Australian Critical Care xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Australian Critical Care

journal homepage: www.elsevier.com/locate/aucc

Case Study

Hydrotherapy for the long term ventilated patient: A case study and implications for practice

Sally Wegner*,
Dr Peter Thomas,
Christine James

Royal Brisbane and Women's Hospital, C/- Physiotherapy Department, Level 2 Ned Hanlon Building, Butterfield St and Bowen Bridge Rd, Herston, Brisbane, 4029 Queensland, Australia

ARTICLE INFORMATION

Article history:
Received 12 May 2016
Received in revised form 7 December 2016
Accepted 12 January 2017

Keywords:
Hydrotherapy
Mechanical ventilation
Critical care
Rehabilitation

ABSTRACT

Hydrotherapy of mechanically ventilated patients has been shown to be safe and feasible in both the acute stages of critical illness and in those requiring long term mechanical ventilation. This case study describes the hydrotherapy sessions of a 36 year old female, who after suffering complications of pneumococcal meningitis, became an incomplete quadriplegic and required long term mechanical ventilation. When implementing hydrotherapy with patients on mechanical ventilation a number of factors should be considered. These include staff resources and training, airway and ventilation management, patient preparation and safety procedures. Hydrotherapy can be safely utilised with mechanically ventilated patients, and may facilitate a patient's ability to participate in active exercise and rehabilitation.

1. Introduction

Rehabilitation of mechanically ventilated patients has been shown to be feasible and safe in the early stages of critical illness[1,2] and in patients requiring long term ventilation.[3] A variety of rehabilitation strategies are being trialled in order to limit the degree of weakness and functional decline that can occur with critical illness. While many of these involve land based exercise, hydrotherapy has also been utilised in patients requiring short-term or prolonged mechanical ventilation.[4–6] When immersed in the hydrotherapy pool, patients with severe weakness may demonstrate increased movement and may be able to attain more upright postures because of the effects of buoyancy on the weight of the trunk and limbs. By achieving increased range of movement in the water, patients may be motivated to increase their participation in hydrotherapy or other land based exercises and rehabilitation.[5] In addition to functional benefits, hydrotherapy has also been shown to improve the respiratory mechanics in ventilated patients through the effects of hydrostatic pressure.[7] The use of hydrotherapy as a rehabilitation strategy for mechanically ventilated patients is novel, and overall utilisation across international facilities is likely to be low. Limited or infrequent application of hydrotherapy in this population may expose patients to risk. This paper presents a case study of a patient requiring long term mechanical ventilation who completed hydrotherapy and outlines considerations for its safe implementation.

2. Case study

The following case study was reviewed and approved by the institution's Human Research and Ethics Committee. In addition, informed consent was provided by the patient. Ms C was a 36 year old female who developed pneumococcal meningitis following a trigeminal nerve decompression. This was further complicated by tonsillar herniation, posterior cerebellar infarct and spinal cord compression at the level of C1. Ms C had undergone two previous trigeminal nerve decompressions without complication but otherwise had no other significant medical history. Ms C was admitted to the 30 bed ICU of a tertiary hospital and remained there for 350 days before being transferred to the respiratory ward. While hydrotherapy sessions were planned during Ms C's ICU stay, early attempts were postponed due to her fluctuating respiratory function. Her first hydrotherapy session occurred after discharge from ICU, when Ms C was an inpatient on the respiratory ward. This session was 14 months after admission, in July 2015. By this stage Ms C had started to develop some motor return (Table 1). At this time she

* Corresponding author.
E-mail addresses: sally.wegner@health.qld.gov.au, wegn.s@hotmail.com (S. Wegner), peterj.thomas@health.qld.gov.au (P. Thomas), christine.james@health.qld.gov.au (C. James).

http://dx.doi.org/10.1016/j.aucc.2017.01.001
1036-7314/

Table 1
Muscle power (as assessed via manual muscle testing) at the time of the first hydrotherapy session.

Strength (1–5 scale)		
	Left	Right
Upper limb		
Shoulder flexion	4	2
Shoulder abduction	3	2
Elbow flexion	4	3
Elbow extension	4	3
Wrist flexion	4	3
Wrist extension	4	4
Lower limb		
Hip flexion	1	1
Hip extension	2	2
Hip abduction	2	2
Knee extension	3	3
Ankle dorsiflexion	1	1
Ankle plantarflexion	1	1

remained ventilator dependent (Philips Trilogy Ventilator) on Synchronised Intermittent Mandatory Ventilation — volume controlled and settings of 10×500 ml, PEEP 7 cm H_2O, PS 15 cm H_2O, FiO_2 0.21. Despite being able to initiate all breaths, all previous attempts at weaning off SIMV had failed due to fatigue and rising $C0_2$ levels. She had a size 8 Portex tracheostomy. Speech was generated using above cuff line voicing. Ms C had a percutaneous endoscopic gastrostomy (PEG) and had a supra-pubic catheter (SPC) in situ. Functionally, Ms C was wheelchair dependent, with transfers via hoist. Rehabilitation to date had included tilt table stands, facilitated stands, sitting balance, lower limb cycling using a Motomed and active assisted upper and lower limb exercises. She had functional use of her dominant arm and managed to feed herself, use an Ipad and clean her teeth, but remained fully dependent for all cares.

Hydrotherapy as a possible rehabilitation option was first discussed with the patient's Respiratory Consultant. Approval was given by the Consultant for the patient to attend hydrotherapy with the physiotherapy staff alone. Informed consent was verbally obtained from the patient and each session was documented in the medical chart.

3. Patient preparation

Ms C's preparation included organising the attachments, establishing a suitable time to attend the session and completing her airway clearance routine. The above cuff line voicing was disconnected. The PEG and SPC were made waterproof using stoma bags (Dansac Nova 1 fold up stoma bags). Ms C's bowel routine was then monitored over several days in order to time the sessions around this and minimise the chance of bowel movements occurring during hydrotherapy. A standard pad was also donned under her swimsuit. When wearing a pad into the hydrotherapy pool, concealment with swimming shorts/togs is required. To minimise the need for suctioning during the hydrotherapy session, chest physiotherapy was provided just prior to leaving the ward, and the patient was suctioned immediately prior to entering the water.

Ventilation equipment used for Ms C whilst in the pool included a Mapleson A circuit for manual hyperinflation. This circuit was chosen as it is most commonly used by physiotherapists for airway clearance. An air viva circuit also accompanied the patient during the transfer to the pool in case of ventilator failure and/or issues with the oxygen cylinder developed. A portable suction unit was taken with Ms C for transport to and from the ward and kept at the pool edge should she require airway clearance during the session. Oxygen for manual ventilation was provided through a wall outlet located in the pool area. Oxygen tubing was reinforced with tape at each connection to prevent inadvertent disconnections. Additional oxygen tubing, oxygen tube connectors, an additional Mapleson A circuit and normal saline to flush the inline suction catheter were also taken.

While Ms C was apprehensive about her first hydrotherapy session, reassurance was provided by staff and by a family member who was in attendance. The family was invited to attend as they highly appreciate the hydrotherapy sessions[4] and often provide good moral support and encouragement. Ms C was also heavily involved in the planning and communication with the assembled team. In this facility, the young children of a previous patient have also been able to swim and interact with their mother during hydrotherapy sessions.[6] In addition to rehabilitation this provided a positive "outing" for the family away from the intensive care unit.

4. Transport and transfers

To transfer down to the pool, Ms C was first transferred into a Transmotion chair via a pat slide with slide sheet transfer. To enter the pool, Ms C was then transferred onto a reclined trolley that attached to a fixed pivoting hoist beside the pool. Once on the trolley, the ventilator was disconnected and from this point, the patient was manually ventilated.

Three staff entered the pool, whilst two remained on the pool deck. Two physiotherapists led airway management, one from in the pool and one from the pool deck. These physiotherapists are responsible for airway security and maintenance of ventilation during the hoist process. This is achieved by passing the manual ventilation circuit between them during the hoist process. Once Ms C was lowered into the pool, a flotation device was positioned under her head and her head and shoulders were supported at all times by a staff member. The SPC drainage bag was positioned on a kickboard allowing it to float. From this point, the other physiotherapist (who was managing the ventilation outside the pool), entered the pool and assisted to float Ms C off the hoist trolley. This process was reversed on completion of the pool session to return Ms C to her chair. Patients should be wrapped in blankets as soon as possible and promptly returned to the ward.

5. Hydrotherapy session activities

For Ms C, hydrotherapy sessions were focussed around three positions, floating, supported sitting and supported standing in front of a secure rail (http://dx.doi.org/10.1016/j.aucc.2017.01.001). These positions were chosen as they allowed active range of the upper and lower limbs to be practised and facilitated trunk and lower limb muscle activation in a supported and less fatiguing environment.

During Ms C's first hydrotherapy session, exercises were completed only in the supine position, allowing her to accommodate to the water and processes involved to enter the pool and to create a feeling of safety. In supine, upper and lower limb reaching to targets was practised. Initially floats were used to support the limb and movements were in the coronal plane (Image 2). The floats were later removed as it allowed Ms C more freedom to move and she found it to be emotionally rewarding to move without the assistance of a therapist or device. Cycling and kicking exercises were also included into the supine program.

Supported sitting was used to achieve functional upper limb exercises. Ms C practised reaching with alternate hands and then gripping the bar whilst she performed lower limb exercises. This position also facilitated trunk muscle activation as the therapists provided the base for her to sit on, but challenged her to support her trunk as much as possible. Finally, standing at the rail was included

Please cite this article in press as: Wegner S, et al. Hydrotherapy for the long term ventilated patient: A case study and implications for practice. *Aust Crit Care* (2017), http://dx.doi.org/10.1016/j.aucc.2017.01.001

for lower limb activation and trunk activation, but also because of the joy it gave MS C and the interaction she could have with the staff when in this position. Mini squats and single leg marching were often included. In each position, buoyancy was used to facilitate different movements, often increasing Ms C's independence with the tasks, compared to when the same tasks were repeated out of the water. This increase in function provided additional motivation for Ms C to continue her therapy.

6. Staffing requirements and training

Hydrotherapy for ventilated patients is resource intensive. This facility required five staff members to be present. The team was to consist of a minimum of three physiotherapists and the remainder, therapy assistants. Local policy mandates that all staff are to complete hydrotherapy competencies which encompass emergency response and evacuation procedures. All physiotherapists must be familiar with the ventilator and competent in manual hyperinflation and suctioning. The physiotherapy team's knowledge and skills must include hydrotherapy and rehabilitation principles, but a senior cardiorespiratory physiotherapist is required for ventilator and airway management. One staff member remains out of the pool at all times as an observer and in order to initiate emergency call responses if required. Each hospital must consider the skill set of the available staff and whether additional team members such as nursing, medical staff and/or anaesthetic technicians are needed in the team.

7. Safety considerations

A number of safety considerations and emergency response plans must be addressed prior to the first hydrotherapy session. Safety considerations should centre on the medical stability of the patient, maintenance of ventilation during hydrotherapy, the number of staff required to transfer and treat the patient and the emergency equipment available and procedures to be undertaken if deterioration occurs.

On the day of each planned hydrotherapy session, the patient should be reviewed for their medical stability, particularly their respiratory and cardiovascular status. In our facility, hydrotherapy would not be considered for ventilated patients who are still receiving sedation or cardiovascular support.

Ms C accessed a 10×18 m hydrotherapy pool (34 °C) that was located on a lower level of the hospital building in which she resided. The hospital's medical emergency response team (MERT) serviced this area. An emergency resuscitation trolley was permanently located next to the hydrotherapy pool and included a portable suction unit, air viva and size C portable oxygen cylinder. When consent was given to attend hydrotherapy, the treating medical staff members were briefed on planned safety considerations.

8. Discussion and implications for practice

While hydrotherapy is possible in patients with either an endotracheal tube or tracheostomy,[4] patients requiring long term ventilation will more likely have a tracheostomy in-situ. Airway management is critical when undertaking hydrotherapy with ventilated patients and planning must consider airway safety and security and ventilation methods. Risks to the airway include ventilator disconnection or aspiration of pool water through incorrect positioning or support by staff.[4] During transfers and throughout the hydrotherapy session, two staff members must be dedicated to airway safety and security. When in the water, one therapist must support the head and shoulders of the patient and have direct visualisation of the ETT/tracheostomy site to ensure it is maintained above the water. Even in the shallow end of the hydrotherapy pool (1.15 m deep), this role is usually allocated to taller staff members. The second therapist is responsible for airway security by supporting the airway and ensuring equipment used to maintain ventilation is intact (Image 1).

Image 1. Patient set up in the supine position.

Image 2. Completing arm exercises in the supine position.

For any patient, with or without ventilatory support, consideration must be given to the effects hydrotherapy and water immersion have on respiratory function. While graded immersion in water is often thought to progressively reduce vital capacity, the effect of immersion on lung function can be different in patients with neurological conditions or respiratory muscle dysfunction when compared to normal subjects.[8] For example, patients with tetraplegia may actually experience improved respiratory function (slow vital capacity, FVC and FEV_1) during immersion in warm water.[7] Ventilation during hydrotherapy can be maintained through the portable ventilator[4] or delivered through manual bag-valve ventilation. For Ms C, manual ventilation was chosen as it offered a number benefits over the ventilator circuit. Firstly, it offered a longer circuit via oxygen tubing which minimised inadvertent tensioning of the ventilation circuit and allowed the patient and therapists to move more easily through the pool to trial different exercises. Additionally, it allowed staff to closely monitor the patient's respiratory demand, and adjust ventilation according to any increase in demand generated by the exercises. Application of

Please cite this article in press as: Wegner S, et al. Hydrotherapy for the long term ventilated patient: A case study and implications for practice. *Aust Crit Care* (2017), http://dx.doi.org/10.1016/j.aucc.2017.01.001

a speaking valve or Swedish nose could be considered for spontaneously breathing tracheostomy patients. Additional support and flotation devices may be required under the head and shoulders to eliminate the risk of water entering these devices. Throughout the hydrotherapy sessions, work of breathing was monitored through subjective and objective measures. Ms C was regularly asked to rate her perceived work of breathing. Her respiratory rate and saturation levels were also checked periodically.

Hydrotherapy for patients with weakness or neurological impairments can involve a range of activities in different body positions, using the water to assist or resist movement. For long term ventilated patients with marked ICU acquired weakness, movements are often in the supine position, but can include activities in sitting and standing, walking and swimming (e.g. backstroke).[4] As demonstrated in the video attachment, Ms C was able to transition from supine exercises with flotation devices, to more active exercises in sitting and standing.

Hydrotherapy can be implemented in patients who are mechanically ventilated. Careful planning is required for effective and safe implementation. In detailing the experiences of one patient's hydrotherapy sessions, this paper has provided the necessary information on equipment and patient preparation to enable and guide other therapists to safely and effectively complete hydrotherapy sessions with other mechanically ventilated patients.

Funding

No financial support was received for the completion of this case study.

Authors' contributions

Each author participated in the hydrotherapy sessions with the patient and assisted in the review of the content of the article. We all agree on the final version of the article for submission and all agree to be accountable for all aspects of the work.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.aucc.2017.01.001.

References

1. Schweickert WD, Pohlman MC, Pohlman AS, Nigos C, Pawlik AJ, Esbrook CL, et al. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. *Lancet* 2009;**373**:1874–82.
2. Needham DM, Korupolu R, Zanni JM, Pradhan P, Colantuoni E, Palmer JB, et al. Early physical medicine and rehabilitation for patients with acute respiratory failure: a quality improvement project. *Arch Phys Med Rehabil* 2010;**91**:536–42.
3. Thomsen G, Snow G, Rodriguez L, Hopkins R. Patients with respiratory failure increase ambulation after transfer to an intensive care unit where early activity is a priority. *Crit Care Med* 2008;**36**:1119–24.
4. Felten-Barentsz KM, Slutsky AS, Heunks LM. Feasibility and safety of hydrotherapy in critically ill ventilated patients. *Am J Respir Crit Care Med* 2015;**191**:476–7.
5. Taylor S. The ventilated patient undergoing hydrotherapy: a case study. *Aust Crit Care* 2003;**16**:111–5.
6. Edmistone L. Paralysed policewoman Melissa may be able to go home. *Courier-Mail (Brisbane)* 2004;(May) [col. 1].
7. Thomaz S, Beraldo P, Mateus S, Horan T, Cerqueira Lea J. Effects of partial isothermic immersion on the spirometry parameters of tetraplegic patients. *Chest* 2005;**128**:184–9.
8. Leal JC, Mateus SR, Horan TA, Beraldo PS. Effect of graded water immersion on vital capacity and plasma volume in patients with cervical spinal cord injury. *Spinal Cord* 2010;**48**:375–9.

Please cite this article in press as: Wegner S, et al. Hydrotherapy for the long term ventilated patient: A case study and implications for practice. *Aust Crit Care* (2017), http://dx.doi.org/10.1016/j.aucc.2017.01.001