventilation support settings.
6	Respiratory physiotherapy assessment should include signs of impaired gas exchange e.g. ABG, FiO_2, SpO_2.
7	Respiratory physiotherapy assessment should include signs of increased work of breathing e.g. minute ventilation, respiratory rate, respiratory pattern, ventilator synchrony.
8	Respiratory physiotherapy assessment should include signs of atelectasis e.g. CXR interpretation, auscultation, chest expansion.
9	Respiratory physiotherapy assessment should include signs of secretion retention e.g. CXR interpretation, auscultation, fremitus, inspiratory strength and cough effectiveness.
10	Physiotherapy assessment should include pre-morbid respiratory disease, functional ability and smoking history.
11	Respiratory physiotherapy assessment should include signs of cardiovascular instability e.g. arterial BP, MAP, HR and rhythm, rate and dosage of vasoactive and inotropic medications.
12	Physiotherapy assessment should include current neurological function.
13	Physiotherapy assessment should include current musculoskeletal function.
Physiotherapy Treatment	
Patient selection and prioritisation	
14	Respiratory physiotherapy treatment is a high priority during the acute intubated phase, when the patient is unconscious.
15	Respiratory physiotherapy treatment is important during the acute intubated phase, even if the patient is conscious and is able to participate actively with intervention.
16	Respiratory physiotherapy treatment is important during the acute intubated phase, even if the patient is conscious but unable to actively participate due to neurological dysfunction or weakness of respiratory muscles.
17	Regular airway suctioning by the nursing staff should *not* be considered a substitute for respiratory physiotherapy treatment.
18	Assuming haemodynamic stability, patients who have evidence of secretion retention and/or high sputum load and/or impaired gas exchange would benefit from frequent respiratory physiotherapy assessment and treatment.

19	Intubated patients with high sputum viscosity would benefit from measures to increase airway humidification, such as use of heated humidifiers, regular saline nebs and fluid optimisation.
Positioning	
20	When the lung pathology is unilateral, the patient should be positioned in side-lying with the affected lung uppermost for respiratory physiotherapy treatment.
21	When the pathology is bilateral, and alveolar recruitment or secretion clearance is the goal of treatment, the patient should be treated in multiple positions with the target area for treatment uppermost, not just in the upright position.
22	When the lung pathology is bilateral, the patient should be positioned in alternate side-lying for respiratory physiotherapy treatment.
23	Positioning the patients with head down tilt is beneficial to target drainage of the lower lobes as long as there are no contraindications and the patient is stable enough to tolerate this position.
24	If the head down tilt position is used, to minimise risk of aspiration of gastric contents into the lungs it is ideal to either stop enteral feeds for at least 30 minutes prior to treatment and/or ensure stomach is emptied by aspirating the nasogastric tube.
Hyperinflation techniques	
25	Patients with reduced consciousness should receive physiotherapy treatment with lung hyperinflation techniques when there is increased sputum volume.
26	Intubated patients with reduced consciousness and high sputum viscosity may also benefit from hyperinflation techniques in conjunction with measures to increase airway humidification.
27	Patients should receive physiotherapy treatment with lung hyperinflation techniques to improve alveolar recruitment when signs of atelectasis are present on CXR or auscultation.
Manual chest wall techniques	
28	Intubated patients with high sputum viscosity may benefit from manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) in conjunction with measures to increase airway humidification.
29	Intubated patients with high sputum viscosity may benefit from combination of hyperinflation and manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) in conjunction with measures to increase airway humidification.
30	Intubated patients with large volumes of sputum may benefit from manual chest wall techniques (such as percussion or chest wall vibrations/expiratory rib cage compressions) to assist secretion clearance.
31	When hyperinflation techniques cannot be used or tolerated, manual chest wall techniques (such as percussion, chest wall vibrations/expiratory rib cage compressions) may be beneficial in assisting secretion clearance in combination with positioning, provided they are not also contraindicated.
Normal saline instillation	
32	When performing respiratory physiotherapy treatment, normal saline should *not* be routinely instilled in the airway prior to airway suctioning.

33	When performing respiratory treatment, normal saline should be instilled in the airway prior to endotracheal suctioning only when the secretions are very tenacious and unable to be cleared using other techniques.
Active modes of treatment and mobilisation	
34	Once the patient is conscious and able to participate in treatment, active modes of respiratory treatment should be used (e.g. deep breathing exercises, active cycle of breathing techniques, forced expiratory technique) rather than passive treatment modes such as hyperinflation and/or manual chest wall techniques?
35	The patient should be mobilised out of bed as soon as they are conscious and haemodynamically stable.
36	Respiratory physiotherapy treatment is still important once the patient is able to participate in active mobilisation.
37	Once the patient is conscious and medically stable, early mobilisation does not replace respiratory physiotherapy treatment but is complementary to it.
38	Respiratory physiotherapy techniques should be continued to be used after mobilisation of the patient commences, until the patent is able to achieve sufficient alveolar recruitment and/or airway clearance with mobilisation alone.

Abbreviations: ABG, arterial blood gas; BP, blood pressure, CAP, community acquired pneumonia; CXR, chest xray; FiO_2, fraction of inspired oxygen; HR, heart rate; ICU, intensive care unit; IQR, interquartile range; MAP, mean arterial pressure; SpO_2, pulse oxygen saturation;