# Intrahospital transportation of mechanically-ventilated COVID-19 patients: a cohort study

## Transporte intrahospitalario de pacientes con COVID-19 con ventilación mecánica: un estudio de cohort

The management of critically ill patients in the intensive care unit (ICU) requires investigations leading to numerous transports outside the unit.[1] Intrahospital transportation (IHT), defined as the movement of a patient from one physical location within the hospital to another, is one of the most frequently performed tasks in the care of ICU patients.[2,3] An emerging issue is the safety during IHT in ICU patients, especially those subjected to invasive mechanical ventilation (MV). Patients under MV are among the high-risk populations for IHT, with reported worsening of respiratory and other essential organ functions.[3–6] Various adverse events, including cardiopulmonary arrest, have been described during IHT.[2] During COVID-19 management, IHT is indicated in many situations, including radiologic images that could potentially change their management.[7] Conducting safe transportation of COVID-19 patients is therefore fundamental. The main objective of this study was to evaluate the incidence of major adverse event (AE) in IHT of severe COVID-19 patients, as well as the modifications in clinical parameters post-procedure.

A cohort study was conducted using retrospective data collected from June 2020 to April 2021 in an 800-bed tertiary hospital, including four clinical-surgical ICUs. All IHTs for diagnostic computerized tomography (CT) of patients who were hospitalized in ICUs and required transport to the diagnostic unit were analyzed. The study was approved by the local Ethics Committee (Plataforma Brasil number 66240017.0.0000.5530) and the requirement for informed consent was waived, and the confidentiality of individual patient data was preserved. All transports were carried out by a transport team consisting of an intensivist, nurse, and nursing technician, in a predefined transport protocol, that consists of the use of a transport monitor, a period of ventilatory stabilisation, a $FiO_2$ of 100% during transport, the assessment of the need for additional doses of sedatives, analgesics, or neuromuscular blockers (NMB), transport through the patient's own bed, and exclusive use of the transport route and elevator. Transport for the CT scan consists of a move between two floors, with the patient being transferred via their own ICU bed and using their own ventilator (Servo-air© or Servo-i© ventilator, Getinge AB, Sweden) or a transport ventilator (Drager Oxylog 3000 Transport Ventilator, Drager Germany). The total time between leaving the ICU and returning the patient was approximately 30 min.

Data were collected on the oxygenation index through the $PaO_2/FiO_2$ ratio; use of vasopressors before and after transport; need to start, combine, or increase sedatives, analgesics, or NMBs after transport; need for increased vasopressors after transport; and presence of an AE related to transport. AEs were divided into major and minor. Major AEs included death, cardiorespiratory arrest during transport or up to 6 h after the failure of devices involved with transport (MV, infusion pumps), and inadvertent removal of devices (tracheal tube, tracheostomy cannula, central venous access, arterial line, indwelling urinary catheter, or enteral tube). Minor AEs included desaturation ($SaO_2$ <90%), agitation, hypotension (new vasopressor or increase in vasopressor dose), or cardiac arrhythmias during or after transport. Continuous variables are presented as median and interquartile range, and categorical variables are presented as frequency and percentage. To compare continuous variables, the Wilcoxon test or Student's t-test was used for paired samples. Statistical significance was defined as $p < 0.05$. We used Jamovi 2.3.21.0 for all analyses.

In total, 170 patients were included in this study. The median SAPS 3 score was 68 points (56–77), and the SOFA score on the day of CT was 6 points.[4–8] The median age was 60 years (range, 50–67 years), and the male:female ratio was 63%:37%. Seventy transports (41%) were carried out in the time range between 11:59 pm and 8 am.

A total of 155 patients did not develop any AE. One patient had a major AE: mechanical ventilator malfunction during transport, requiring manual ventilation with the aid of an appropriate device. There were no occurrences of cardiorespiratory arrest, death, accidental extubation, or the pulling of other devices. As shown in Table 1, 15 patients (8.8%) presented with minor AEs, which were reversed with the established treatment.

The use of noradrenaline, as well as the $PaO_2/FiO_2$ ratio pre- and post-transport are described in Table 1. There was no difference in the median norepinephrine dose between pre- and post-transport, with a mean difference (MD) of 0 μg/kg/min (95% CI: -0.02, 0.02; $p = 0.84$). Patients who developed pre-transport AEs did not have a higher dose of noradrenaline compared to those who did not develop AEs: MD 0.01 μg/kg/min (95% CI −0.03–0.05; $p = 0.62$). Also, there was no difference in the $PaO_2/FiO_2$ ratio before and after transport (MD = 2; 95% CI −6–10; $p = 0.58$).

It is particularly challenging as patients move to an environment with a changed care setting, which carries the potential risk of deterioration of clinical parameters, equipment and facilities malfunction, and tubes and lines malfunction.[8] Despite this risk,[3] we demonstrated the safety of IHT with a relatively low incidence of AEs. Different definitions regarding a serious AE secondary to IHT, however, may lead to different incidences in the literature.[6] Our definition of AE is quite specific and may be one of the reasons for the incidence of AEs found. As it is a retrospective study,

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**Table 1** Prevalence of minor complications in the study.

| Complications | N |
|---|---|
| Hypoxemia | 9 (5%) |
| $PaO_2/FiO_2$ ratio pre-CT in patients who developed hypoxemia post-CT: median (IQR) | 128 (107–131) |
| $PaO_2/FiO_2$ ratio post-CT in patients who developed hypoxemia post-CT: median (IQR) | 106 (98–126) |
| New arrythmia | 2 (1%) |
| Psicomotor agitation | 4 (2%) |
| Pharmacological treatment after CT | |
| Increase in sedative dose | 19 (11%) |
| New sedative agent | 11 (6%) |
| Increase in analgesia dose | 14 (8%) |
| New analgesic agent | 6 (3%) |
| Increase in NMB drug dose | 2 (1%) |
| New NMB drug agent | 9 (5%) |
| Noradrenaline use | |
| Pre-CT | 65 (38%) |
| Median dose pre-CT (IQR) | 0.04 μ/kg/min (0–0.04 μ/kg/min) |
| Post-CT | 55 (32%) |
| Median dose post-CT (IQR) | 0.03 μ/kg/min (0–0.03 μ/kg/min) |
| Increase in vasopressor dose | 11 (6%) |
| $PaO_2/FiO_2$ ratio | |
| Median $PaO_2/FiO_2$ ratio pre-CT (IQR) | 168 (132–220) |
| Median $PaO_2/FiO_2$ ratio post-CT | 167 (126–213) |
| Measurement of $PaO_2/FiO_2$ ratio pre-CT (h): median (IQR) | 7 (3–13) |
| Measurement of $PaO_2/FiO_2$ ratio post-CT (h): median (IQR) | 8 (6–11) |

CT, computerized tomography; IQR, interquartile range; NMB, neuromuscular blocker.

the incidence of AEs may be underestimated when compared to prospective studies. Our study was carried out in a population at risk for AEs, due to the high incidence of hypoxemia, the need for vasopressors, and the need for multiple infusions of sedatives, analgesics, and continuous neuromuscular blockers. However, our cohort presents data similar to another study in the literature on oxygenation stability in patients undergoing IHT.[5] The IHT process requires an interdisciplinary approach, in an established protocol.[2] This fact may be a protective factor that minimises AE related to transport, such as equipment checks, patient preparation, and an experienced transport team.[1,4] Our results corroborate this hypothesis, suggesting that IHT is a safe procedure in this context, when carried out under the best patient safety practices, through structured preparation management for the procedure.

## Authors contribution

SFP, study design, review data, wrote the manuscript; PHRS, study design, ethics approval, review data; MGP, study design, review the manuscript; LSM, study design, review the manuscript; WN, study design, review data, wrote the manuscript.

## Ethics approval

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## References

1. Veiga VC, Postalli NF, Alvarisa TK, Travassos PP, da Silva Vale RT, de Oliveira CZ, et al. Adverse events during intrahospital transport of critically ill patients in a large hospital. Rev Bras Ter Intensiva. 2019;31(1):15–20.
2. Lin SJ, Tsan CY, Su MY, Wu CL, Chen LC, Hsieh HJ, et al. Improving patient safety during intrahospital transportation of mechanically ventilated patients with critical illness. BMJ Open Qual. 2020;9(2).
3. Schwebel C, Clec'h C, Magne S, Minet C, Garrouste-Orgeas M, Bonadona A, et al. Safety of intrahospital transport in ventilated critically ill patients: a multicenter cohort study. Crit Care Med [Internet]. 2013;41(8):1919–28. Available from: https://pubmed.ncbi.nlm.nih.gov/23863225/
4. Marx G, Vangerow B, Hecker H, Leuwer M, Jankowski M, Piepenbrock S, et al. Predictors of respiratory function deterioration after transfer of critically ill patients. Intensive Care Med [Internet]. 1998;24(11):1157–62. Available from: https://pubmed.ncbi.nlm.nih.gov/9876978/
5. Huq F, Manners E, O'Callaghan D, Thakuria L, Weaver C, Waheed U, et al. Patient outcomes following transfer between intensive care units during the COVID-19 pandemic. Anaesthesia [Internet]. 2022;77(4):398–404. Available from: https://pubmed.ncbi.nlm.nih.gov/35226964/
6. Jia L, Wang H, Gao Y, Liu H, Yu K. High incidence of adverse events during intra-hospital transport of critically ill patients and new related risk factors: a prospective, multicenter study in China. Crit Care [Internet]. 2016;20(1). Available from: https://pubmed.ncbi.nlm.nih.gov/26781179/
7. Yousuf B, Sujatha KS, alfoudri H, Mansurov V. Transport of critically ill COVID-19 patients. Vol. 46, Intensive Care Medicine. Springer; 2020. p. 1663–4.
8. Gimenez FMP, De Camargo WHB, Gomes ACB, Nihei TS, Andrade MWM, Valverde MLAFS, et al. Analysis of Adverse Events

during Intrahospital Transportation of Critically Ill Patients. Crit Care Res Pract. 2017;2017:6847124, http://dx.doi.org/10.1155/2017/6847124.

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## Before and after the first extracorporeal cardiopulmonary resuscitation due to accidental hypothermia in Spain

### Antes y después de la primera reanimación cardiopulmonar extracorpórea por hipotermia accidental en España

*Dear Editor:*

On November 3, 2019, a 34-year-old woman in cardiac arrest (CA) due to accidental hypothermia was transferred to Hospital Universitario Vall d'Hebron, Barcelona, Catalonia, Spain. The patient was rescued in the Pyrenees with an initial esophageal temperature of 19.4 °C, initial rhythm of asystole, cyanosis in acral parts, and bilateral unresponsive mydriasis. The first venous blood gas revealed: pH levels of 6.8, potassium levels of 4.6, and lactate levels of 10.3. A HOPE score of 88% was calculated, which led to the indication of extracorporeal life support (ECLS) with venoarterial extracorporeal membrane oxygenation (VA-ECMO) via ipsilateral right femoro-femoral surgical cannulation. After gradual rewarming at a rate of 3 °C/h, spontaneous circulation was restored after defibrillation once the central temperature exceeded 30 °C. The patient progressed favorably, which eventually led to removing ECMO support 45 h later. The patient was eventually discharged 11 days later with a Cerebral Performance Category of 1.[1,2]

To date, another case of CA due to accidental hypothermia resuscitated for 3 h had been published in *Medicina Intensiva* in Spain, but it was an in-hospital CA, and no previous experiences of extracorporeal cardiopulmonary resuscitation (ECPR) had ever been reported in these patients.[3]

The initially reported case represents the first successful resuscitation in Spain of an out-of-hospital CA patient due to accidental hypothermia and the longest resuscitation published nationally. Nearly 5 years after the accident, the patient is in excellent general condition. To evaluate functionality in activities of daily living, a Barthel test was performed which showed a score of 100/100. Additionally, a multidimensional quality of life test perceived by the person was performed too (the World Health Organization Quality of Life scale abbreviated – WHOQOL-BREF). A psychologist reviewed the test, which revealed a total score of 125/130 (10/10, general area; 34/35, physical; 26/30, psychological; 15/15, social; 40/40, environmental). These data demonstrate that recovery after such a long resuscitation has been complete and reintegration into a normal life in all areas has been successful.

In Catalonia, Spain more than 19,000 rescues have been reported in the natural environment since 2010, with almost 50% being mountain rescues.[4] In the past 2 decades, there have been other cases of CA due to accidental hypothermia. With the authorization of the ethics committee of hospital Arnau de Vilanova (CEIC-1308) and the analysis of the reports from the Mountain Intervention Unit of Mossos d'Esquadra and the Mountain Rescue Group of Bombers d'Andorra, all fatal accidents due to accidental hypothermia in the Pyrenees of Catalonia and Andorra from 2000 through 2024 have been compiled (Table 1). A total of 29 cases have been documented so far. Of these, 65.5% involved men, with a median age of 40 years (IQR, 35–48). A total of 48.2% of the cases occurred outside the winter season. The most practiced activity was ski mountaineering, followed by hiking, with most cases occurring in the Ripollés region (51.7%) and Val d'Aran (24.1%). No CPR measures were initiated in 69% of the victims, and only 4 victims (13.8%) were transferred to an ECMO center. Grouping data by number of reported accidents, a total of 17 accidents occurred (6 in winter, 5 in autumn, 4 in summer, and 2 in spring). These data indicate that 64.7% of the accidents occurred in non-winter seasons.

These results should warn us on the de-seasonalization of accidents due to accidental hypothermia and the need for careful evaluation of each case by personnel trained in hypothermia. Currently, hypothermia remains a poorly recognized entity with many biases in its assessment and management.[5] Without the presence of environmental cold or a triggering environment (high mountains, drowning, or snowy terrain), hypothermia can be difficult to suspect. However, hypothermia exists in our environment, both in rural and urban settings, and failing to consider it can lead to underdiagnosis. In turn, the most severe cases could be dismissed for transfer to an ECLS center due to lack of knowledge or protocols.

Some specific cases—like the one initially presented in this article—demonstrate the possibility of surviving an out-of-hospital CA due to accidental hypothermia despite the presence of typical markers of poor prognosis in normoth-

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