Intensive Care Med (2022) 48:756–758
https://doi.org/10.1007/s00134-022-06686-1

LETTER

Time course of physiological variables during inter-hospital helicopter transport of ventilated COVID-19 patients

Ed J. Spoelder[1*], Jos Lerou[1], Ewald Bronkhorst[2], Geert-Jan van Geffen[1] and Cornelis Slagt[1]

Dear Editor,

During the coronavirus disease 2019 (COVID-19) outbreak in the Netherlands, a serious lack of intensive care unit (ICU) beds arose. ICU patients were distributed nationwide by ground-based Mobile Intensive Care Units. In addition, we used an EC-145 Airbus helicopter for long-distance inter-hospital transport, staffed by experienced Helicopter Emergency Medical Service anesthesiologists.

Clinical guidelines from the United Kingdom Intensive Care Society assert that, during helicopter transport, vibration and acceleration/deceleration forces significantly adversely affect patient hemodynamics and monitoring [1]. However, evaluation of the impact of helicopter transport on physiological variables is scarce [2] and frequent serial measurements are lacking. Accordingly, we undertook a prospective observational cohort study in mechanically ventilated patients with COVID-19 to determine whether changes in physiological variables occurred during helicopter transport.

Between March 2020 and March 2021, we measured invasive mean arterial blood pressure (MAP), arterial oxygen saturation (SpO_2), heart rate (HR) and end-tidal carbon dioxide partial pressure (P_{ET} CO_2) with 1-min intervals during transport. Three time spans were defined: the last 10 min before helicopter take-off (Tref), time spent airborne (Tair), and the first 10 min after landing (Tground). Tref served as reference for Tair and Tground. Our longitudinal study has the distinguishing feature that the physiological variables are measured numerous times on each patient. To account for the within-subject correlation of repeated measurements, we used generalized linear mixed-effects models. Such a model allows to analyse the effect of time span on the physiological response variables. Critical thresholds were defined for MAP, SpO_2 and HR [3, 4].

In 117 patients, we obtained a total of 32,664 measurements (8166 per variable) (Fig. 1). Supplementary Material shows details on transfers and patients.

Patients were airborne for 50 (SD = 15) min. During Tref, average MAP, SpO_2, HR and P_{ET} CO_2 were 84 (95% CI = 82–86) mmHg, 93.8 (93.5–94.2) %, 83 (79–87) bpm and 42 (40–43) mmHg, respectively. During Tair, these values decreased with 1.8 (1.2–2.5) mmHg, 0.2 (0.1–0.3) %, 1.7 (1.4–2.1) bpm and 1.4 (1.3–1.6) mmHg, respectively. All differences between Tref and Tair, and between Tref and Tground may be qualified as clinically irrelevant. This applies to the point estimates as well as to the entire range of the 95% confidence intervals (Table S3).

Potentially harmful events, such as MAP < 65 mmHg or SpO_2 < 90% for more than 5 min, occurred only in a minority of patients (Fig. S2). More importantly, these events were less likely to occur during the time spent airborne than on firm ground before take-off (Table S3). For Tair:Tref, odds ratios were 0.34 (95% CI = 0.26–0.43) and 0.23 (0.16–0.35) for MAP and SpO_2, respectively. For Tground:Tref, these odds ratios were 0.49 (0.35–0.68) and 0.21 (0.12–0.39).

No life-threatening complications occurred. The number of minor adverse events per hour was lowest during Tair (Table S4).

*Correspondence: Ed.Spoelder@radboudumc.nl
[1] Department of Anesthesiology, Pain and Palliative Medicine, Radboud University Medical Center, Nijmegen, The Netherlands
Full author information is available at the end of the article

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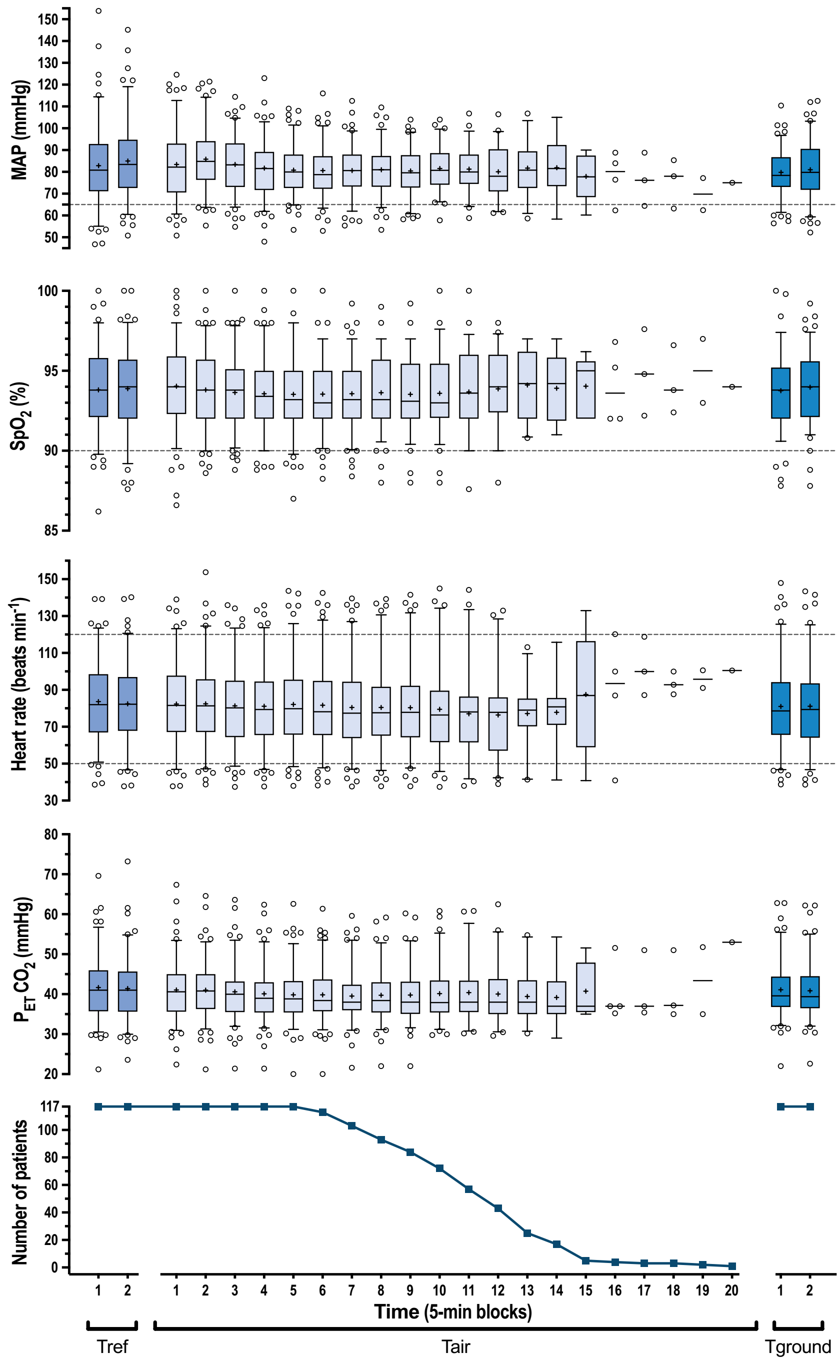

Fig. 1 Box-and-whisker plots for the measurements of mean arterial pressure (MAP), arterial oxygen saturation (SpO_2), heart rate (HR) and end-tidal carbon dioxide partial pressure (P_{ET} CO_2) obtained at 1-min intervals. Each box presents measurements averaged per patient over a 5-min time block. Three consecutive time spans used for statistical analysis are shown: the reference 10 min just before take-off (Tref), the time span when patients are airborne (Tair), and the first 10 min after landing (Tground). The number of patients (*N*) per 5-min time block declines with increasing time on board. Note that there is no time gap between Tref and Tair or between Tair and Tground. A box represents the 25th, 50th and 75th percentile, while a cross within the box is the mean. Whiskers denote the 5th and 95th percentiles. Outliers are plotted as individual points. If $N < 5$, only individual values and their median are plotted. $N = 1$ for the last time block in Tair (#20) of only 2 min. The horizontal dashed lines are the thresholds used to analyze the occurrences of MAP < 65 mmHg, SpO_2 < 90%, and HF < 50 beats min^{-1} or HR > 120 beats min^{-1}

In conclusion, being airborne aboard a helicopter had minimal and clinically irrelevant impact on the physiological variables, compared with the reference period prior to take-off. Noteworthy, a simulation study showed that variations in invasive blood pressure readings during accelerations or decelerations can be artifacts resulting from inevitable physical phenomena [5]. The time courses of physiological variables and absence of complications suggest that helicopter transport can contribute to safe inter-hospital transfers of ventilated COVID-19 patients. Although we cannot exclude that sicker patients may have been triaged away from air transport, our findings may be of relevance in deciding how to transport critically ill patients.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1007/s00134-022-06686-1.

Author details

[1] Department of Anesthesiology, Pain and Palliative Medicine, Radboud University Medical Center, Nijmegen, The Netherlands. [2] Department for Health Evidence, Radboud University Medical Center, Nijmegen, The Netherlands.

Acknowledgements

We would like to thank Hans van der Hoeven and Patrick Schober for their critical remarks on earlier versions of the manuscript.

Author contributions

All the authors have contributed substantially to the conception and design of the study, the acquisition of data, or the analysis and interpretation of the data. All the authors drafted or provided critical revision of the article. All the authors approved the final version submitted for publication. Detailed contributions: conception and design: ES, CS, GJG, JL, and EB. Data collection: ES, CS, and GJG. Analysis and interpretation of data: ES, GJG, JL, and EB. Critical revision of the manuscript for important intellectual content and approval of the final version to be published: all the authors.

Funding

None.

Data availability

All the data that support the findings of this study will be available from the corresponding author upon reasonable request.

Declarations

Conflicts of interest

The authors have no conflict of interest.

Compliance with ethical standards

Permission to use the data collected during this new operation was granted by the Medical Ethics Committee Arnhem-Nijmegen (file 2020-6822) on 29 July, 2020. Additional approval was granted 10 February 2021 (file 2021-7313) and 22 November 2021 (amendment date), including a waiver for informed consent.

Publisher's Note

Accepted: 18 March 2022
Published: 12 April 2022

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