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SCIENTIFIC LETTER

Quality and safety of ECMO transport. Practical aspects from our experience

Calidad y seguridad del transporte en ECMO. Aspectos prácticos derivados de nuestra experiencia

Dear Editor:

The use of extracorporeal membrane oxygenation (ECMO) systems in critical cardiac and respiratory disease has continued to grow steadily in recent years, despite being a highly complex technique with a variable impact on patient morbidity and mortality. In addition to the evidence obtained in clinical trials, expert recommendations such as those published by the Spanish Society of Intensive Care Medicine, Critical Care and Coronary Units (SEMICYUC), in the context of use and indications[1] or transport of the technique,[2] are very useful. We present our experience with the organization and transfer in ECMO, highlighting organizational and safety aspects that may be useful for other groups to improve the quality of care for these complex patients.

The hospital's mobile ECMO program grew out of the need to provide secondary transport, i.e., to transfer patients already on ECMO from our center to the referral hospital for cardiac transplant evaluation. Shortly thereafter, and to facilitate access to the technique for patients located in other nearby hospitals, it was decided to expand coverage to include primary transport, i.e., the displacement of an expert team for cannulation and the start of therapy in a hospital without ECMO capacity, followed by transfer to our center with the support.[2] The first step was the creation of a multidisciplinary unit, which we call the Mechanical Circulatory Assist Unit (UAMC-HUVN), consisting of intensivists, cardiovascular surgeons and perfusionists. We remain committed to this multidisciplinary organizational model, which enhances the quality of care and covers all events that may occur during cannulation and transport. The model considers the role of the cardiovascular surgeon if surgical cannulation or vascular repair is required, or the role of the perfusionist in managing potential device incidents.

The mobile ECMO team consists of an intensivist, a cardiovascular surgeon and a perfusionist, along with out-of-hospital transport staff (technician and nurse) and, also often one or two resident physicians. We have established an ''ECMO code'' with the out-of-hospital transport system, and with a single call, two ambulances are activated: a conventional ambulance for staff and supplies; and a second one specific for transfer of the critical patient. Since 2016, at UAMC-HUVN we have performed 40 interhospital ECMO transfers (80% primary transfers), 28 of which (70%) were performed in the last four years. Ten of the transfers (25%) were to a hospital in the same province, while the rest corresponded to interprovincial transport: 17 to Almería (42.5%), eight to Córdoba (20%), four to Jaén (10%) and one to Málaga (2.5%). The clinical characteristics of the patients are shown in Table 1. All transfers were by land. There were no deaths or serious complications during transfer, although five minor complications occurred: three related to the means of transport (low power supply and mechanical failure), one to the patient (hypoxemia), and one to the staff (incorrect labeling of blood products).

In full accordance with the aforementioned SEMICYUC recommendations,[2] we would like to highlight the strengths of our mobile ECMO program (Fig. 1):

- **Continuous and effective communication** between the participating hospitals, particularly in aspects such as optimization of the pre-ECMO clinical situation, adequate preparation of the patient before team arrival (cannulation of new vascular accesses, need for prior transfusion or preparation of blood products for transport, availability of ultrasound and/or transesophageal probe, light source, etc.), or information for the patient's family. To strengthen this good relationship between hospitals, lectures have been given at the ''donor'' centers and joint conferences have been held, thus creating an environment of trust and cooperation.
- **Multidisciplinary decision-making**. Once the patient's medical record is received, all cases are discussed amongst the intensivist (with ECMO experience) and cardiovascular surgeon - and often by several members of each specialty - which promotes shared decision-making and provides reassurance to the specialists. In this way, we gain a better perspective when making decisions and reinforce teamwork, which is associated with bet-

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Table 1 Demographic and clinical characteristics of the transferred patients on ECMO.

Age in years (mean ± SD)	46 ± 12
Gender (n, % males)	28 (72)
BMI	28 ± 5
SAPS-3	63 ± 12
Previous history (n, %)	
Smoking	20 (50)
AHT	12 (30)
DM	7 (17.5)
DL	12 (30)
Ischemic heart disease	4 (10)
Diagnoses (n, %)	
AMI	18 (45)
Myocarditis	3 (7.5)
Decompensated chronic HF	2 (5)
Arrhythmic storm	1 (2.5)
Bacterial pneumonia	6 (15)
COVID-19 pneumonia	6 (15)
Influenza A pneumonia	3 (7.5)
Polytrauma	1 (2.5)
Cannulation (n, %)	
Percutaneous, peripheral	38 (95)
Surgical, peripheral	2 (5)
Configuration (n, %)	
Veno-arterial	24 (60)
Veno-venous	16 (40)
Type of transfer (n, %)	
Primary	32 (80)
Secondary	8 (20)
Distance in km (mean ± SD)	112 ± 70
Days on ECMO (mean ± SD)	12 ± 10
Mortality in support (n, %)	10 (25)
In-hospital mortality (n, %)	14 (35)

AHT: arterial hypertension; AMI: acute myocardial infarction; BMI: body mass index; DL: dyslipidemia; DM: diabetes mellitus; ECMO: extracorporeal membrane oxygenation; HF: heart failure; SAPS: Simplified Acute Physiology Score.

ter outcomes.[3] This is what we call dual **opinion or dual assessment** in decision-making.

- **Proper transfer planning** is essential. We have a specific protocol that is summarized in the form of a checklist (Fig. 2), but prior planning for each case is also crucial:
  - Which hospital are assisting? Have we been there before? How far is it and what is the expected travel time?
  - Do we know the compatibility of materials and connections? Sometimes there may be compatibility problems with the monitoring equipment (electrodes, pulse oximeters, etc.), which we have solved by moving with an autonomous portable monitor and its consumables.
  - What cannulation strategy will we use? What vascular accesses does the patient have?
- With experience, we have learned to **simplify things within the complexity** of this procedure. The transfer material and medication have been reduced to the minimum expression (cannulas and wires, double circuit, surgical material, etc.), and are integrated into two transfer cases (one with medication and consumables, periodically checked by the intensivist; other with surgical material and cannulas, checked by the perfusionist) (Fig. 3A). We included a refrigerator for blood products and oxygen cylinders (from two to four, depending on the distance), but we have left out the gasometer, which is less useful for short transfers. Similarly, we were able to **find solutions to problems** that arose in some cases, such as checking the electrical system of the ambulance at the exit of the team, minimizing the number of perfusions to facilitate transfers, or obtaining adapters for oxygen/air supply points that we may find in other centers (Fig. 3B).
- The professionals are in a **period of continuous learning**, as it cannot be otherwise.[4] The transfer protocol is constantly being revised and updated, which has allowed us to simplify it based on the experience gained. It is a good idea to keep a record of cases and to debrief transfers and possible incidents.[5] In the absence of simulations, the incorporation of new professionals into the program is

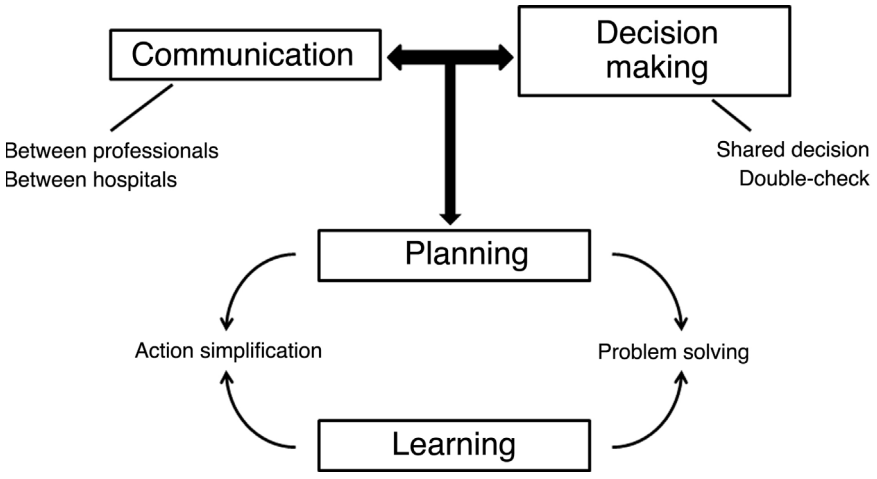

Figure 1 Key points of the mobile-ECMO program.

TRANSFER CHECKLIST OF ECMO PATIENTS

Intensive Care Unit - H.U. Virgen de las Nieves (Granada)

PRE-ECMO PHASE (in case of primary transfer)		
DATA TO BE REQUESTED	- Weight and height.	
	- Vascular accesses: are there any changes to be made?	
	- Crossmatching and blood product reserve: is prior transfusion required?	
	- TTE / TEE available	
	- Type of gas connection	
	- Information to family members and informed consent	

TRANSFER ACTIVATION AND PREPARATION	
REQUEST CRITICAL TRANSPORTATION (indicate "ECMO Code")	
PREPARE DEPARTURE MATERIALS: medical bag, transfer monitor, ECMO machine, surgical bag and O_2 canisters.	
STAFF VERIFICATION: Cardiovascular surgeon, Intensivist, ECMO specialist, Perfusionist, Resident, Critical care transport staff.	
CHECK POWER SUPPLY OF THE AMBULANCE.	

PRE-TRANSFER OPTIMIZATION OF THE PATIENT WITH ECMO	
Increase, if necessary, the **temperature of the heat exchanger**, and place a **thermal blanket**.	
Administer as much **medication** as possible prior to transfer (e.g., antibiotics), and prepare the medication for transfer (e.g., sedation).	
Renew all perfusions to be transferred (mainly vasoactive drugs)	
Perform **gasometric control** of the patient and ECMO before departure.	
Consider carrying out an **ACT control** prior to departure.	
Prepare blood products (2-4 packed red blood cell units) in a refrigerator for transport, **check the identity of the products**, and add specific infusion systems.	
NGT to gravity,	
Change **urine collector** to a carrying bag.	
Place **closed suction probe** in the orotracheal tube.	
Ensure adequate monitoring (remove BIS, remove CVP/PAP transducer, place transfer patches, etc.).	

ADDRESS THE SITUATION INSIDE THE AMBULANCE	
Patient restraint; *assess* head immobilization if jugular cannulation is performed.	
Fixation of ECMO and monitoring **devices**.	
Accessibility of **airway material** and check operation of the suction system.	
Keep important **medication at hand**	

Figure 2 Interhospital transfer checklist with ECMO.

facilitated by progressive participation in transfers, under the supervision of another experienced intensivist, and by the existence of a transfer checklist which, in addition to being a patient safety measure,[6] is of great help during the learning phase.

In summary, mobile ECMO programs should consist of multidisciplinary teams with problem-solving skills and continuous learning, where communication and shared decision-making are the norm.

Appendix A. UAMC (Unidad de Asistencia Mecánica Circulatoria) del Hospital Universitario Virgen de las Nieves

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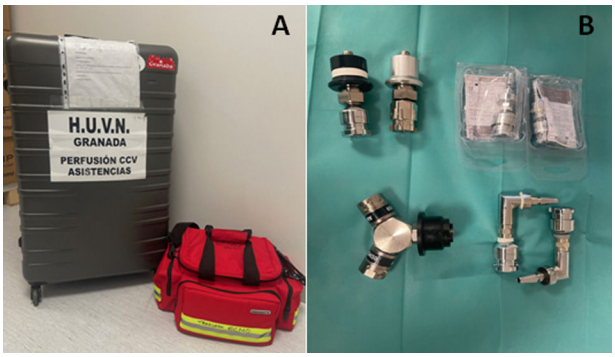

Figure 3 A. Interhospital transfer suitcases; B. Various adapters for air and oxygen connections.

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Declaration of competing interest

The authors declare that they have no conflicts of interest.

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