

The leading “blended” civil medical evacuation operation (MEDEVAC) in unforeseen health emergency. From military use to civil development

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ABSTRACT

Introduction: Medical evacuation has historically been rooted in military contexts. It involves the systematic transfer of sick or injured individuals from the battlefield to designated medical facilities. Medical evacuation has found application in civilian settings: the Ebola outbreak and the COVID-19 pandemic. This paper examines the medical evacuation that occurred during the COVID-19 pandemic in Lombardy, Italy (Operation “MEDEVAC”), where overloaded hospitals required the transfer of patients to other regions and even internationally.

Methods: MEDEVAC was implemented by the Regional Emergency and Urgency Agency (AREU). Data from MEDEVAC were analysed using the AREU register, detailing patient characteristics, transfer logistics, and outcomes.

Results: From March to April 2020, 121 intensive care patients were transferred via MEDEVAC, primarily by air. 65 % of patients were moved to other Italian regions. The Federal Republic of Germany received 35 % of patients, all transported by air. Outcome and mortality rates among transferred patients were comparable to those within regional intensive care units. One life-threatening event was reported during transport. The return of patient to Lombardy showed a 100 % survival rate.

Conclusion: This study emphasises the importance of standardised protocols, improved information exchange systems, and enhanced training for medical personnel involved in medical evacuation. MEDEVAC was found to be feasible and able to cope with demands that were excessive in relation to available resources. This study proposes the development of a shared protocol for air transport of patients and a model for international cooperation among emergency response agencies to optimise future medical evacuation activities in civil context.

1. Introduction

The concept of medical evacuation has been developed for military use since the World War II [1,2]. Medical evacuation consists of the evacuation of sick or injured from the theatre of war to protected facilities in the rear, in order to provide medical care appropriate to their condition. Medical evacuation is often the result of inter-force organisation. This concept, which is characterised by planning and logistical organisation, should not be confused with CASEVAC (Casualties Evacuation), i.e. the rapid and unplanned evacuation of the wounded by makeshift vehicles. The evacuation process is further subdivided into two phases: TACTICAL MEDEVAC and STRATEVAC. The former consists of the sudden transfer of the wounded to a lower intensity area. The latter concerns the management of the patient and eventual repatriation, as well as the allocation of the resources necessary to conduct operations. Medical evacuation has also proved useful for the evacuation of patients for civil purposes [3,4]. The Ebola virus outbreak in West Africa

in 2013–2016 led to the transport of 33 patients to the United States and Europe [5,6]. Recently it was applied in the COVID-19 pandemic scenario [7–16].

In Italy, the use of medical evacuation to transport casualties from a critical area to another accepting facility, was carried out in a civil context for the first time during the earthquake in Albania on November 26, 2019. The agencies active in this context were the Civil Protection Department and the Remote Emergency Operations Centre (CROSS). They organised the immediate dispatch of expert personnel, checked the availability of hospitals beds and possible accepting facilities in Italy. Regional rescue agencies were also involved. CROSS and Civil Protection Department coordinated the dispatch and the management of resources, assessed the availability of rescue vehicles (on that occasion 20 helicopters from the various 118 Regional Services) and interfaced with the National and Albanian Health Systems.

Recently, the civil medical evacuation was implemented by the Regional Emergency and Urgency Agency (AREU) of the Lombardy

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[17], the most densely populated region in Italy, in two different scenarios. The first time during the COVID-19 pandemic, operation “MEDEVAC”. The second in March 2022, at the beginning of the Ukrainian-Russian conflict, when hospitals were bombed and onco-haematological children who needed to continue treatment in a hospital were transferred to Italian paediatric hospitals, via fixed-wing aircrafts.

MEDEVAC was successfully applied by AREU, the largest public agency dealing with health emergency in Lombardy [17–21], during the first pandemic wave from SARS-CoV-2 in 2020 because of the difficulties in managing the excessive number of patients who required intensive care and that could not be accommodated in the region’s hospitals facilities [22–24]. The pandemic scenario also required a rapid reorganisation of resources. AREU had to adapt the time-dependent network for neurological urgencies, coronary syndromes and pre-hospital management of major trauma [18,20,25,26]. At the same time, the emergency system was asked to provide support for the transfer of critical patients between hospitals, an activity normally handled by the hospital without the intervention of AREU. Until then, there were few protocols in place to manage the transfer of intensive care patients on such a large scale. Decisions were made based on suggestions from military resources or simple recommendations from experts in field [27–29].

In order to enable hospitals within the “red zone” (areas interdicted to population where the virus initially spread) to allocate resources and personnel to COVID-19 patients in need, transfer was initially organised for all COVID-19 negative patients. Hospitals outside the so-called “red zone” initially only accepted COVID-19 negative patients, to prevent the spread of the virus, hoping to keep it within the established boundaries. At a later stage, as the infection spread throughout Italy and the saturation point of facilities in Lombardy was reached, COVID-19 patients were also transferred.

There were 720 beds available before the COVID-19 pandemic in Intensive Care Units (ICUs) in Lombardy, with an occupancy rate of up to 90 % during the winter months [22]. In order to cope with this unpredictable emergency, a gradual expansion of the ICUs was necessary, and on April 02, 2020, the maximum number of occupied beds was reached ($n = 1511$).

From March 07, 2020, it was also necessary to transfer patients (both COVID-19 positive and negative patients) to non-regional ICUs. The Civil Protection Department activated the CROSS “for the coordination of both urgent medical relief and Regional Health Referrals in the event of a national emergency”, and AREU constantly coordinated with the CROSS for the management of transfer requests proposed by hospitals.

The purpose of this article was to analyse the management of MEDEVAC as a rapid response tool to an additional demand for ICU beds. The request occurred during the first COVID-19 wave in Lombardy, since the hospitals were not able to expand their ICU bed capacity beyond a certain limit. This study investigated: I- the evaluation process of patients included in MEDEVAC; II- the follow-up of patients at their destination; III- the outcome of patients returned to Lombardy; IV- indications for the organisation of the system in the event of future challenges.

2. Methods

This is a retrospective observational cohort study, carried out in the AREU Lombardy Headquarters. The study was conducted in accordance with the principles of the Helsinki declaration and was approved by the AREU Data Protection Officer on May 30, 2022.

Data were provided by the AREU registers. A MEDEVAC dossier contained i) the data from the hospitals that requested the transfer of patients; ii) the e-mails exchanged between the coordination centre and the doctors who were treating the patients, and iii) the existing data relating to the transfer and repatriation of patients. We analysed the data recorded from the first request, the end of February 2020, till the end of the MEDEVAC operation (beginning of April 2020).

The data recorded by the system were as follows.

- 1 before the transfer. The data recorded by the departure hospital and sent to AREU for the organisation of the transport were: peripheral oxygen saturation, ratio of oxygen pressure to inspired fraction of oxygen (P/F), use of vasoactive amines in therapy, patient positioning (supination if applicable), presence of tracheostomy or oro-tracheal intubation, length of stay in intensive care.
- 2 during the transport. Destination facility; mileage; the number of patients transported by air (fixed-wing aircraft or helicopter) and those transported by road; the geographical distribution of the transfers.
- 3 upon return. The outcome and the destination of the patient were assessed.

2.1. Patient transfer

Ambulances were used to transport the patient by road whenever possible; when distances did not allow other vehicles, helicopters or fixed-wing aircrafts were used. To be transported by air, the patient had to meet the following minimum criteria.

- Haemodynamic stability;
- Oro-tracheal intubation or tracheostomy performed for at least 24 h;
- Arterial oxygen pressure and inspired fraction of oxygen ratio (P/F) > 100 mmHg, $\text{FiO}_2 < 0.7$, positive end expiratory pressure (PEEP) < 12 cmH₂O, $\text{pH} > 7.30$, $\text{PaCO}_2 < 50$ mmHg, Lactate < 1.5 mmol/L;
- No pronation in the last 48 h, and patient responding to recruitment manoeuvres;
- Recent chest X-ray ruling out pneumothorax and recent CT scan ruling out massive pulmonary embolism;
- Weight < 90 Kg, Height < 180 cm. These limiting factors were related to the size of the biocontainment structure, which was used in the initial phase of COVID-19 to transport patients by helicopter, and the maximum load of the helicopter platform. Firstly, in the helicopter, it was not possible to microbiologically isolate the cockpit from the area where the infected patient was located. In addition, the helicopter platform had a maximum load: the weight of the stretcher, the containment cell and the patient must be taken into account to avoid an unexpected overload. These parameters did not constitute a contraindication for transporting patients with fixed-wing aircraft.

Based on these parameters, a form was structured that allowed the intensivist to complete a request with all the necessary data (SUPPLEMENTARY MATERIAL).

2.2. Statistical analysis

The categorical variables are presented as number and percentage, and the continuous variables are presented as mean and standard deviation (SD) or as median and interquartile range (IQR). Chi-Square test, odds ratios (OR) and interval confidences (IC95 %) are computed for categorical variables. The Mann-Whitney test is used to analyse continuous variables or by ANOVA and post-hoc analysis, when appropriate.

Differences are considered significant when $p < 0.05$, otherwise non significant (NS). Prism 8.0.1 software has been used for statistical analysis (GraphPad Software LLC, San Diego, CA, USA).

3. Results

The MEDEVAC activity was performed from March 07, 2020 to April 04, 2020, allowed the transfer of 121 intensive care patients, of which (Table 1).

Table 1

Modality of transport, patients characteristics, length of stay (LOS), and outcome of patients moved by MEDEVAC during the first month of pandemic. * $p < 0.05$ vs the other three reported mean distances.

	COVID19 POSITIVE 82 patients		COVID19 NEGATIVE 39 patients	
	BY AIR	BY AMBULANCE	BY AIR	BY AMBULANCE
Number of patients	65	17	24	15
	32 Airplane		1 Airplane	
	33 Helicopter		23 Helicopter	
Males n (%)	53 (81.5 %)	13 (76.5 %)	19 (79.2 %)	11 (73.3 %)
Age mean (SD) in years	58.3 (8.5)	58.6 (11.6)	57.9 (17.0)	68.6 (11.6) [§]
Destination (n)	43	0	0	0
	22	17	24	15
Federal Republic of Germany				
Other Regions (Italy)				
Distance - mean (SD) in km	807 (281)*	305 (135)	383 (193)	289 (195)
LOS - median (IQR)	15.5 (9.75–25.5)	10 (7–22)	19 (16–63.0)	6.5 (6–13.7)
Deaths	40	41 (32–64)	36	53 (45–69)
Alive	(29.5–50)		(25.5–61.5)	
Outcome n. (% of single column)	20 (30.8 %)	3 (17.6 %)	5 (20.8 %)	6 (40.0 %)
	13 (20.0 %)	2 (11.8 %)	7 (29.2 %)	3 (20.0 %)
Deaths	16 (24.6 %)	4 (23.5 %)	4 (16.7 %)	3 (20.0 %)
Transfer to Hospital	15 (23.1 %)	7 (41.2 %)	8 (33.3 %)	3 (20.0 %)
Rehabilitation Home	1 (1.5 %)	1 (5.9 %)	0	0
Not transferred by AREU				

- 65 and transported by air;
- 17 COVID-19 patients transferred by road;
- 39 COVID-19 negative patients transferred either by air or road.
- 36 non-transferred patients.

Most of the transfers (77 patients, about 65 %) were toward Italian regions. Analysing instead the transfers to the Federal Republic of Germany, German hospitals (Erlangen, Cologne, Dresden) received 43

patients - the remaining 35 %, in this case all transferred by air.

Fig. 1 and Table 1 show the trend of transfers with respect to the date of departure from the hospital requiring logistical support and the destination.

3.1. Characteristics of critical patients

Table 2 shows the characteristics of the patients transferred. During the first critical phase, only first name, surname and date of birth were collected for patients transferred by ambulance, whereas for patients transferred by air, additional data were available.

Of the 65 COVID-19 patients transferred by air, 18.5 % of the patients were transported with a tracheostomy cannula, the others with orotracheal intubation, except for three patients who were undergoing oxygen therapy without orotracheal intubation. The applied PEEP values ranged from a maximum of 15 cmH₂O (values used to support the patient in case of ARDS) to a minimum of 6 cmH₂O. The average was about 10 cmH₂O of PEEP (value used for ventilation of acute lung injury). Regarding prone/supination manoeuvres, no patient transferred by helicopter underwent the pronation manoeuvre in the 48 h preceding transport. In fact, this manoeuvre constituted an absolute exclusion criterion for helicopter transport, due to the risk of untreatable

Table 2

Characteristics and clinical parameters of patients transport by air.

COVID19 patients transported by air (n = 65)	
Weight (kg)	81 ± 13
Height (cm)	174 ± 8
Body Max Index (BMI)	26.8 ± 3.7
SpO₂ (%)	97.2 ± 1.8
Heart Rate (min⁻¹)	85 ± 18
Systolic Arterial Pressure (mmHg)	130 ± 16
Diastolic Arterial Pressure (mmHg)	68 ± 10
Positive End Expiratory Pressure, PEEP (cmH₂O)	10.5 ± 2.3
pH	7.44 ± 0.05
pCO₂ (mmHg)	42.7 ± 8.4
FiO₂	0.56 ± 0.18
pO₂ (mmHg)	97.8 ± 31
pO₂/FiO₂	193 ± 72
Tidal Volume (mL)	462 ± 74
Respiratory Rate (min⁻¹)	20.5 ± 5.9
Lactate (mmol L⁻¹)	1.1 ± 0.4
EtCO₂ (mmHg)	38.4 ± 7.2
Tracheostomy n (%)	12 (18.5 %)

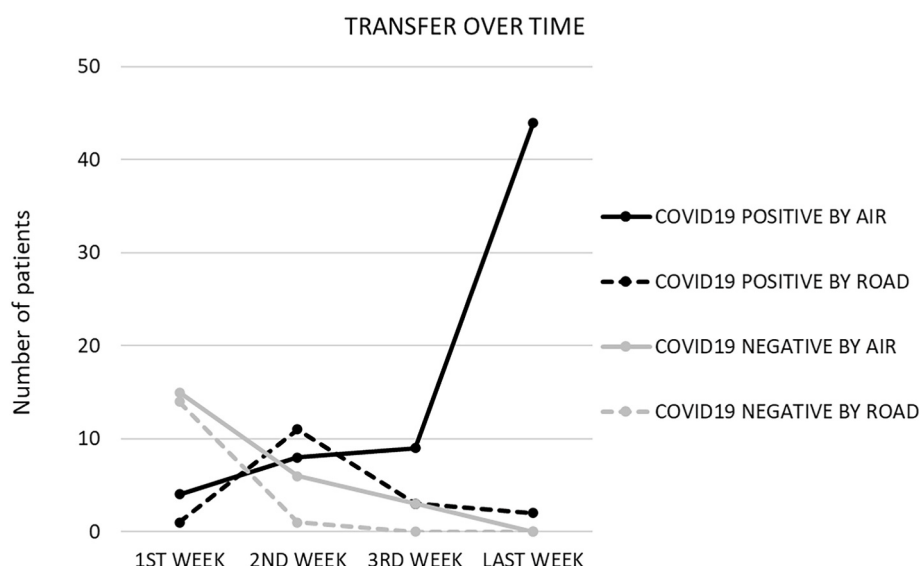


Fig. 1. Trends and modalities of transport during the four weeks of MEDEVAC.

hypoxaemia during the transport which could not be treated with postural changes. A different case was made for patients who benefited from transfers by fixed-wing aircraft. Despite the fact that 2 pronated patients were transferred, it can still be said that these constituted an absolute minority in relation to the majority of patients transferred. Amine therapy was in progress in 6 patients, allowing adequate haemodynamic stability for long-distance transfer.

The mortality of COVID-19 patients transferred by air was 20/65 patients (30.8 %), by land 3/17 (17.6 %). COVID-19 patients had an overall mortality of 28.0 %, and a mortality of 28.2 % COVID-19 negative transferred patients.

In order to undertake the return to Lombardy, the patient had to be “clinically recovered”. No major critical problems were found during the return to Lombardy, being able to report that patients had a 100 percent survival rate.

3.2. Mission logistics

On 28 of March, a multiple transfer of six patients from three different hospitals was carried out from Orio al Serio airport to Cologne. During this operation, there was a delay in four vehicles reaching the airport (despite the fact that the arrival time at the facility was the same for all of them and was extremely tight), also due to the scarcity of resources related to the emergency context.

The delay, of about 3 h, not only risked jeopardising the feasibility of the mission itself, but also entailed a longer stay at the airport of two critical patients, with the associated inconveniences (despite the hangar equipped for the management of intensive patients made available at the Orio al Serio airport).

On the basis of this experience, it was ensured that for subsequent MEDEVAC missions the patients would all come from the same facility or from hospitals close to each other, in order to be certain that transfer times would be respected, thus implementing the management capacity of such operations.

The distances covered by the three different means of transport have been computed. Distances flown by fixed-wing aircraft were significantly greater than those covered by ambulance and helicopter ($p < 0.0001$). At the same time, distances covered by helicopter were greater than those managed by ambulance ($p = 0.031$).

4. Discussion

This is the first Italian experience that required in an emergency situation the transfer of a large number of patients requiring intensive care in a short time and at a distance from the patients' access hospitals. Indeed, in Lombardy, during the first phase of the pandemic, hospitals could not guarantee care for all critical patients due to the limited number of beds available. Therefore, the region was faced simultaneously with the challenges of transferring critical patients to ICUs and the lack of a unified assessment tool to facilitate their transport to different facilities. For this purpose, the operation “MEDEVAC” was set up. The Director of AREU, who is also the Lombardy Region's Health Contact Person, initially contacted the Head of the Italian Civil Protection Department. This led to contacting the Ambassador of the Federal Republic of Germany in Italy and establishing contact with the Director of the AREU. Subsequent relations ensured the following steps: the periodic reconnaissance of beds in military hospitals in the German regions (promptly communicated to the CROSS) and the use of military vectors for the medical transport of some patients.

4.1. Operation MEDEVAC timeline, modalities, and involved facilities

The first transport took place on March 07, 2020, when the first of 121 transfers to non-regional hospitals and to the Federal Republic of Germany was carried out. The conclusion of the MEDEVAC procedures occurred on April 04, 2020. AgustaWestland Leonardo AW139

helicopters (from the AREU fleet, Lombardy, and the Rega fleet, Switzerland), C-130J Hercules aircrafts, and Dassault Falcon aircrafts were used for this purpose.

Fig. 1 shows the number of patients transferred via MEDEVAC over the month. Initially, COVID-19 negative patients were transferred to reduce the workload of the hospitals in the “red zone”, where the virus first spread out. From the second week onwards, a gradual increase in transports of COVID-19 patients occurred. This was probably due to the fact that transferring COVID-19 patients was extremely complex at the beginning, whereas already by the second week the management was easier. Initially, transports by road were favoured, with preference given to Italian hospitals closed to the Lombardy region. In the following weeks, the system occupied all possible neighbouring places, thus requiring European support and transferring mainly by air an extremely high number of patients in the last week. Indeed, the peak of transports by fixed-wing aircrafts or helicopters occurred about one month after the implementation of MEDEVAC. Patients were relocated to hospitals far away from Lombardy, in the Federal Republic of Germany or in southern Italian regions. Of the 65 flights performed, 43 were to the Federal Republic of Germany and 22 to other Italian regions. This change in the number of patients transferred using fixed-wing aircrafts and helicopters was also a consequence of better organisation, which made it possible, especially in the last week, to use a more complex system that by then had been tried and tested. Flights to the Federal Republic of Germany benefited from fixed-wing aircraft transport only, while Italy benefited from a ‘blended’ mode, by air and by road, thanks to missions carried out by helicopters and ambulances.

For patients to be transferred over long distances, fixed-wing aircraft was confirmed as the best carrier. A difference in terms of mileage can be observed between transfer by fixed-wing aircraft, helicopter and ambulance (Fig. 2). As far as distances are concerned, several criteria guided the system towards the use of the helicopter over the road: the

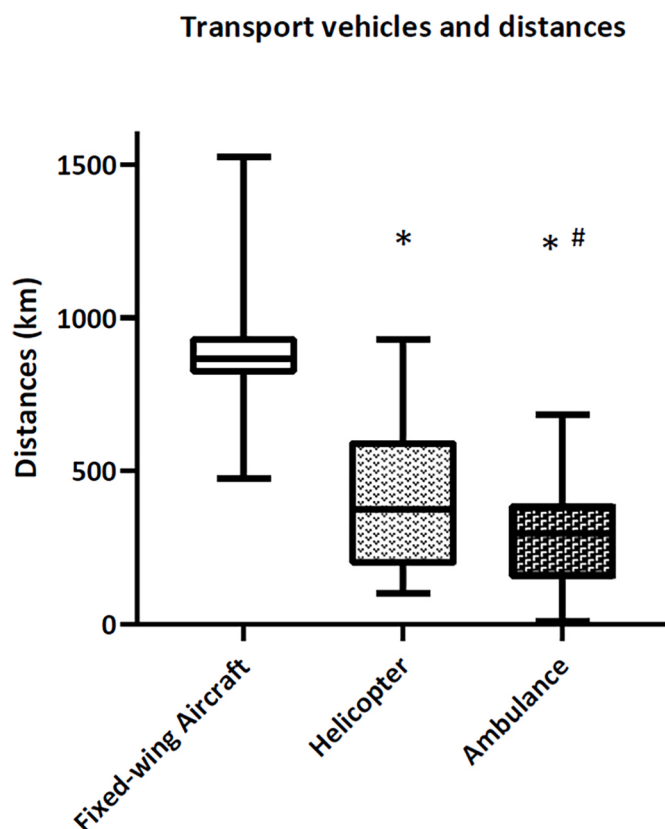


Fig. 2. Mean distances covered by the three different vehicles. * $p < 0.0001$; # $p = 0.031$.

time factor, hospital logistics, and whether or not the patient could cope with a long transfer. The limiting factor for the shorter distance covered by the helicopter with respect to the fixed-wing aircraft could be the need for oxygen therapy. Indeed, the amount of oxygen that could be transported by helicopter was small.

4.2. Patient selection criteria

In a very early phase (from 21 February to March 07, 2020), due to the fast-moving nature of the situation, evaluations and arrangements for the transfer of patients were made through telephone conversations between doctors or through the exchange of e-mails. During the acute phase, extremely limited data and information were collected for patients transferred by ambulance, due to organisational reasons and the impossibility of handling other data in an extremely hectic phase. The dialogue took place between the hospital doctors receiving the patient, or the doctors in charge of the transport, and the colleague from the accepting facility.

There was no flow-chart available that could be activated immediately with a suitable organisation for the purpose. Since patient 'O' COVID-19 was diagnosed on February 21, 2020, within a short time (15 days), the ICU beds available in the Lombardy region became saturated, a condition that required extraordinary measures that led to long-distance transfers starting on March 07, 2020.

As a result, while medical transports by road and transfers of COVID-19 patients were carried out according to standard transport criteria and methods, it became necessary to draw up an 'ad hoc' evaluation form for the eligibility to fly of COVID-19 patients. Indeed, From the very beginning, there was a need for a standardised assessment, a tool that would allow the different facilities to provide a homogenous assessment of the patients to be transported. This form not only contained the 'standard' flight suitability criteria for long-term fixed-wing aircraft medical transport, but also included additional check elements for helicopter transport, which were added on the basis of the experience of transferring COVID-19 patients.

A further step to improve the exchange of information was the creation by the AREU of a "drop box" dedicated to requests for transfers of critical COVID-19 patients. "Drop box" was a data sharing system among institutions to expedite and facilitate the handovers.

With regard to air transport, the final evaluation of transport eligibility was carried out by the aviation doctors in charge of the actual transfer. On the basis of the clinical data collected, the question arose as to whether some of these could represent guideline criteria for selecting patients eligible for air transport. Age was not a limiting factor for patient selection, however, COVID-19 patients were on average younger than patients admitted to intensive care units (mean age 63 years) and those transferred by COVID-19 negative ambulance. Most of the patients transferred were male.

The parameters (within which the patients must fall) were initially taken from the available literature. Compared to flying by plane, in order to be transported by helicopter, the patient had to fall within minimum suitability criteria: weight <90 Kg and height <180 cm were two limiting factors, related to the size of the containment cell (can carry patients less than 180 cm in height) and the maximum load that can be carried on the helicopter platform, which must take into account the weight of the stretcher, the containment cell and the patient; orotracheal intubation or tracheostomy performed for at least 24 h; P/F > 100 mmHg; FiO₂ ≤ 0.7; PEEP ≤ 12 cmH₂O; pH ≥ 7.30; pCO₂ ≤ 50 mmHg; Lactate ≤ 1.5; no protonation in the last 2 days; recent X-Ray ruling out pneumothorax; recent CT scan ruling out massive pulmonary embolism; patient SpO₂ responding to recruitment manoeuvres.

4.3. Means of transport

In that context it is worth pointing out how, at least as far as secondary transport was concerned, an attempt was made to dedicate

specific ambulances to COVID-19 patients. The entire health system created two parallel routes: the 'dirty' one for patients infected with the COVID-19 and the 'clean' one for patients with a negative swab, in an attempt to prevent any worsening of the pandemic. The available ambulance, apart from AREU vehicles, of course, also came from local rescue associations and non-regional emergency services.

At the same time, as the number of critical patients to be managed decreased, Lombardy's hospitals progressively redistributed the number of patients to the various detachments and wards, thus being able to guarantee better care. Air transport took place thanks to the means of the Helicopter Emergency Medical Service (HEMS) bases, the Italian Air Force and the German Air Force. The carrier mainly used was the helicopter of the HEMS base in Como (AW139) with a full team (pilot, co-pilot, doctor and critical area nurse): the vehicle was authorised (and used) to transport COVID-19 patients, as well as having the suitability for night flying, being able to carry out H24 missions.

On the basis of several parameters, a form was structured, to be filled in by the intensivist in order to formulate a request complete with all the necessary data (Fig. 3). The patient form was revised and distributed more widely after the death of a patient during the transfer to Bari hospital, which occurred during the first transport.

Before the pandemic, the availability of vehicles for high biocontainment transport was limited [7,8,30,31]. Additionally, there was also a reduced availability of fixed-wing aircrafts properly equipped for advanced medical transport. Gradually, during the management of the pandemic emergency, efforts were made to address these shortcomings. In particular, the helicopter in Como was equipped for transport with a biocontainment cell. This device was abandoned shortly afterwards due to the lack of a decontamination system for the external envelope: the procedures for loading the patient into the cell took place either directly in the ICU ward or at the Emergency Department of the sending facility, inevitably contaminating the external wall of the cell.

Most of the transports with the AREU Helicopter were therefore carried out in a manner entirely similar to those performed in a Basic Life Support ambulances: by separating the driver's compartment from the sanitary compartment in conjunction with the use of personal protective equipment. Specific protocols were developed for personnel dressing and the sanitisation of vehicles used to transport COVID-19 patients. Over the following two years, these procedures underwent a process of revision and improvement: during the first flights, preventive measures were taken, that were later shown to be completely useless, such as turning off the heating systems on the helicopter, resulting in considerable discomfort for the patient being transported and the crew.

Another limiting factor that affected the possibility of transporting critical patients at that stage was, on the one hand, the shortage of oxygen and, on the other, the mode of transporting it [14]. As far as air transport is concerned, fixed-wing aircrafts must provide adequate storage and anchorage systems for O₂-therapy cylinders, as well as systems for securing mobile cylinders. In addition to this, devices with a suitable connection to the dispenser on the vehicle had to be provided. The amount of transportable oxygen was a severely limiting factor for the maximum distances that can be reached with the helicopter: the crew had to request permission, during the vehicle's stopover, to replace their oxygen cylinders. This operation would normally have been the prerogative of the technicians at the airport, who, in some cases, did not want to approach the carrier for fear of contagion.

In addition to the lack of protocols, there was a lack of information and specific training for secondary transports of this type. The only official document used to monitor the condition of the patient in flight during the transfer by helicopter was the rescue report (normally also used by the AREU during primary missions, both by helicopter and by road). With regard to transfers carried out by non-AREU crews, it can be said that there was no univocal document similar to the MSA rescue report.

Fig. 3. Patient transfer request form.

4.4. Facing an unpredictable emergency

Undoubtedly, the COVID-19 emergency represented an important test for the entire nation, and in particular the Lombardy region found itself in an unprecedented emergency condition whose management involved all the institutions, both political and technical. The central concept at the basis of the criticalities encountered was based on the fact that the pandemic was completely unexpected: healthcare personnel found themselves facing the virus without being able to rely on specific protocols, without the necessary resources (at least at the beginning) and without adequate preparation.

Initially, one of the primary challenges, contributing to a significant absence of a database (despite efforts to reassemble), was the unavailability of a standardised computer system for sharing patient data and facilitating communication among the entities involved in air transfers. AREU partly addressed this information gap by establishing registers that contained.

- Track of the clinical course (often reconstructed through telephone interviews);
- Available transport selection sheets;
- Any emails concerning the patient retrieved from the “drop box” created ad hoc by AREU;
- The evaluation sheet for the return of the patient to Lombardy;
- The ambulance staff's report on the return of the patient to Lombardy.

Also due to the overload of work to which the medical personnel of the facilities in the “red zone” were subjected, the transfer request form was often characterised by incomplete compilation. Indeed, the parameters entered were probably those that the clinician considered most representative of the situation, omitting the others. As a consequence, it happened that some patients, already included in flight programmes, were then not suitable for a ‘second look’: finding and preparing in a short time another patient to be transported in certain cases slowed down the operations.

This category of patients deserved further consideration: as with COVID-19 patients, efforts were made to ensure them an adequate level of continuity of care. However, the criteria for selecting the patients to be transported were unknown: no medical record were drawn up for this type of MEDEVAC, which was entirely parallel to that of COVID-19 patients, the main focus of the study. In any case, consulting the medical history of these patients revealed that they were critically ill. The same applied to road transfers: at the beginning of this story, a format with selection criteria was missing.

5. Conclusions

The MEDEVAC concept in the civil sphere was finally consolidated during the pandemic context. There, civil aircraft were fielded alongside military means. Despite of the extreme changeability of events, an organisational model was created from scratch, which could be adapted to the situation on the basis of the resources already present and those made available from time to time with regard to the needs encountered.

The selection of patients to be transferred was based on clinical and logistical criteria, but it was not possible to trace the rules used to definitively validate transport requests. In any case, considering the overall mortality of patients involved in MEDEVAC operations (28 %) and comparing it with the mortality of those admitted to ICUs during the same period (26 %), it can be stated that, thanks to the transfers, an adequate level of continuity of care was maintained.

On the basis of this MEDEVAC experience and the critical points outlined above, some suggestions for improving the logistics system are proposed.

- Create a computer system for the exchange of clinical and management information between CROSS, AREU, transport authorities (Air Force, private companies), HEMS bases;
- Draw up and disseminate the MEDEVAC guidelines to all hospital facilities, maintaining the patient assessment form and urging clinicians to complete it accurately;
- Draw up a common transport report to be attached to the patient's file (regardless of the type of air or land transport);
- Create shared protocols regarding patient management (pre-transfer, during loading manoeuvres, in flight and after landing);
- Implement courses to train medical personnel and make them aware of the problems involved in transporting critical patients in flight and instruct them in the management of in-flight emergencies;
- Reserve and permanently equip a number of fixed-wing aircrafts for medical transport;
- Implement dialogue with the CROSS in order to develop shared protocols, also with a view to cooperation in other contexts.

CRedit authorship contribution statement

Nazzareno Fagoni: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Giuseppe Stirparo:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Giuseppe Maria Sechi:** Writing – review & editing, Validation, Supervision, Project administration. **Andrea Comelli:** Writing – review & editing, Validation, Supervision, Project administration. **Gabriele Perotti:** Writing – review & editing, Validation, Supervision, Project administration. **Guido Francesco Villa:** Writing – review & editing, Validation, Supervision, Project administration. **Alberto Zoli:** Writing – review & editing, Validation, Supervision, Project administration. **Marco Botteri:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization.

Declaration of competing interest

I hereby declare there are no interests to disclose, in accordance with the guidelines set forth by the journal in relation to the manuscript entitled “*The leading “blended” civil medical evacuation operation (MEDEVAC) in unforeseen health emergency. From military use to civil development*” submitted for publication in “*Travel Medicine and Infectious Disease*”.

I understand that the disclosure of interests ensures transparency and upholds the integrity of scientific research. Furthermore, I assure the journal that our research has been conducted impartially and without bias.

All authors concurred with the submission of this paper. The work contained within this paper is not being considered for publication elsewhere.

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