Time course of physiological variables during inter-hospital helicopter transport of ventilated COVID-19 patients: an observational cohort study using longitudinal data

Supplementary Material

Ed J. Spoelder, Jos Lerou, Ewald Bronkhorst, Geert-Jan van Geffen, Cornelis Slagt

Here we present the following supplementary material:

1) Flow chart of the transfer process (Fig. S1)
2) Eligibility criteria for a COVID-19 patient to be transported by helicopter (Table S1)
3) Clinical characteristics of inter-hospital helicopter transport (Table S2)
4) Impact of inter-hospital helicopter transport on physiological variables (Table S3)
5) Charts showing the individual episodes with MAP < 65 mmHg or with SpO_2 < 90% (Fig. S2)
6) Details on minor adverse events (Table S4)

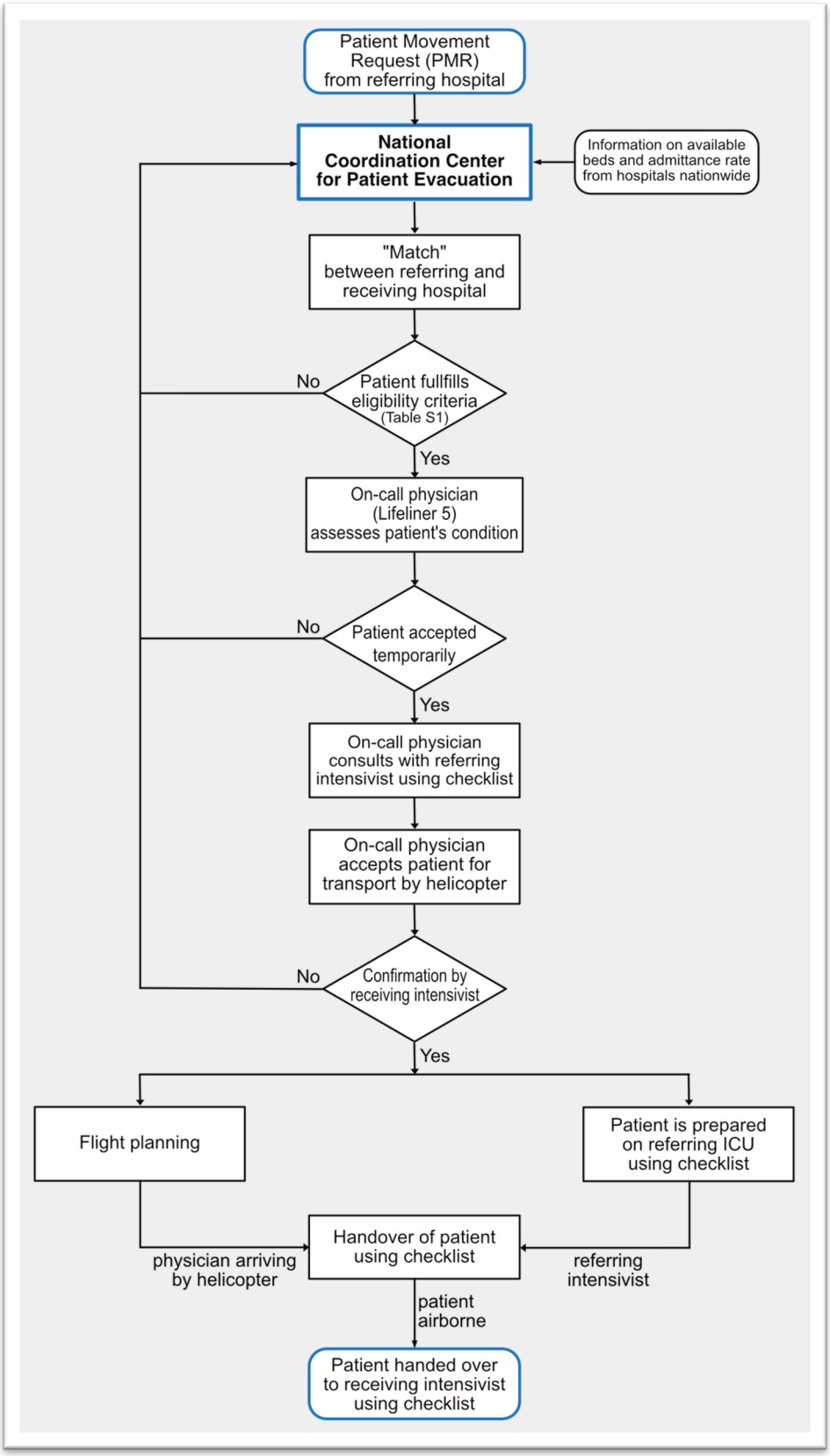

Figure S1. Flow chart of the inter-hospital transfer process. The National Coordination Center for Patient Evacuation[1] (known as LCPS = Landelijk Coördinatiecentrum Patiënten Spreiding) has been set up with help of the Dutch Ministry of Defense

[1] https://www.igh.com/post/a-look-inside-the-national-coordination-center-for-patient-evacuation-lcps (Accessed 27 October, 2021)

Table S1 Eligibility criteria for a COVID-19 patient to be transported by helicopter

General	distance for ground-based transport by a Mobile Intensive Care Unit exceeds 100 km
	risks of transport outweigh health benefits
Patient	has a tracheal tube or tracheostoma if mechanically ventilated
	is in supine position
	is deeply sedated according to the Richmond Agitation Sedation Scale (RASS), i.e., RASS is -4 or -5
	weighs preferably less than 135 kg [a]
	requires less than 2580 liters oxygen during the flight, i.e., the helicopter's maximum oxygen capacity
	has a clinical condition permitting eligible aeromedical transport
	does not depend on medical equipment other than a ventilator and a maximum of six syringe pumps

[a] at the discretion of the crew of the Helicopter Emergency Medical Service team

Table S2 Clinical characteristics of inter-hospital helicopter transport (n=117) (continued on next page)

Label		Mean[a] (SD) [minimum-maximum] or n (%)
Patient data		
	Age (yr)	63 (11) [23-82]
	Male	89 (76)
	Reported body weight (kg)	91 (17) [40-160]
	Body Mass Index (kg m^{-2})	30 (5) [16-49]
	Ideal body weight[b] (kg)	70 (10) [50-91]
	NACA[c] score 4 or 5	117 (100)
Sedation level		
	RASS[d] -4 or -5	114 (97)
	RASS -3	2 (2)
	RASS -2	0 (0)
	RASS -1	1 (1)
Ventilation		
Airway	Tracheal tube	110 (94)
	Tracheostoma	7 (6)
Mode	Pressure controlled	94 (80)
	Volume controlled	16 (14)
	Pressure support	7 (6)
Volumes and pressures	Tidal volume (mL)	463 (77) [280-775]
	Frequency (min^{-1})	22 (4) [14-32]
	Max. inspiratory pressure (cm H_2O)	24 (5) [13-36]
	PEEP (cm H_2O)	12 (3) [6-20]
	Tidal volume per kg reported BW (mL kg^{-1})	5.2 (1.3) [3.1-10.6]
	Tidal volume per kg ideal BW (mL kg^{-1})	6.5 (1.0) [4.4-9.9]
Oxygen	F_IO_2 (%)	50 (12) [30-90]

(continued on next page)

Table S2 (continued)

Label		Mean[a] (SD) [minimum-maximum] or n (%)
Sedatives		
	Propofol	30 (26)
	Midazolam	33 (28)
	Propofol / Midazolam	46 (39)
	Propofol / Clonidine	2 (2)
	Propofol / Midazolam / Clonidine	
	Midazolam / s-Ketamine	4 (3)
	Midazolam / Clonidine	1 (1)
	None	0 (0)
Opioid		
	Sufentanil	50 (43)
	Fentanyl	24 (20)
	Remifentanil	19 (16)
	Morphine	15 (13)
	Piritramide	2 (2)
	None	7 (6)
Vasopressor - Inotrope		
	Norepinephrine	102 (87)
	Norepinephrine / Isoprenaline	1 (1)
	Norepinephrine / Milrinone	1 (1)
	Dopamine	1 (1)
	None	12 (10)
Neuromuscular blocker		
	Rocuronium	46 (39)
	Atracurium	1 (1)
	None	70 (60)
Access to circulation		
Central venous	Jugular	88 (83)
	Subclavian	2 (2)
	Femoral	16 (15)
	None	11 (10)
Arterial	Radial	108 (93)
	Brachial	4 (3)
	Femoral	4 (3)
	Pedal	1 (1)
Syringe pumps		
	2	2 (2)
	3	9 (8)
	4	40 (34)
	5	38 (32)
	6	28 (24)

[a] n=117, except for body mass index (BMI), body weight (BW) as well as PEEP (n=114), inspired oxygen concentration (F_IO_2) (n=112) and volumes as well as pressures (n=92) because of missing values
[b] Ideal BW = 0.9079 × height – 88.022 for male and 0.9049 × height – 92.006 for female patients
[c] NACA = National Advisory Committee for Aeronautics
[d] RASS = Richmond Agitation and Sedation Scale

Table S3 Impact of inter-hospital helicopter transport on physiological variables of 117 ventilated COVID-19 patients

Mixed-Effects Linear Regression [a]					Mixed-Effects Logistic Regression [d]				
Response Variable	**Explanatory Variable**		**Estimate** [b]	**(95% CI)** [c]	***p*-value**	**Response Variable**	**Explanatory Variable**	**Odds Ratio** [e]	**(95% CI)** [c]	***p*-value**
MAP		Intercept	83.9	(82.1 ... 85.7)		**MAP < 65 mmHg**				
	Time						**Time**	Tref	1.000 (reference level)	
		Tair	-1.8	(-2.5 ... -1.2)	< 0.001			Tair	0.335 (0.260 ... 0.431)	< 0.001
		Tground	-3.5	(-4.3 ... -2.7)	< 0.001			Tground	0.486 (0.350 ... 0.675)	< 0.001
SpO_2		Intercept	93.84	(93.47 ... 94.22)		**SpO_2 < 90%**				
	Time						**Time**	Tref	1.000 (reference level)	
		Tair	-0.20	(-0.27 ... -0.13)	< 0.001			Tair	0.231 (0.155 ... 0.345)	< 0.001
		Tground	0.02	(-0.07 ... 0.11)	0.723			Tground	0.214 (0.119 ... 0.385)	< 0.001
HR		Intercept	83.0	(79.0 ... 87.1)		**HR < 50 min^{-1}**				
	Time						**Time**	Tref	1.000 (reference level)	
		Tair	-1.7	(-2.1 ... -1.4)	< 0.001			Tair	2.658 (1.450 ... 4.871)	0.002
		Tground	-1.9	(-2.4 ... -1.4)	< 0.001			Tground	3.400 (1.622 ... 7.130)	0.001
$P_{ET}CO_2$		Intercept	41.5	(40.3 ... 42.8)		**HR > 120 min^{-1}**				
	Time						**Time**	Tref	1.000 (reference level)	
		Tair	-1.4	(-1.6 ... -1.3)	< 0.001			Tair	1.921 (1.160 ... 3.184)	0.011
		Tground	-0.6	(-0.8 ... -0.4)	< 0.001			Tground	2.097 (1.103 ... 3.968)	0.024

[a] Mixed-effects linear regression estimates the relationship between one response variable and the explanatory variable 'time'. 'Time' is a factor with three levels: 1) reference level, i.e., the last ten minutes prior to take-off (Tref), 2) the time when patients are airborne on board the helicopter (Tair), and 3) the first ten minutes after landing (Tground)

[b] Estimates obtained for 'Intercept' are estimated values for average mean arterial pressure (MAP expressed in mmHg), arterial oxygen saturation measured by pulse oximetry (SpO_2 in %), heart rate (HR in bpm) and end-tidal carbon dioxide partial pressure ($P_{ET}CO_2$ in mmHg) during Tref

Estimates obtained for Tair and Tground are differences with the estimated values for Tref

Estimates were obtained with 'winsorization' if the residuals of the linear regression were not normally distributed. The estimates listed in the table are those obtained without winsorization as they were similar to those obtained with winsorization

[c] 95% CI = 95% confidence interval, given as (lower limit … upper limit) because of the occurrence of negative numbers

[d] Mixed-effects logistic regression estimates the association between each of the four binary response variables (MAP<65 mmHg, SpO_2<90%, HF<50 bpm and HR >120 bpm) and the explanatory variable 'time'

[e] Logistic models are structured such that an odds ratio < 1 indicates that the period Tair or Tground is associated with observing the binary response variable relatively less often than during Tref, which is favorable

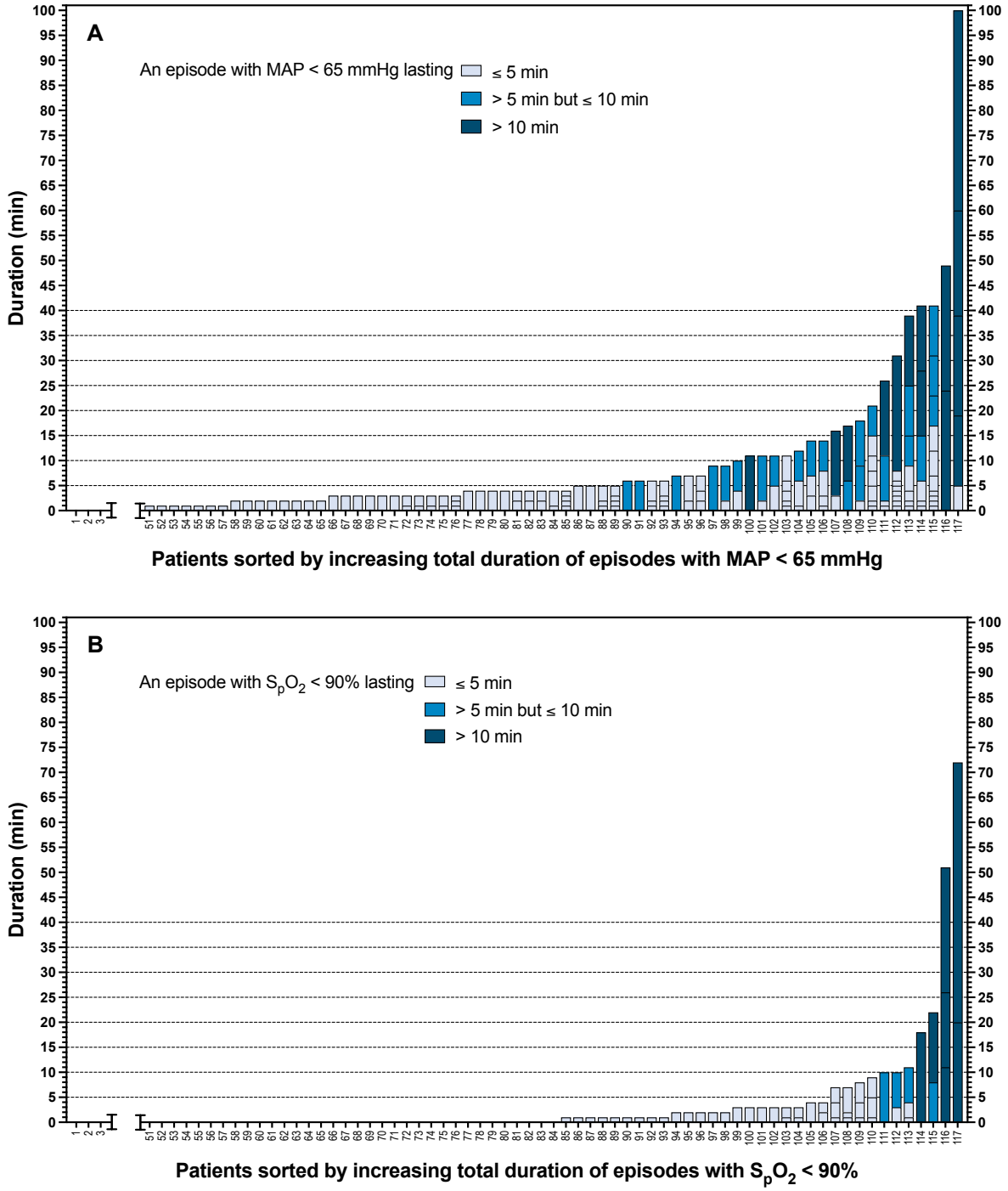

Fig. S2 Stacked bar charts showing the individual episodes with MAP < 65 mmHg (a) or with SpO_2 < 90% (b) for each of the 117 patients. The gap in the x-axis saves space. The discrete episodes with MAP<65 mmHg (ranging from 1 to 40 min) or S_pO_2<90% (ranging from 1 to 52 min) are grouped by patient. Patient numbers in (a) do not correspond with those in (b) as a result of sorting the patients according to the total duration of MAP < 65 mmHg or SpO_2 < 90%. Fifty patients (43%) had no episode with MAP < 65 mmHg, and 84 patients (72%) had no episode where SpO_2 < 90%. At least one episode lasting > 5 min with MAP < 65 mmHg or S_pO_2 < 90% occurred in 20% or 6%, respectively, of the patients. For episodes lasting >10 min these percentages were 8% or 3.4%, respectively

Table S4. Minor adverse events that occurred between patient handover at the referring ICU and patient handover at the receiving ICU

Type of adverse event	Period	Case #	n (%)[a]
Equipment related events			
Black out of Hamilton ventilator display	Tref	72	1
Battery failure Hamilton ventilator shortly before landing	Tair	3[b]	1
Battery failure Braun syringe driver block shortly before landing	Tair	3[b]	1
Subtotal			**3 (2.6)**
Medical adverse events			
Disconnection of pump delivering propofol resulted in blood pressure increase	Tref	80	1
Difficulty to ventilate the patient resulting in increased end-expired pCO_2	Tair	124	1
Disconnection of orotracheal tube during disembarkation	Tground	18	1
Disconnection of orotracheal tube during transport towards ICU	Tground	126[c]	2
Subtotal			**5 (4.3)**
Human factor related events			
Unfamiliarity with Hamilton ventilator	Tair	39	1
Damage syringe driver after drop	Tground	126[c]	1
Subtotal			**2 (1.7)**
Grand total			**10 (8.5)**

[a] Percentage of 117 missions
[b] Two incidents were noted in case #3
[c] Three events were noted in case #126