


CASE REPORT

Use of mechanical insufflation exsufflation and manual techniques in an intubated adult with COVID-19 positioned in prone—A case study

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Abstract

Background and Purpose: The therapeutic benefits of prone positioning have been described over the last 50 years culminating in a systematic review supporting this management strategy for patients with severe hypoxaemic respiratory failure. Early work detailing treatment approaches for COVID-19 have advocated the use of prone positioning. Limited data exists regarding physiotherapy intervention in patients with COVID-19 owing to the recent emergence of this novel disease. Despite the acknowledged beneficial effects of physiotherapy on secretion clearance and lung recruitment in the general critical care population, there is a lack of evidence pertaining to physiotherapeutic intervention for acutely unwell intubated adults in prone lying.

Methods: This case study report follows the CARE case report guidelines. One patient with COVID-19 pneumonitis who underwent physiotherapy intervention in prone lying is discussed. Informed consent was gained from next of kin for data to be published.

Results: Treatment techniques including mechanical insufflation-exsufflation in prone were feasible and well tolerated by this patient with only transient adverse effects noted. Treatment techniques assisted with secretion clearance.

Discussion: Further work on safety, feasibility, and efficacy of physiotherapy intervention in patients with and without COVID-19 in prone will contribute to the evidence base on this subject.

KEYWORDS

case reports, patient positioning, physical therapy modalities

1 | INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has had widespread global impact since detection in Wuhan, China in December 2019 (Li et al., 2020). Coronavirus disease 2019 (COVID-

19) caused by SARS-CoV-2 has affected almost 250 million people with numbers continuing to increase (World Health Organization, 2021).

To date, over 45,000 people have been admitted to critical care in England, Wales, and Northern Ireland (Intensive Care National Audit and Research Centre, 2021). Therapeutic strategies for

patients include lung protective ventilation, fluid balance management and prone positioning (PP). Positioning patients in prone was first described in those with acute respiratory distress syndrome (Piehl & Brown, 1976). A systematic review advocates PP, with early consideration for patients with severe hypoxaemic respiratory failure (Bloomfield et al., 2015). Following reports of its efficacy early in the COVID-19 pandemic, PP has become a cornerstone of treatment for patients in critical care (Bouadma et al., 2020; Langer et al., 2021).

Physiotherapy in critically ill patients enhances secretion clearance, reduces ventilator-associated pneumonia, improves static lung compliance and reverses atelectasis (Choi & Jones, 2005; Guimarães et al., 2014; Hodgson et al., 2000; Ntoumenopoulos et al., 2002). Evidence regarding physiotherapeutic intervention in COVID-19 is in its infancy owing to the recent emergence of this disease. Furthermore, literature detailing physiotherapy treatment for patients positioned in prone with or without COVID-19 is sparse. From a physiological viewpoint, PP improves ventilation/perfusion (V/Q) matching and arterial oxygenation (Guérin et al., 2013). Secretion clearance could be enhanced in prone lying owing to the orientation of the airway (Dupont et al., 2016). Conversely, there is potential for endotracheal tube obstruction (Guerin et al., 2004, 2013; Taccone et al., 2009).

Between 1st February and 15th May 2020, 96 patients were positioned in prone lying whilst mechanically ventilated in our critical care unit (CCU), 7% ($n = 7$) were receiving extracorporeal membrane oxygenation (ECMO) and 3% ($n = 3$) had a tracheostomy in situ. Median (IQR) age was 57 (14) years and 75% ($n = 72$) were male. Twenty-seven (28%) patients received physiotherapy treatment whilst in prone on 48 separate occasions in total. This case study discusses a patient who received physiotherapy treatment whilst in prone. To our knowledge, this is one of the first reports of physiotherapy intervention in an intubated adult with COVID-19 positioned in prone.

2 | METHODS

This case study report follows the CARE case report guidelines. Informed consent was gained from next of kin for data to be published. This case report was deemed to not require ethical approval (NHS Health Research Authority, 2021).

2.1 | Patient information

A 59 year old gentleman was admitted to hospital with a 2-day history of fever, productive cough, myalgia, lethargy, and shortness of breath (SOB) at rest. He had a background of pernicious anaemia, nephrectomy, investigations for autoimmune myopathy, visual impairment, and previous traumatic cerebral haemorrhage. He was previously independent and lived with his family. He was not vaccinated against COVID as vaccines were not available at that time.

2.2 | Clinical findings

The patient was intubated and ventilated on day two of admission secondary to type I respiratory failure which progressed to type II respiratory failure early on during his admission. He was confirmed SARS-CoV-2 positive. Inhaled nitric oxide was trialled with limited success.

Physiotherapy intervention commenced on day four after admission with the patient in the supine position. Treatment was completed on 14 occasions over 12 days with the patient in the supine position. This consisted of expiratory vibrations, manual assisted cough, suction, and repositioning to aid V/Q matching and secretion clearance.

The patient underwent six episodes of prone positioning and received physiotherapy treatment during the last two episodes.

3 | TIMELINE

The patient timeline of events is shown in Figure 1.

3.1 | First physiotherapy intervention in prone

3.1.1 | Diagnostic assessment

This patient was ventilated on biphasic positive airway pressure (BiPAP) mode via endotracheal tube (ETT). Baseline respiratory, cardiovascular, and renal parameters prior to intervention are shown in Table 1. He was sedated on fentanyl, midazolam and propofol and paralysed on atracurium. He was not on any specific COVID-19 pharmacological treatment. His inflammatory markers and lactate were raised on blood chemistry results. On day 10, physiotherapy assessment identified reduced breath sounds throughout both lung fields most notably in the left lower lobe and an absent cough reflex. No tactile fremitus was present. Indications for physiotherapy intervention were reduced lung volumes, likelihood of secretion retention, V/Q mismatch and respiratory pump failure.

3.1.2 | Therapeutic intervention

Physiotherapy treatment included: mechanical insufflation-exsufflation (MI-E), expiratory vibrations, manual assisted cough, and closed suction with saline. MI-E was deemed to be clinically indicated because the patient had an absent cough reflex. The potential risk/benefits of disconnection and MI-E were discussed with the Critical Care Consultant and agreement was reached to proceed with treatment. The ETT was clamped prior to disconnection to prevent aerosolisation of SARS-COV-2. MI-E was administered using the NIPPY® Clearway (Breas Medical, Stratford-upon-Avon, UK) on manual mode. Pressures of MI-E delivered were, insufflation of

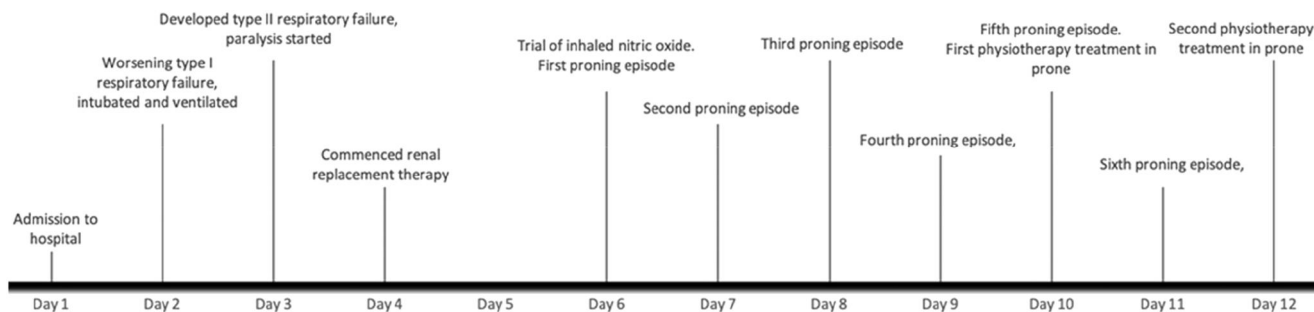


FIGURE 1 Patient timeline of events

TABLE 1 Baseline assessment parameters prior to the first and second physiotherapy intervention

Parameter	First physiotherapy intervention	Second physiotherapy intervention
P_{insp}	32 cmH ₂ O	32 cmH ₂ O
PEEP	12 cmH ₂ O	10 cmH ₂ O
V _{Te}	461 mls	394 mls
RR	28 breaths per minute	28 breaths per minute
MV	12.8 L/min	10 L/min
SpO ₂	96%	90%
FiO ₂	0.4	0.35
ABG	Uncompensated respiratory acidosis. Type II respiratory failure	Uncompensated respiratory acidosis
CXR	Basal airspace opacities	Bilateral patchy airspace opacification. No pleural effusion or pneumothorax
HR	103 bpm	117 bpm
MAP	79	68
Inotropic support	Noradrenaline	N/A
Temperature	Normothermic	Normothermic
Fluid balance	Positive	Positive

Abbreviations: ABG, arterial blood gas; bpm, beats per minute; CXR, chest x-ray; FiO₂, fraction of inspired oxygen; HR: heart rate; L/min: litres per minute; MAP: mean arterial pressure; MV, minute volume; P_{insp} , inspiratory pressure; PEEP, positive end expiratory pressure RR, respiratory rate; SpO₂, oxygen saturation measured by pulse oximetry; V_{Te}, expiratory tidal volume.

+35 cmH₂O and exsufflation of -45 cmH₂O with 15 L of oxygen entrained into the MI-E circuit. Oscillations were switched off. Three cycles of 3:1 (insufflation: exsufflation) were performed. Expiratory vibrations were applied after the completion of each insufflation. Thoracic manual assisted cough and saline suction were applied contemporaneously with exsufflation. Three physiotherapists were required to deliver the intervention. Expiratory vibrations are a combination of compression and oscillation of the chest wall applied during expiration (McCarren et al., 2006b). Thoracic manual assisted cough compresses the thoracic cage and was timed with suctioning and the exsufflation phase to optimise secretion removal. Two recruitment breaths at a pressure of +35 cmH₂O were delivered at the end of each cycle of MI-E. The patient was reconnected to the ventilator after each cycle. Minimal secretions were cleared. During the third cycle of MI-E, there was a transient drop in saturations to

90%. On reassessment, added sounds were heard on auscultation and it was documented secretions had moved proximally. The patient was reviewed later that day whilst in the supine position and received further treatment for secretion clearance.

3.2 | Second physiotherapy intervention

3.2.1 | Diagnostic assessment

On day 12 it was reported the patient desaturated the previous evening secondary to sputum plugging. The patient remained ventilated on BiPAP, baseline respiratory, cardiovascular, and renal parameters prior to intervention are shown in Table 1. He was sedated on fentanyl, midazolam, propofol, and paralysed on

rocuronium. Blood chemistry showed raised inflammatory markers. Physiotherapy assessment identified added sounds throughout both lung fields on auscultation, palpable fremitus bi-apically and absent cough reflex. Indications for physiotherapy intervention were loss of lung volume, secretion retention, V/Q mismatch and respiratory pump failure.

3.2.2 | Therapeutic intervention

A hypertonic (3%) saline nebuliser was given prior to physiotherapy treatment. It was noted that the patient had low oxygen saturations therefore FiO_2 was increased to 0.5 and closed suction was applied by the physiotherapist. When oxygen saturation levels had increased, treatment continued. Initially, three sets of 8–10 expiratory vibrations were applied bilaterally to the thoracic cage. The ETT was clamped prior to disconnection. MI-E was applied as per the previous pressure settings with a reduction in entrained oxygen to 10 L/min. Two cycles of 4:1 (insufflation: exsufflation) were performed. Expiratory vibrations were applied after the completion of each insufflation. Thoracic manual assisted cough and saline suction were applied simultaneously with exsufflation. Two recruitment breaths at a pressure of +35 cmH_2O followed each cycle. The patient was reconnected to the ventilator after the second MI-E cycle. Nil secretions were cleared but palpable fremitus remained. The exsufflation pressure was increased to –50 cmH_2O . Two further 4:1 cycles of MI-E, with expiratory vibrations, thoracic manual assisted cough and saline suction as detailed previously were performed, followed by two recruitment breaths after each cycle. A moderate amount of tenacious secretions were cleared. The patient was reconnected to the ventilator after the second MI-E cycle. Two further sets of three 4:1 cycles of MI-E, with insufflation and exsufflation pressures of +35 and –50 cmH_2O , respectively were completed, with expiratory vibrations, manual assisted cough, and saline suction. Two recruitment breaths were given following each MI-E cycle. The patient was reconnected to the ventilator after each MI-E cycle. Three physiotherapists were required to deliver the intervention. A moderate amount of tenacious secretions were cleared on the first set and minimal amount on the second set. On reassessment, harsh breath sounds remained throughout both lung fields, but palpable fremitus was reduced. Oxygen saturations remained stable throughout treatment.

4 | DISCUSSION

This case study highlights a critically ill intubated adult with COVID-19 pneumonitis who underwent physiotherapy treatment whilst in the prone position. Prone lying in our CCU is instigated when $\text{PaO}_2/\text{FiO}_2$ ratio is less than or equal to 13 kPa and is undertaken for at least 16 hours in line with the current evidence base (Bloomfield et al., 2015). Owing to the number of individuals adversely affected by COVID-19, a high number of patients were

positioned in prone on our CCU during the first wave of the pandemic.

There is a lack of information about physiotherapy treatment in intubated and ventilated adults with COVID-19. Interventions which require disconnection from the ventilator have been discouraged owing to the infection control risk of aerosolisation (Thomas et al., 2020). For this patient, the risks and benefits were discussed and considered in full by the multidisciplinary team to inform the decision to implement MI-E. Aerosolisation was minimised by clamping the ETT prior to any disconnection of ventilator tubing or MI-E circuit. ETT clamping is commonplace within our unit, thus staff were already trained and comfortable with this practice. Risk was further minimised as all staff wore appropriate personal protective equipment for aerosol generating procedures.

Variable amounts of secretions were cleared during treatment sessions. Numerous factors need to be met for secretion clearance to occur and different ventilator modes can embed or aid expulsion of secretions (Benjamin et al., 1989; Kim et al., 1987; Ntoumenopoulos et al., 2011; Volpe et al., 2008). A peak inspiratory to expiratory flow ratio >1.1, as seen in some clinical settings of BiPAP, has the potential to embed mucus (Ntoumenopoulos et al., 2011). This patient was on BiPAP prior to both treatment sessions commencing which may have impacted on the amount of secretions cleared. Expiratory vibrations and manual assisted cough were implemented in conjunction with MI-E to create and optimise expiratory flow bias in an attempt to overcome this (McCarren et al., 2006a; Shannon et al., 2010).

The use of hypertonic saline nebulisers may also have affected secretion clearance. Mucoactive agents aid expectoration of secretions and/or decrease hypersecretion. Their use in adult UK critical care units is reported to be high, with 83% of units utilising at least one agent (Borthwick et al., 2020). Justification for use in our CCU is the presence of tenacious secretions which cannot be cleared with airway clearance techniques alone. This rationale is echoed in a recent study exploring UK physiotherapy practice (Connolly et al., 2020). Despite high use, a recent systematic review and meta-analysis does not support the use of mucoactive agents in critically ill patients with acute respiratory failure, however it is noted the existing evidence base is of low quality (Anand et al., 2020).

The patient described here is representative of the population of COVID-19 treated by the physiotherapy team in our CCU with regard to demographic data and assessment findings. The treatment modality of MI-E in an intubated and ventilated patient in prone is of particular interest. In a recent survey of practice in the United Kingdom, MI-E was reported to be utilised by 53% of critical care physiotherapists when treating intubated patients, the presence of an ETT was highlighted as a barrier to MI-E use (Swingwood et al., 2020). Despite use of MI-E in intubated and ventilated adults being reported by just over half of physiotherapists surveyed, it is frequently utilised for this cohort of patients in our CCU. Indications for MI-E include secretion retention and a peak cough

flow <60 L/min, suggestive of an absent or ineffective cough (Smina et al., 2003). A growing evidence base for MI-E suggests it is safe, increases removal of secretions compared with manual techniques and manual hyperinflation and reduces re-intubation rates (Ferreira de Camillis et al., 2018; Gonçalves et al., 2012; Sánchez-García et al., 2018). Literature pertaining to use of MI-E in intubated patients in prone lying or in patients with COVID-19 is currently limited.

A transient adverse event, desaturation, was observed during the first physiotherapy intervention in prone. No adverse effects were noted during the second intervention. Fluctuations in physiological parameters and adverse changes have been demonstrated to occur spontaneously in the critically ill population (Shoemaker et al., 1989). Critical care audit data from Australia have demonstrated that adverse events are not linked with physiotherapy treatment in the non-COVID-19 critical care population (Beckmann et al., 2003). Similarly, a study carried out in five hospitals in Australia examining adverse events during physiotherapy found an incidence of only 0.2% (Zeppos et al., 2007). However, it is unknown if prone lying was utilised within the participating critical care units or if physiotherapists in these units routinely treat patients in this position.

The limited nature of this case study means findings may not be reflective of the wider picture and cannot be extrapolated. We recognise that treatment modalities that require disconnection from the ventilator will not be appropriate for all patients with or without COVID-19 and a thorough multidisciplinary risk assessment must be completed prior to any intervention. Outcome data for this patient was limited to information which is routinely recorded within clinical records and cost effectiveness of the intervention cannot be determined.

5 | CONCLUSION

The emergence of COVID-19 as a novel disease has expedited experiential learning for all involved in the care of this patient group. This case study describes a critically ill intubated adult with COVID-19 who received physiotherapy treatment for secretion clearance in prone lying. Physiotherapy treatment for this patient was achievable, although a transient adverse event in the form of desaturation was observed. Further investigation into safety, feasibility and efficacy is warranted to enhance the evidence base in patients with and without COVID-19 who undergo airway clearance techniques in prone lying.

5.1 | Implications for physiotherapy practice

Evidence regarding physiotherapeutic intervention in COVID-19 is in its infancy owing to the recent emergence of this disease. The paucity of literature regarding physiotherapy management for critically unwell patients in prone lying with and without COVID-19 is apparent.

This case study highlights that physiotherapy intervention in prone lying is achievable in a critically ill intubated adult with COVID-19. Furthermore, this patient had a secretion load which was amenable to physiotherapy treatment in the prone position. This initial foray will help to enhance future work on important aspects of this treatment modality and treatment in the prone position.

AUTHOR CONTRIBUTIONS

Leyla Osman and Chloe Apps prepared the manuscript. All authors contributed to manuscript revision and approved the final version for submission.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

ETHICS STATEMENT

This case report was deemed to not require ethical approval (NHS Health Research Authority, 2021).

CONSENT TO PARTICIPATE

Informed consent was gained from next of kin for data to be published.

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