Virtual Reality in the Intensive Care Unit to improve Noninvasive Ventilation Tolerance: a case report

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Case Report

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Abstract

Purpose

This case report describes the use of virtual reality (VR) to improve noninvasive ventilation (NIV) tolerance in the intensive care unit (ICU).

Clinical Features

A 65-yr-old man was admitted to the ICU with hypercapnic respiratory failure resulting from an acute exacerbation of COPD. He had type-2 diabetes mellitus and post-smoking COPD but no history of psychiatric disease. Carbon dioxide narcosis required NIV and resulted in the recovery of normal consciousness. However, the tolerance and comfort of the patient during the 1-hour sessions repeated twice a day were moderate, leading us to propose virtual reality to improve his well-being. To combine VR with NIV, a Bridge-free NIV mask was necessary. The tolerability of NIV was significantly improved and the patient was very satisfied and enthusiastic, demonstrating the possibility of effectively combining VR with NIV to improve patient well-being.

Conclusions

This case paves the way to combine advantageously VR with NIV to improve the well-being of ICU patients.

Introduction

Noninvasive ventilation (NIV) is a life-saving intervention commonly used in the intensive care unit (ICU). NIV is effective to treat hypercapnic respiratory failure resulting from chronic obstructive pulmonary disease (COPD) exacerbation. NIV, compared with endotracheal intubation and mechanical ventilation, is associated with a reduced risk of pneumonia, lower mortality, and shorter ICU length of stay [1]. Unfortunately, patients requiring NIV often find this therapeutic intolerable because the facemask has been associated with discomfort, claustrophobia, and skin breakdown [2]. Therefore, intolerance to NIV may require escalation to tracheal intubation and mechanical ventilation. Although sedative drugs such as propofol or dexmedetomidine can improve compliance with NIV, they also can cause sedation, respiratory depression, hypotension, or bradycardia [3].

Virtual reality (VR) is a relatively new technique using head-mounted display to deliver immersive video and audio that enables interaction through tracking head and hand movements. In this way, the patient can experience combinations of visual and auditory stimuli that help immerse him or her in the computer-generated reality and create a sense of presence in the environment [4]. VR was demonstrated to be a useful technique to improve post-ICU mental health in sepsis survivors and could also be safely used and implemented in post-ICU care [5, 6]. Likewise, VR has been proven to be effective for treating pain [7], anxiety, and post-traumatic-stress-disorder [8].

We report the successful use of VR combined with NIV, using a novel under-nose mask design (F&P Visairo™), to improve comfort and tolerance in a patient suffering from an acute exacerbation of COPD.

Materials And Methods

The case

Mr. P., a 65-yr-old patient, was transferred to our ICU in March 2022 for hypercapnic respiratory failure resulting from an acute exacerbation of COPD. His medical history included type-2 diabetes mellitus, post-smoking COPD with active smoking estimated at 60 cigarettes/day, and no psychiatric history. At home, the patient was not oxygen dependent. He was hospitalized in the ICU for acute respiratory distress complicated by impaired consciousness (GCS = 6). The arterial gasometry showed: pH = 7.21, PaCO2 = 95, PaO2 = 62 (with 4 l/min of O2 supply). The computed tomography chest concluded an infectious origin of the respiratory decompensation linked to the appearance of a small focus of condensation in the right lung base. The infection was treated with a bi-antibiotherapy based on cefotaxime and spiramycin, but no bacteria or virus was finally identified. Bronchial spasticity was treated with terbutaline, intravenous corticoids, and aminophylline. Carbon dioxide narcosis required NIV and resulted in the recovery of normal consciousness. However, the tolerance and comfort of the patient during the 1-hour sessions repeated twice a day were moderate, leading us to propose virtual reality to improve his well-being.

Virtual reality system

VR was provided using the Oculus Go™ headset (Fig. 1). In ICU setting, we needed VR content that would improve comfort and not require patients to turn their heads or move around to view important elements of the scene (since the virtual environment is by definition displayed at 360°). Previous studies have shown that viewing elements of nature promote physiological relaxation [9], reduces stress, improves mood [10], and enhances the recovery process following a stressful event [11]. For example, visualization of waterscapes has been associated with increased neural activation in the attention area of the brain [12]. After giving explanations and obtaining consent for the procedure, we asked the patient about his preferences regarding natural landscapes such as mountains, scuba diving with dolphins, drone flights over the sea or mountains. Finally, the patient's original choice was the observation of a Rocky Mountains movie shown in an artificial space station (Fig. 2). Relaxing music was coupled with the video. The 360-degree virtual landscape of the space station rotated with the participant's gaze, creating an immersive environment with the feeling of being inside the decor.

Noninvasive ventilation mask compatible with the VR-headset

In order to position the virtual reality headset, the use of a Bridge-free NIV mask was necessary (F&P Visairo™). This new mask eliminates nasal bridge breakdown and clears the way for an open field of vision, without compromising performance. VR was performed in a 30° recumbent position during a 60-

minute session. The session was performed in a visually vertical manner, with the horizontal axis reset to zero so that the horizon was in the center of the view [13]. Once the VR session was over, we removed the headset and asked the patient about their feelings.

Results

The primary outcome was the feasibility of the VR intervention coupled with NIV treatment in an ICU setting. The 60-minute session was completed without any problems or adverse events (no cyber-sickness, i.e. feelings of nausea and disorientation) [14]. The patient felt relaxed with drift into sleep at the end of the session [15, 16]. VR provided a feeling of privacy and escape from the ICU room. He was very enthusiastic ("great guys, the mountains reminded me of my trip to the USA in 2004"). Patient satisfaction with NIV treatment was assessed with the Visual Analogic Scale (self-assessed scale that ranges from 0 to 10, with 0 being the worst score and 10 being the best satisfaction) [17]. The patient rated his experience with NIV coupled with VR 10/10 (high satisfaction) as opposed to without VR with the same mask 5/10 (moderate satisfaction). He strongly wished to repeat the virtual reality experience. The patient was very enthusiastic about the novelty of the experience and would recommend it to all patients treated with NIV. Two days later, the patient was discharged from the ICU.

Discussion

To our knowledge, this is the first case study describing the feasibility of coupling VR with NIV to improve the patient experience in ICU. The patient described showed a considerable increase in satisfaction score concerning NIV treatment when coupled with VR. Interestingly, the relaxing effect of VR helped him sleep better after the session [15, 16]. The patient enjoyed the VR experiences.

In the field of psychology, VR is becoming an accepted treatment modality for many psychological disorders, related or not to the stressful ICU environment [15, 16, 18]. Previous studies have shown the beneficial effect of VR to improve the well-being of patients. The study of Ong and colleagues [16] showed that VR meditative intervention improved patients' ICU experience with reduced levels of anxiety and depression. In the same way, Lee and collegues [15] showed that a 30-minute virtual reality meditation may improve the quality of sleep of ICU patients. In post-ICU setting, Vlake and collegues [6] used VR to treat post-intensive care syndrome: they reported that VR was able to reduce post-traumatic stress disorder, depression scores and improve mental health status. The ICU is a noisy and busy place, with constant surveillance that leaves no room for privacy. Frightening memories and low satisfaction negatively impact psychological sequelae after critical care [19]. By diverting the patient's attention by immersing her/him in a more pleasant virtual universe, it becomes possible to solicit positive feelings through a non-pharmacological approach despite the stressful context of hospitalization in intensive care.

Although the current report does not provide absolute evidence, it shows the feasibility of using an innovative technology such as VR to improve psychological well-being during NIV treatment in ICU. In a

simple way, we used a qualitative analysis of the patient's experience instead of more complex scales, but time-consuming, that would have been less appropriate in the ICU setting [17]. Of note, we have opted for a personalized choice of VR theme and decor based on the patient's preferences. Therefore, a standard choice without adjustment to the patient's personality would likely have yielded less convincing results [17]. The psychologist's interaction with the patient may have had an effect on the patient's motivation and this therapeutic relationship may have improved satisfaction. Nevertheless, VR was emotionally evocative: the movie about the Rocky Mountains evoked a pleasant feeling of nostalgia in this patient. It was only the discussion prior to the VR session that allowed for a satisfying choice for the patient (for example, a film about the sea could have been experienced negatively by a person with a phobia of water, or with traumatic memories related to her/his life experience) [16].

In conclusion, the combination of VR distraction therapy with NIV is feasible and has the potential to improve psychological well-being in intensive care.

Declarations

Authors' contributions

Benoît Bataille and Jean-Christophe Iozzia have made substantial contributions to the design and interpretation of this case report. Jean-Christophe Iozzia has made substantial contributions to the technical support. Pierre Cocquet contributed to the concept of this case report. Benoît Bataille and Stein Silva have written the manuscript. All authors agree to the conditions outlined in the Instructions for Authors.

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Declaration of interests

We disclose no conflicts of interest, past or future, from all the authors. Our work has not been funded by any source in addition to our regular and independent salary. We have no financial interest in the subject, in the materials or equipment used in the manuscript, or its competitors. All authors are in complete agreement with the contents of the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Written consent prior to enrolment was obtained. The patient provides informed consent for publication of the image in Figure 1c.

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Figures

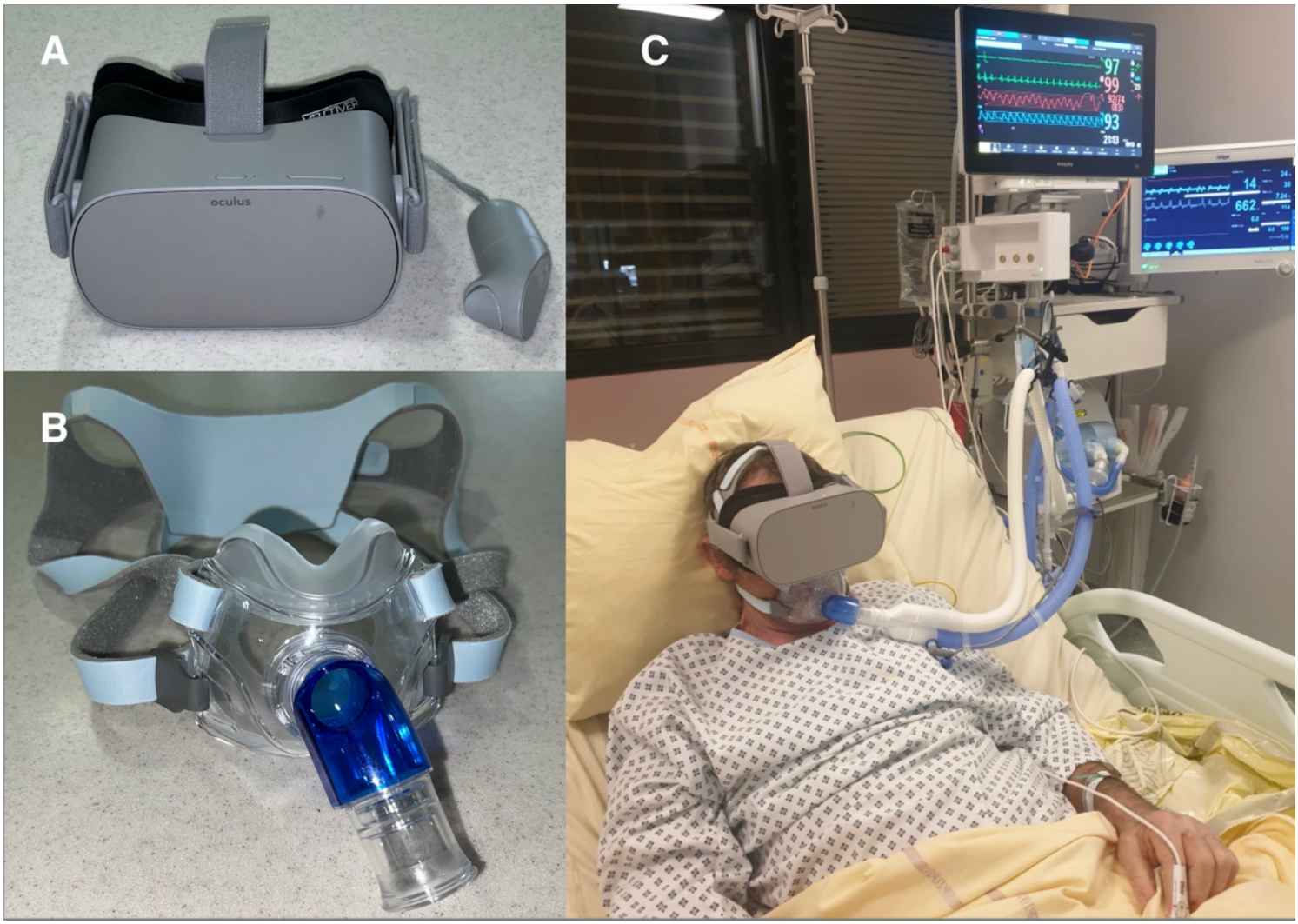

Figure 1

A: Virtual reality (VR) system; **B:** Bridge-free Noninvasive ventilation (NIV) mask; **C:** Patient with the VR-headset and NIV mask.

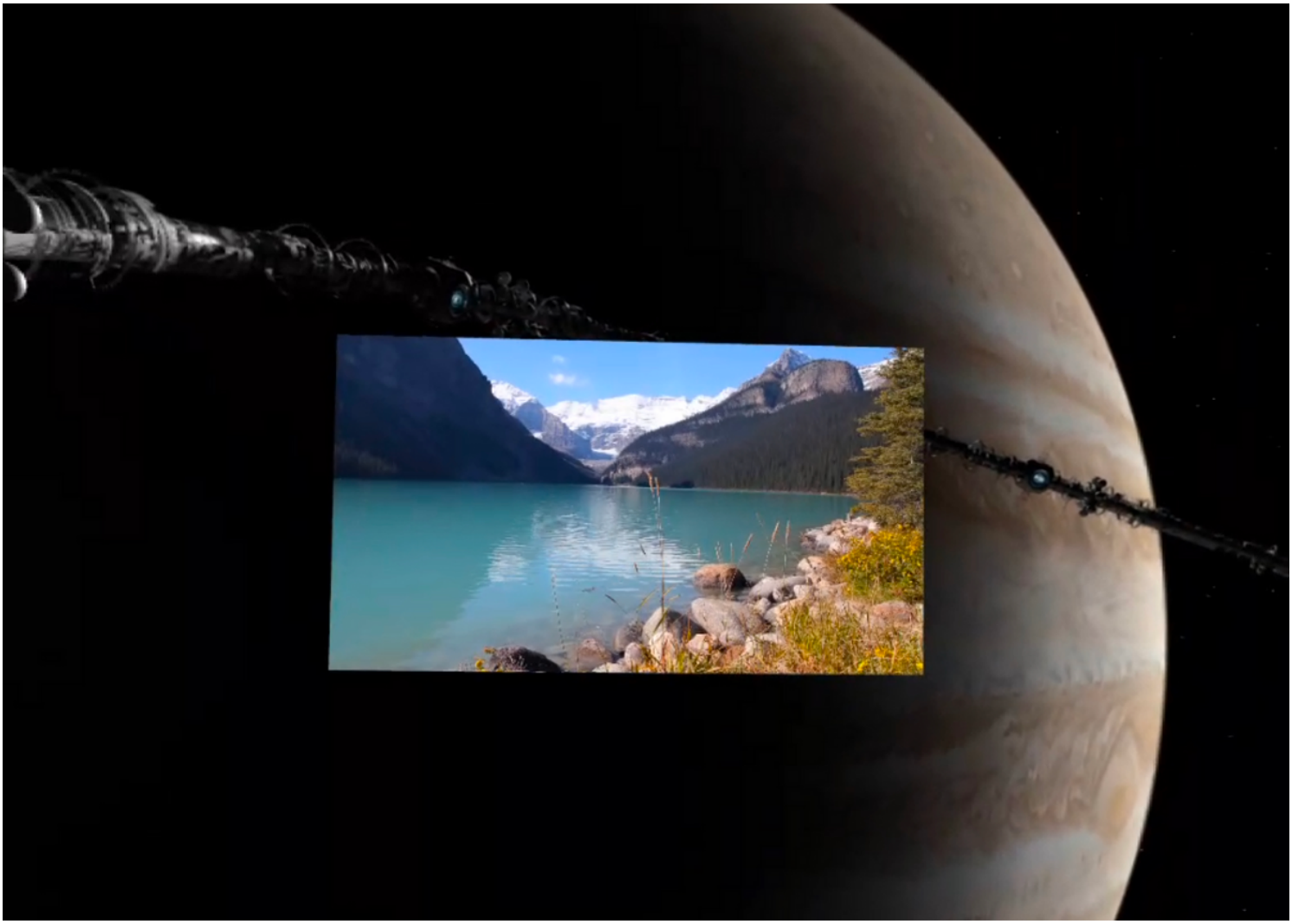

Figure 2

Screenshot of virtual reality environment.