Feasibility and Safety of Hydrotherapy in Critically Ill Ventilated Patients

To the Editor:

Early mobilization can improve outcomes in critically ill ventilated patients (1). Although preliminary data suggest that mobilization in a swimming pool (hydrotherapy) may enhance rehabilitation in very weak patients (e.g., congestive heart failure [2] and multiple sclerosis [3]) because of the reduced gravitational forces, there are challenges and potential safety issues when applied to ventilated patients. In this study, we report feasibility and safety of hydrotherapy in critically ill, ventilated patients.

In 2010, the 35-bed adult intensive care unit (ICU) of the Radboudumc hospital implemented a slightly modified Morris early mobilization program (4). In 2012, a dedicated pool (maximum depth, 1.35 m; total volume, 30 m^3) with a movable floor became available. Ventilated patients admitted to the medical, surgical, or thoracic ICU were eligible for hydrotherapy if they were severely weak (inability to stand upright despite support by physiotherapist) and were able to respond to verbal commands. Exclusion criteria included high ventilator support (fractional inspired oxygen $>$ 0.6; positive end expiratory pressure $>$ 10 cm H_2O; inspiratory support $>$ 15 cm H_2O), vasopressors, large wounds, severe agitation, and colonization with multiresistant bacteria. Patients and primary decision makers were informed about the novelty of the therapy and potential complications. Formal informed consent was waived by the Radboudumc ethics committee.

Patients were screened prospectively for eligibility. Before hydrotherapy, any central venous catheters (internal jugular vein) and arterial catheters (radial artery) were disconnected and covered with transparent dressing (Tegaderm; 3M, St. Paul, MN) and secured with elastic bandage (Elastomul, Hamburg, Germany). During transfer and hydrotherapy, patients were ventilated with a portable ventilator (LTV 1000; Carefusion, San Diego, CA), using pressure support mode. Pulse oximetry and heart rate were monitored using a handheld device with finger clip during transport, and during hydrotherapy the pulse oximeter was used only as needed, based on clinical judgment. An individualized program for hydrotherapy was designed for each patient and could include standing, walking, moving upper extremities, and back stroke swimming. The mobility team included two ICU nurses, a physical therapist, and a physician.

The following adverse events were reported prospectively: tachycardia ($>$100 bpm), bradycardia ($<$60 bpm), peripheral oxygen saturation lower than 90% while on ventilator, and accidental removal of arterial catheters, central venous catheters, or artificial airway. To assess water quality, samples were obtained twice daily for biochemical analysis (chloride and pH) and at least once per month for cultures, according to Dutch law (5).

Between July 2012 and October 2013, a total of 3,686 patients were admitted to our ICU. After excluding patients admitted after elective uncomplicated surgery and all patients admitted to the neuro-ICU, 259 patients were evaluated for hydrotherapy. Twenty-five patients received at least one hydrotherapy session in addition to the regular early mobilization program. Reasons for not receiving hydrotherapy were failure to meet inclusion criteria (mostly not being severely weak) or meeting exclusion criteria and limited availability and logistical reasons. Total duration of one hydrotherapy session was approximately 60 minutes, including briefing, transportation to the pool, patient preparation at poolside, hydrotherapy, showering, and transportation back to the ICU. The movie shows a representative patient during hydrotherapy (*see* Movie E1 in the online supplement). Reasons for ICU admission and other patient characteristics are given in Table 1.

Five patients died while in the ICU. In four patients, active treatment was withdrawn on the patient's request. In one patient, further treatment was deemed futile because of metastatic carcinoma not responding to chemotherapy. No complications as defined here were reported during transport or hydrotherapy. In the study period, microbiological analysis was performed 17 times. Biochemical and microbiological analysis of pool water demonstrated that water quality met standards as dictated by the Dutch law at all times (Table 2) (5).

The duration of each hydrotherapy session was determined by the physiotherapist, based on the development of fatigue. None of the sessions was discontinued because of safety issues or adverse events. Although not systematically analyzed, patients and their loved ones highly appreciated the hydrotherapy sessions. None of the patients refused subsequent hydrotherapy sessions.

This is the first report describing the feasibility and safety of hydrotherapy in critically ill mechanically ventilated patients. The most important finding is that hydrotherapy appears to be safe in a selected group of ventilated ICU patients. It should be acknowledged

Table 1. Patient Characteristics at Admission and during First Hydrotherapy Session

N	25
Male, %	72
Age, yr	61 ± 16
Body mass index, kg/m^2	26 ± 5
Cardiovascular failure, %	16
Septic shock, %	16
Mean APACHE-2	19 ± 5
Mortality, %	20
First hydrotherapy session	
Time on ventilator, d	33 ± 25
Tracheostomy, %	76
PEEP, cm H_2O	6.7 ± 1.7
$F_{I_{O_2}}$	0.40 ± 0.03
Sp_{O_2}, %	97.8 ± 1.9*
$Pa_{O_2}/F_{I_{O_2}}$ ratio, mm Hg	260 ± 72†
Arterial catheter, %	80
Central venous catheter, %	16
Foley catheter, %	100

Definition of abbreviations: APACHE = Acute Physiology and Chronic Health Evaluation; $F_{I_{O_2}}$ = fractional inspired oxygen; Pa_{O_2} = partial pressure of oxygen in arterial blood; PEEP = positive end expiratory pressure; Sp_{O_2} = pulse oximeter oxygen saturation.
Variables are mean ± SD. Cardiovascular failure was defined as cardiac failure as primary reason for intensive care unit admission. Septic shock was defined as meeting the systemic inflammatory response syndrome criteria, evidence for infection, hypotension despite adequate fluid administration, and organ failure.
*Missing value: 1.
†Missing value: 6.

This letter has an online supplement, which is accessible from this issue's table of contents at www.atsjournals.org

Table 2. Characteristics of the Hydrotherapy Sessions and Water Quality

Duration per session, mean (range), min	29.6 (15–40)
Type of exercises*	
Movements in supine position	72%
Swimming (back stroke)	12%
Seated position	36%
Standing position	64%
Walking	56%
Rate of complications (95% confidence interval)	0% (0–4.1%)
Number of sessions during intensive care unit stay	
Total	88
Median (interquartile range)	2 (1–3)
Mean (range)	3.5 (1–20)
Microbiological screening of pool water (17 samples in 15 mo)	
Coagulase-negative *Staphylococcus*	2 (1 and 2 cfu)
Gram-negative rods, not *Pseudomonas*	2 (43 and 27 cfu)
Nonfermative gram-negative rods	3 (51, 22, and 55 cfu)

*Exercises could be combined during one session.

that hydrotherapy was performed in a university hospital with extensive experience with early mobilization in ICU patients. No patient reported discomfort or exhibited severe oxygen desaturation or hemodynamic instability. No interventions were needed to improve hemodynamics.

In addition to immediate complications, transmission of infections through contaminated water was an initial concern. However, microbiological screening of pool water did not reveal any relevant contamination.

In conclusion, hydrotherapy appears to be a feasible and safe intervention in selected critically ill ventilated patients. Future studies are needed to evaluate potential clinical benefits and cost-effectiveness. ■

Author disclosures are available with the text of this letter at www.atsjournals.org.

Acknowledgment: The authors thank Peterpaul Mazure, P.T. (Radboud University Medical Centre, Nijmegen, The Netherlands) and his colleagues for the application of the hydrotherapy. They did not receive compensation for their contribution. The authors also thank Joanne Postma for the voiceover in the video.

Karin M. Felten-Barentsz, P.T., M.Sc.
Antonius J. C. Haans, R.T.
Radboud University Medical Centre
Nijmegen, The Netherlands

Arthur S. Slutsky, M.D.
St. Michael's Hospital
Toronto, Ontario, Canada
and
University of Toronto
Toronto, Ontario, Canada

Leo M. A. Heunks, M.D., Ph.D.
Johannes G. van der Hoeven, M.D., Ph.D.
Radboud University Medical Centre
Nijmegen, The Netherlands

References

1. Schweickert WD, Pohlman MC, Pohlman AS, Nigos C, Pawlik AJ, Esbrook CL, Spears L, Miller M, Franczyk M, Deprizio D, *et al*. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. *Lancet* 2009;373: 1874–1882.
2. Cider A, Schaufelberger M, Sunnerhagen KS, Andersson B. Hydrotherapy—a new approach to improve function in the older patient with chronic heart failure. *Eur J Heart Fail* 2003;5: 527–535.
3. Kargarfard M, Etemadifar M, Baker P, Mehrabi M, Hayatbakhsh R. Effect of aquatic exercise training on fatigue and health-related quality of life in patients with multiple sclerosis. *Arch Phys Med Rehabil* 2012;93: 1701–1708.
4. Morris PE, Goad A, Thompson C, Taylor K, Harry B, Passmore L, Ross A, Anderson L, Baker S, Sanchez M, *et al*. Early intensive care unit mobility therapy in the treatment of acute respiratory failure. *Crit Care Med* 2008;36:2238–2243.
5. Overheid.nl. Besluit hygiëne en veiligheid badinrichtingen en zwemgelegenheden [accessed 2014 Oct 13]. Available from: http://wetten.overheid.nl/BWBR0003716/geldigheidsdatum_13-10-2014

Early Peripheral Perfusion–guided Fluid Therapy in Patients with Septic Shock

To the Editor:

Septic shock remains the most frequent cause of death in patients admitted to the intensive care unit (ICU) (1). Careful titration of therapy is essential; undertreatment results in persistence of impaired tissue oxygenation, whereas overtreatment leads to a positive fluid balance that can result in pulmonary edema, prolonged mechanical ventilation, and finally death (2–6). Although peripheral perfusion alterations are stronger predictors of outcome than systemic hemodynamic variables in patients with septic shock, end points to guide volume resuscitation are still based on systemic parameters, and little is known about resuscitation guided by endpoints of peripheral tissue perfusion (7–9). We therefore undertook a proof-of-concept randomized controlled study comparing early goal-directed fluid resuscitation based on clinical assessment of peripheral perfusion with standard fluid therapy to investigate whether peripheral perfusion–guided resuscitation is feasible and would lead to less fluid administration in patients with septic shock. Some of the results of these studies have been previously reported in the form of an abstract (10).

Clinical trial registered with www.clinicaltrials.gov (NCT 01397474).

Author Contributions: M.E.v.G. conducted the study, analyzed and interpreted the data, and drafted the manuscript. N.E. assisted in conducting the study. R.J.P.v.d.V. assisted in analyzing the data and reviewed the final data. A.L. assisted in the design of the study and assisted in conducting the study and participated in data interpretation and statistical analysis. E.K. assisted in the design of the study and data interpretation. J.B. assisted with study design and manuscript preparation. J.v.B. conceived the study, participated in its design and coordination, and reviewed the manuscript. All authors read and approved the final manuscript.

This letter has an online supplement, which is accessible from this issue's table of contents at www.atsjournals.org