Scientific letter

Initial experience of an interhospital rescue program through a mobile extracorporeal membrane oxygenation team within a cardiology department

Experiencia inicial de un programa de rescate interhospitalario mediante oxigenador extracorpóreo de membrana dependiente de cardiología

To the Editor,

Cardiogenic shock (CS) remains a major cause of morbidity and mortality.[1] In recent years, attention has focused on the organization of CS treatment through a "shock code" to ensure early and comprehensive treatment covering the full spectrum of CS. A key element of this strategy for improving outcomes is the centralized treatment of CS patients at referral centers. This strategy addresses the complexity of the treatment required by these patients, the need for specialized staff, and the dedicated health care technology used to treat CS, which significantly increases costs and is associated with a high complication rate.[2] One of the most challenging aspects of shock-code organization is the interhospital transit of unstable CS patients. Patient survival is improved by the establishment within the shock code of mobile units able to travel to lower-level centers, implant an extracorporeal membrane oxygenation (ECMO) circulatory assist device, and transfer the patient to the referral center.[3]

As part of our integrated SC care program, in March 2019 our referral hospital established a mobile ECMO unit to provide cover to the other centers located in our Spanish autonomous community. The program is available 24 hours a day, and medical staff at the lower-level center alert the referral center about a patient requiring ECMO by calling the same emergency telephone number used for the heart transplantation program. The mobile ECMO unit is activated on an individual basis, according to the patient's clinical status and possible contraindications. The unit is led by 2 cardiologists, who travel to the lower-level center to implant a venoatrial ECMO (VA-ECMO). The ECMO unit cardiologists take charge of circuit priming, device implantation, and subsequent clinical treatment. The accompanying nursing staff and ambulance technician are members of the emergency ambulance service. The team travels to the patient in a mobile ICU. The device used is the CARDIOHELP-system (MAQUET-Cardiopulmonary-AG, Germany). The procedure is performed at the patient's bedside and is monitored by transesophageal echocardiography. For ambulance transit, the patient is sedated, given analgesic therapy, and placed on mechanical ventilation.

From March 2019 to November 2020, the mobile ECMO unit attended 9 patients with severe CS (7 men and 2 women; mean age 51.0 ± 12.6 years, median age 52 [interquartile range, 17.5]). Demographic characteristics and the indications for circulatory assistance are summarized in table 1. The most frequent indication was CS subsequent to myocardial infarction (3 patients; 33.3%). ECMO was implanted in 1 patient with refractory cardiorespiratory arrest. The mean distance traveled was 92 ± 55 km, and the median distance was 128 [100] km. The mean and median times from program activation to arrival at the intervention hospital were 80 ± 36 minutes and 100 [62] minutes, respectively. The mean and median times from arrival to treatment initiation were 35 ± 11 minutes and 35 [20] minutes, and the mean and median cannulation times were 24 ± 9 minutes and 25 [14] minutes. Cannulation was percutaneous in 8 patients, whereas 1 patient required vessel exposure due to the presence of a femoral pseudoaneurysm. Due to the severity of the CS, all patients were deeply sedated and mechanically ventilated before

Table 1
Demographic characteristics and indications for ECMO

	Patients								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
Sex	M	W	M	M	M	W	M	M	M
Age, y	66	60	55	37	50	51	52	26	62
Indication	AMI	PTE	RCA	Toxins	ES	Sepsis	AMI	Myocarditis	AMI
Distance, km	128	5	5	128	128	128	128	50	128
Time from activation to arrival, min	105	20	20	100	100	95	105	65	110
Time from arrival to treatment, min	45	25	15	35	40	35	45	25	50
Cannulation time, min	25	15	11	25	22	25	36	18	40
Total time, min	275	105	90	260	240	235	260	160	280
Inotropic index*	87	210	15	107	103	210	107	80	510
mSOFA score	9	11	9	8	10	8	7	11	15
Lactate, mmol/L	5.2	7	10	15	3	3.9	5.1	8	9
ECMO, days	19	2	10	8	6	4	10	8	1
Progression	Explant	Death	Explant	Explant	Death	Explant	BVAD, HT	Explant	Death
Survival	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No
Cause of death	—	Bleeding	—	—	CVA	—	—	—	MOF

AMI, acute myocardial infarction; BVAD, biventricular assist device; CVA, cerebrovascular accident; ECMO, extracorporeal membrane oxygenation; ES, electrical storm; HT, heart transplantation; M, man; MOF, multiorgan failure; mSOFA, modified Sequential Organ Failure Assessment; P, patient; PTE, pulmonary thromboembolism; RCA, refractory cardiorespiratory arrest; W, woman.

* Wernovsky inotropic index = dopamine dose + dobutamine dose + 100 × epinephrine dose + 100 × norepinephrine dose + milrinone dose × 15 mg/kg/min.

the arrival of the mobile ECMO unit. Mean and median arterial lactate concentrations before ECMO were 7.4 ± 3.7 mmol/L and 7.0 [5.0] mmol/L, respectively. Mean and median values for the modified Sequential Organ Failure Assessment scale[4] (mSOFA) were 10 ± 2 and 9 [3], and the corresponding values for the Wernovsky inotropic index were 159 ± 145 and 107 [127]. The mean and median times from ECMO unit activation to the arrival of the patient at our center were 212 ± 74 minutes and 240 [135] minutes, respectively. None of the patients had transit-associated complications or morbidity, and there were no device-related logistical or technical complications. Mean treatment time was 7.5 (range, 1-19) days. ECMO was successfully removed from 55.9% (5/9) of the patients; 3 patients died during treatment and 1 required heart transplant (with prior implantation of a Centrimag biventricular assist device after 10 days of ECMO). In-hospital survival was 66.7% (6/9), and all 6 survivors were alive at the time of writing. Of the deceased patients, 2 died due to bleeding complications (1 due to hemorrhage at the femoral artery cannula and 1 due to intracerebral hemorrhage), and the other died of multiorgan failure during treatment.

There is little accumulated experience in Spain with programs for the interhospital transfer of patients on VA-ECMO.[5] Most interhospital transfers of this type have been of patients implanted with the device at a lower-level hospital and transferred to a referral center for heart transplant evaluation. Our findings demonstrate the feasibility of an ECMO rescue program focused on percutaneous access and run by a cardiology service. The success of such a service requires staff training not only in the implantation technique, but also in device control and the clinical treatment of the patient. The establishment of this type of unit is essential for centralizing expertise and resources to optimize the networked treatment of CS.

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Caval valve implantation for percutaneous treatment of tricuspid regurgitation: preprocedural anatomical assessment

Implante de prótesis en cavas como tratamiento percutáneo de la insuficiencia tricúspide: evaluación anatómica preprocedimiento

To the Editor,

Moderate to torrential tricuspid regurgitation (TR) is estimated to affect 1.6 million people in the United States.[1] The classic treatment for TR is optimal medical therapy—mainly diuretics or surgery. However, surgical mortality in isolated tricuspid valve interventions is significantly higher than in any other single valve (~9%).[1] Across the growing range of percutaneous therapeutic alternatives for TR, heterotopic caval valve implantation (CAVI) including Tricento (NVT, Germany) and TricValve (Products&Features, Austria) systems[2,3] might be the preferred option when right chamber dilation is more advanced or in patients with prior pacemaker leads. Evaluation of caval anatomy is crucial. Therefore, we aimed to analyze the computed tomography (CT) scans of candidates for this therapy as well as cadaveric models in order to: *a)* describe main variations of right heart and caval anatomy relevant for CAVI candidates; and *b)* develop a standardized CT evaluation prior to CAVI procedure.

CT scans from 32 patients with severe to torrential TR eligible for CAVI procedure after exclusion of alternative therapies were centrally analyzed. Images were obtained on a 128-detector row CT scanner (Revolution CT, GE Healthcare, Waukesha, Wisconsin, United States). We tailored the protocol by injecting 75 mL of iodixanol (Visipaque 320 mg/mL) via an antecubital vein. We manually started the acquisition when the pulmonary artery was completely opacified. Additionally, we prepared a delayed acquisition to be started 70 to 90 seconds after contrast material injection (portal phase) to be performed if the inferior vena cava (IVC) and the hepatic veins were not well opacified in the first study. Finally, 3 cadaveric models were used for structural direct analysis. All patients provided informed consent and the study was approved by local ethics committee.

The main measurements and risk thresholds for superior vena cava (SVC) and IVC are summarized in figure 1. The mean cranial-caudal length of SVC was 59.3 ± 10.5 mm potentially leading to mean protrusion into the right atrium of 8 mm, but up to 31.6 mm with the self-expanding TricValve device (simulated in figure 1C). In addition, 7 patients (21.9%) showed marked tapering (confluence-junction index < 0.6). Both might condition a higher risk of leak and/or valve embolization suggesting the need for higher device implantation. However, this might be associated with a higher risk of azygous vein occlusion during the procedure as identified in the cadaveric model (figure 2C,D). The clinical relevance of this complication is currently unknown. Finally, in 11 patients (34.4%), a pacemaker lead was present.

The mean distance from IVC to upper part of hepatic veins was 8.9 ± 2.5 mm, potentially excluding 30 patients (93.75%) from receiving a self-expanding Tricento device whose current limit is 12 mm. However, in none of them was this distance prohibitive for TricValve. In addition, the angle determined by the IVC segments