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Prehospital management of acute respiratory distress in suspected COVID-19 patients

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ABSTRACT

Background: In December 2019, coronavirus disease (COVID-19) emerged in China and became a world-wide pandemic in March 2020. Emergency services and intensive care units (ICUs) were faced with a novel disease with unknown clinical characteristics and presentations. Acute respiratory distress (ARD) was often the chief complaint for an EMS call. This retrospective study evaluated prehospital ARD management and identified factors associated with the need of prehospital mechanical ventilation (PMV) for suspected COVID-19 patients.

Methods: We included 256 consecutive patients with suspected COVID-19-related ARD that received prehospital care from a Paris Fire Brigade BLS or ALS team, from March 08 to April 18, 2020. We performed multivariate regression to identify factors predisposing to PMV.

Results: Of 256 patients (mean age 60 ± 18 years; 82 (32%) males), 77 (30%) had previous hypertension, 31 (12%) were obese, and 49 (19%) had diabetes mellitus. Nineteen patients (7%) required PMV. Logistic regression observed that a low initial pulse oximetry was associated with prehospital PMV (ORa = 0.86, 95%CI: 0.73–0.92; $p = 0.004$).

Conclusions: This study showed that pulse oximetry might be a valuable marker for rapidly determining suspected COVID-19-patients requiring prehospital mechanical ventilation. Nevertheless, the impact of prehospital mechanical ventilation on COVID-19 patients outcome require further investigations.

1. Introduction

Coronavirus disease (COVID-19) is currently spreading freely worldwide, after the first cases described in Asia in late 2019 [1-4]. On March 11th, 2020, the World Health Organization (WHO) declared COVID-19 a pandemic [5]. Despite worldwide COVID-19 affected over 2 million patients, the overall mortality rate remains low around 765,000 deaths [6-9], at this time of writing. COVID-19 is caused by an infection with severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), and it presents in various clinical manifestations [10]. Although most infections are not serious, 25% of cases are life-threatening [6]. Among these, the respiratory form is the most severe, because it presents as acute respiratory distress (ARD) without clinical signs. Typically, respiratory presentations of COVID-19 may be various and it often present different degrees of hypoxia and hypoxemia, which require in-hospital admissions to the emergency department (ED), a special ward, or an intensive care unit (ICU).

In the prehospital setting, we previously reported that dyspnea was the main symptom required for dispatching the Paris Fire Brigade prehospital emergency service [11]. Due to the pandemic status of COVID-19, there is a gap between patient needs (i.e., severe COVID-19 ARD, which requires support ventilation) and medical resources (medical ventilator devices). Consequently, it is important to understand the prehospital clinical characteristics of COVID-19 and the management of patient flow after the prehospital setting.

This study aims to describe the prehospital management of ARD related to COVID-19 and to identify factors associated with the need of prehospital mechanical ventilation (PMV) for suspected COVID-19 patients.

2. Methods

2.1. Design, setting, and participants

This retrospective observational study included all patients over 18 years old that required intervention by a Paris Fire Brigade team (BLS and/or ALS) between March 08 and April 18, 2020, due to ARD related to suspected COVID-19 accord to the world health organization (WHO) definition [12]. No exclusion criteria were applied. ARD was defined as the presence of a constellation of symptoms suggestive of COVID-19, dyspnea and/or a requirement for oxygen supplementation,

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based on initial prehospital pulse oximetry. Suspicion of COVID-19 was based on the latest WHO definition [12].

The prehospital Paris Fire Brigade emergency medical system is a 2-tiered response system: the BLS tier is served by 200 teams of 3–5 rescuers deployed in 77 stations; the ALS tier is served by 7 ambulance teams comprising an emergency physician, a nurse, and a driver [13]. The prehospital Paris Fire Brigade ALS team utilizes a prehospital mobile ICU equipped with medical devices and drugs, which enables the initial management of primary organ deficiencies (neurological, respiratory, and cardiovascular) [14]. ALS team physicians can perform echography and blood gas analyses in the prehospital setting. Upon assessing an emergency call, the dispatch center operator might decide to send a BLS team, an ALS team, or both teams at the same time, based on the clinical history and symptoms reported by the patient, the relatives, or a witness. Once rescue teams have arrived at the scene and the emergency physician has examined the patient, the patient can either remain at the scene or be transported for admission to the ED or directly to the ICU, depending on the status of critical organs. In addition, the ED and the ICU might not be located in the same hospital; in those cases, the dispatch center physician must notify the appropriate hospital department and communicate approval to the teams on site. Transport to the hospital is then carried out, either by a BLS team, for ED admissions, or an ALS team, for ICU or ED admissions, at the discretion of the emergency physician. In Paris, the particularity is that there is another prehospital emergency medical service, the SAMU [14]. Briefly, SAMU is an emergency medical system also based on a 2-tiered response system. The BLS tier is served by ambulances of 3 rescuers whereas the ALS tier is based on served by 7 ambulance teams comprising an emergency physician, a nurse, and a driver [14]. Parisian prehospital emergency services, SAMU and Paris Fire Brigade, are interconnected and daily work together.

2.2. Data collection

Data were collected from prehospital medical observation records; initial, e.g. at the first contact, vital sign values (blood pressure, heart rate, respiratory rate, pulse oximetry, body core temperature) were used for statistical analysis. We collected data on epidemiological variables, clinical symptoms (respiratory, gastrointestinal, anosmia, fever), point-of-care testing (blood lactate, myocardial enzymes, and glucose levels, blood gas, and ultrasonography), vasopressor treatment, and the immediate outcome (mode of respiratory support and mode of transportation to the hospital).

2.3. Ethical considerations

This study was approved by the French Society of Anesthesia and Intensive Care Ethics Committee on 04/07/2020 (Ref: IRB 00010254–2020–055).

2.4. Statistical analysis

Descriptive results concern the overall population, i.e. all adults that required intervention by a Paris Fire Brigade team between March 08 and April 18, 2020, due to ARD related to suspected COVID-19.

Results are expressed as the mean ± standard deviation (SD) for quantitative parameters with normal distributions; the median and interquartile range (IQR: Q1-Q3) for parameters with a non-gaussian distribution; and the absolute value and percentage for qualitative parameters.

Further analyses were performed on a subpopulation after excluding patients not admitted to the hospital alive at home and deceased on the scene.

Bivariate analyses were performed to evaluate the relationship between covariates and immediate outcomes (e.g., prehospital mechanical ventilation (PMV) or transport to the ED or ICU via BLS or ALS ambulances).

Multivariate logistic regression analyses were performed to assess the relationship between demographics and prehospital clinical characteristics (covariates) of in-hospital admitted patients and PMV. The covariates for the logistic regression included the initial respiratory rate, initial pulse oximetry for measuring blood oxygen saturation, age, hypertension, cardiovascular disease, chronic renal failure, chronic obstructive pulmonary disease, diabetes mellitus, and obesity, similar to previous publications [6,9,11,15,16]. Multivariate analysis results are expressed as the adjusted odds ratio (ORa) and 95% confidence interval (95%CI).

All analyses were performed with R software version 3.4.2 (http://www.R-project.org; the R Foundation for Statistical Computing, Vienna, Austria).

3. Results

This study included 256 consecutive patients with ARD due to suspected COVID-19 that were assessed by a prehospital Paris Fire Brigade ALS team, between March 08 and April 18, 2020. Descriptive data concern the overall population, i.e. patients admitted and not admitted to the hospital. During this time period, 30,993 BLS responses were performed. This number represented a 14% reduction compared to the number performed between March 08 and April 18 in 2019 (35,951 BLS interventions).

3.1. General patient characteristics

The overall population characteristics are summarized in Table 1 and the main functional symptoms, collected from prehospital medical observation records, that motivated the call for medical assistance in Table 2.

The mean age of patients was 60 ± 18 years, and 82 (32%) were male. Among the 256 patients, 77 (30%) had previous hypertension, 31 (12%) were obese, and 49 (19%) had diabetes mellitus. The median initial respiratory rate was 26 breaths·min^{-1} (IQR: 19–28); the median pulse oximetry value was 89% (IQR: 76–98). Nineteen patients (7%) required PMV, and 86 (33%) received non-invasive ventilation. Patients that did not receive PMV required a median oxygen supplementation of 9 L min^{-1} (IQR: 8–15).

Among the 256 patients analyzed, 39 (15%) received cardiopulmonary resuscitation, but all 39 (100%) died in the prehospital setting. This group of patients had a mean age of 71 ± 13 years, 12 (31%) were male, 19 (49%) had previous hypertension, 11 (28%) had diabetes mellitus, and 5 (13%) were obese. These patients were excluded from statistical analysis.

Thirty-two patients (13%) had care limitation, i.e. previous advanced directive for not to be reanimated was known since the prehospital setting. Their mean age was 80 ± 9 years and 18 (56%) were male. Of these, 13 (41%) had previous hypertension, 7 (22%) had diabetes mellitus, and 3 (10%) were obese. These patients were also excluded from statistical analysis.

3.2. Patients not admitted to the hospital

Thirty-two patients (12%) had no serious symptoms. Therefore, they did not require hospitalization and could remain at home (Table 1). These patients were excluded from statistical analysis.

3.3. Patients admitted to the hospital

A BLS team transported 82 patients (44%) to the hospital, and all were admitted to the ED. An ALS team transported 103 patients (56%) to the hospital; 49 (48%) were immediately admitted to the ICU, and 54 (52%) were admitted to the ED (Fig. 1).

Table 1
Patient demographics, initial prehospital clinical parameters and airway management.

Parameter	Hospital admission (n = 185)			No hospital admission (n = 71)		Overall population (n = 256)
	BLS transport (n = 82)	ALS transport (n = 103)		Alive at the scene (n = 32)	Deceased at the scene (n = 39)	
		NIV (n = 84)	PMV (n = 19)			
Demographics						
Age (years)	61 ± 20	64 ± 18	60 ± 11	49 ± 17	71 ± 13	60 ± 18
Male sex	38 (46)	10 (12)	5 (26)	17 (53)	12 (31)	82 (32)
Hypertension	27 (33)	11 (13)	9 (47)	11 (34)	19 (49)	77 (30)
Coronary artery disease	6 (7)	7 (8)	0 (0)	1 (3)	3 (8)	17 (7)
Obesity	11 (13)	9 (10)	4 (21)	2 (6)	5 (13)	31 (12)
Diabetes Mellitus	21 (26)	7 (8)	8 (42)	2 (6)	11 (28)	49 (19)
Immunosuppression	3 (4)	0 (0)	2 (11)[a]	4 (13)	5 (13)	14 (5)
Asthma	7 (9)	5 (6)	2 (11)	2 (6)	1 (3)	17 (7)
Active smoking	7 (9)	5 (6)	0 (0)	3 (9)	3 (8)	18 (7)
Chronic Renal Failure	0 (0)	3 (3)	2 (11)	4 (13)	1 (3)	10 (4)
Stroke	6 (7)	1 (1)	0 (0)	10 (31)	1 (3)	18 (7)
Clinical						
Body core temperature (°C)	37.5 [36.4–38.2]	37.3 [36.3–38.3]	37.0 [35.9–38.7]	36.4 [36.0–36.9]	35.4 [32.8–36.1]	37.2 [36.2–38.2]
Glasgow coma scale	15 [15–15]	15 [14–15]	14 [3–15][a]	15 [15–15]	3 [3–3]	15 [15–15]
SBP (mmHg)	141 [128–157]	139 [123–150]	134 [121–150]	130 [117–141]	NA	138 [122–153]
Prehospital catecholamine	0 (0)	0 (0)	6 (32)[a]	0 (0)	16 (41)	22 (9)
Respiratory						
HR (beats · min^{-1})	93 [86–110]	90 [78–110]	110 [87–116][a]	85 [73–110]	NA	91 [80–110]
RR (movements · min^{-1}) before oxygen	25 [18–32]	30 [23–38]	34 [25–40][a]	20 [10–25]	NA	26 [19–28]
Air ambient pulse oximetry (%)	92 [85–99]	85 [67–93]	45 [43–56][a]	98 [96–100]	NA	89 [76–98]
Pulse oximetry with oxygen (%)	98 [96–100]	95 [92–98]	90 [85–92]	NA	NA	97 [92–99]
RR (movements · min^{-1}) with oxygen	25 [19–30]	28 [22–35]	15 [13–20]	NA	NA	26 [20–32]
Oxygen supplementation (L min^{-1})	9 [6–15]	NA	15 [12–15]	NA	NA	15 [9–15]
FiO2 (%)	NA	NA	100 [80–100]	NA	NA	100 [100–100]
PEEP (cmH20)	NA	11 [5–15]	9 [8–15]	NA	NA	12 [5–15]
EtC02 (mmHg)	NA	35 [33–42]	NA	NA	NA	37 [32–39]

Results are the mean ± SD, the median [interquartile range], or the number (%), as indicated.
ALS: advanced life support, BLS: basic life support, PMV: prehospital mechanical ventilation, NIV: non-invasive ventilation, SBP: systolic blood pressure, HR: heart rate, RR: respiratory rate, FiO2: fraction of inspired oxygen, PEEP: Positive end-expiratory pressure, EtCO2: end tidal CO2.
[a] Means a significant association with PMV after bivariate analysis.

Table 2
Main functional symptoms collected from prehospital medical observation records.

Symptom	n	%
Dyspnea	128	70
Fever	122	66
Cough	77	42
Chest pain	42	23
Myalgia	31	17
Discomfort	25	14
Diarrhea	20	11
Vomiting	9	5
Anosmia	9	5

3.4. Prehospital acute respiratory distress management and PMV

Nineteen patients (7%) required PMV and 86 patients (53%) required non-invasive ventilation, i.e. without intubation. Non-invasive ventilation was delivered either with the Boussignac system or another system for delivering continuous airway pressure. High flow nasal oxygen devices are not available for prehospital Paris Fire Brigade ALS team.

For the 19 patients intubated, after exclusion of cardiac arrest, in the prehospital setting (Table 1), the initial median respiratory rate was 34 (IQR: 25–40) breaths·min^{-1} ($p < 0.05$ vs non-invasive ventilation and BLS transport) and the median pulse oximetry without oxygen was 45% (IQR: 43–56) ($p < 0.05$ vs non-invasive ventilation and BLS transport). After intubation, the median pulse oximetry reached 90% (IQR: 85–92) with a median respiratory rate of 15 breaths·min^{-1} (IQR: 13–20), a median positive end-expiratory pressure of 11 cmH2O (IQR: 5–15), and a median fraction of inspired oxygen of 100% (IQR: 80–100).

3.5. Factors associated with PMV

The multivariate logistic regression analysis revealed that PMV was significantly associated with the initial pulse oximetry value (ORa = 0.86, 95%CI: 0.73–0.92; $p = 0.004$).

4. Discussion

This study showed that, among patients with suspected COVID-19 that were assessed for ARD by a prehospital ALS team, a low initial pulse oximetry was associated with PMV. Our results were consistent with previous studies performed in other countries. First, we observed the same main functional symptoms associated with COVID-19: febrile dyspnea with cough [10]. Second, our general demographic and clinical characteristics were consistent with those observed in Italy and China [6,9]; the typical patient was a middle aged, obese adult with hypertension and diabetes mellitus. Studies from other countries identified COVID-19 mortality risk factors among which: age, hypertension, cardiovascular disease, chronic renal failure, chronic obstructive pulmonary disease, diabetes mellitus, and obesity [6,9,11,15,16]. In contrast to the US study, we observed less obesity in our population, due to the lower incidence of obesity in the European population compared to the study population [15].

In France, the main cause of out-of-hospital cardiac arrest in adults is acute coronary syndrome [17,18]. In the present study, among the 15% of patients that died at the scene, the incidence of cardiovascular risk

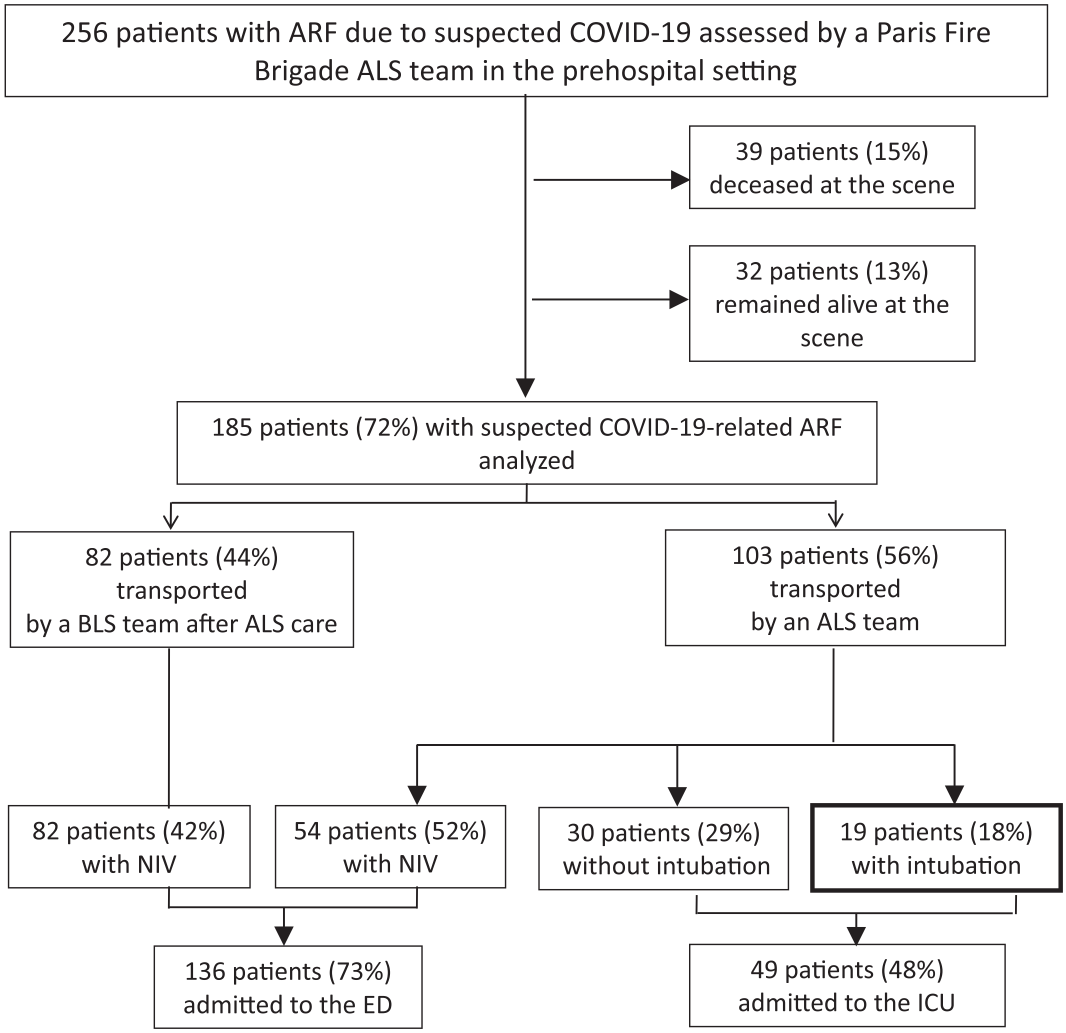

Fig. 1. Flow chart of prehospital patient management. ED: emergency department, ICU: intensive care unit, BLS: basic life support, ALS: advanced life support, NIV: non-invasive ventilation.

factors was not high. Thus, we speculated that most prehospital deaths were related to hypoxia, not coronaropathy per se. One of the issues related to COVID-19 is the detection of silent hypoxia [11], which could partly explain the observed transient two-times increase in OHCA incidence, coupled with a reduction in survival [19]. However, we could not confirm this hypothesis, because no autopsy was performed.

Patients transported by the BLS unit and admitted to the ED had a low initial respiratory rate and responded to oxygen supplementation. Patients that required PMV had a lower initial pulse oximetry and a higher initial respiratory rate [11]. Independent of COVID-19, ARD is a life-threatening medical emergency commonly encountered in the prehospital setting [17,20]. ARD prehospital management involves oxygen delivery and disease-specific treatments. It remains controversial whether the treatment of choice for ventilation should be non-invasive (simple oxygen supplementation, continuous positive airway pressure, or bilevel positive airway pressure) or invasive (mechanical support with intubation), especially given that the underlying condition can be fatal and COVID-19 is highly contagious [21,22]. Except for facial masks for delivering high oxygen concentrations, the low rate of applying non-invasive ventilation (positive airway pressure modes) could be explained by the fear of risking SARS-CoV-2 aerosolization and contamination of healthcare providers [23-26]. To date, no data are available on the rate of healthcare provider contamination or on how the low rate of prehospital non-invasive ventilation use might impact patients with suspected COVID-19 ARD. Currently, for patients with suspected COVID-19 ARD, the optimal mode of respiratory support, before PMV is required, is a matter of debate [27]. This issue has become a challenge in prehospital pandemic COVID-19 ARD management, due to the inadequate balance between needs and resources. Therefore, it is crucial to identify patients at risk of unfavorable respiratory evolution to ensure adequate prehospital ARD management and transportation to the appropriate facility. We believe that the key is careful patient selection to avoid delaying PMV to patients that require it. Our results suggested that the pulse oximetry, measured before and after oxygenation, might provide a means of identifying patient eligibility for prehospital non-invasive ventilation. Further prospective studies are needed to confirm the usefulness of this potential marker.

Our study had some limitations. First, it was a retrospective study, with the usual inherent limitations. Second, children were not included in the study; thus, our results might not be applicable to a pediatric population, particularly because SARS-CoV-2 does not have equivalent effects in children and adults [28]. Third, this study was conducted in a single country and in single city, based on a particular prehospital emergency system with a 2-tiered response. Therefore, it might not be generalizable to all emergency systems. Fourth, we did not have data on the rate of hospital admissions for patients with SARS-CoV-2 infection that did not receive a prehospital emergency service intervention. Fifth, we could not rule out the potential impact of unknown confounders on our results, e.g. we did not assess the potential effect of the underlying frailty and disease duration prior call to the EMS. Sixth, we cannot report the potential of non-invasive positive pressure ventilator devices, i.e. high flow non-invasive oxygen therapy device, because they are not recommended because of a presumed aerosol generating risk in an ambulance. Last, but not least, this study did not report any association between prehospital care and the outcome; for example, we did not report the rate of in-hospital deaths or the rate of in-hospital MV applications, which could have demonstrated the adequacy of the prehospital intervention.

In conclusion, to the best of our knowledge, this study was the first study to describe a large number of consecutive patients with ARD and suspected COVID-19 that were assessed by a prehospital ALS team. We found that a low initial pulse oximetry value was associated with the need for PMV. Further prospective studies are needed to confirm the usefulness of pulse oximetry in selecting patients that are eligible for prehospital non-invasive ventilation, the greatest challenge in the prehospital management of COVID-19-related ARD.

Authors' contributions

RJ conceived the study, prepared the initial protocol,
RJ and DJ analyzed data and drafted the manuscript.
SL, CD, RK, MS, JB, BP, FL and BF collected data.
All authors read and approved the final manuscript.

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None.

Declaration of competing interest

None.

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