

REFERENCES

1. Holmes Jr DR, Mack MJ, Kaul S, Agnihotri A, Alexander KP, Bailey SR, et al. 2012 ACCF/AATS/SCAI/STS expert consensus document on transcatheter aortic valve replacement. *J Am Coll Cardiol*. 2012;59:1200–54.
2. Mummert J, Sirois E, Sun W. Quantification of biomechanical interaction of transcatheter aortic valve stent deployed in porcine and ovine hearts. *Ann Biomed Eng*. 2013;41:577–86.
3. Tzamtzis S, Viquerat J, Yap J, Mullen MJ, Burriesci G. Numerical analysis of the radial force produced by the medtronic-corevalve and edwards-sapien after transcatheter aortic valve implantation (TAVI). *Med Eng Phys*. 2013;35:125–30.
4. Achenbach S, Delgado V, Hausleiter J, Schoenhagen P, Min JK, Leipsic JA. SCCT expert consensus document on computed tomography imaging before transcatheter aortic valve implantation (TAVI)/transcatheter aortic valve replacement (TAVI). *J Cardiovasc Comput Tomogr*. 2012;6:366–80.
5. Hayashida K, Bouvier E, Lefevre T, Chevalier B, Hovasse T, Romano M, et al. Transcatheter aortic valve implantation for patients with severe bicuspid aortic valve stenosis. *Circ Cardiovasc Interv*. 2013;6:284–91.
6. Sun W, Li K, Sirois E. Simulated elliptical bioprosthetic valve deformation: Implications for asymmetric transcatheter valve deployment. *J Biomech*. 2010;43:3085–90.

<http://dx.doi.org/10.1016/j.rec.2013.10.014>

Initiation of an Inter-hospital ECMO Transfer Program for Patients Suffering From Severe Acute Heart and/or Pulmonary Failure



Experiencia inicial de un programa de transporte interhospitalario con ECMO para pacientes con insuficiencia cardíaca aguda y/o insuficiencia respiratoria grave

To the Editor,

Extracorporeal membrane oxygenators (ECMO) are an efficient means of providing emergency pulmonary and circulatory support for patients with cardiogenic shock refractory to conventional intensive therapy or hypoxic-hypercapnic respiratory failure refractory to advanced ventilation strategies.^{1,2}

Currently, ECMO use is limited to certain specialized tertiary centers that are both equipped to implement programs and experienced in their management. Hospitals that cannot undertake heart surgery or initiate ECMO find it extremely difficult to treat patients in refractory cardiogenic shock. Transferring patients to centers with better technical resources can be the only alternative but is often considered inviable due to their hemodynamic instability. Recent experience confirms that creating mobile heart surgery units—where support devices can be implanted in situ, followed by stabilization and transfer to a specialized center—offers these critical patients a chance of survival.^{3–5}

The objective of the present study is to determine the feasibility and safety of an inter-hospital transfer program for critical patients with ECMO support. We describe the logistic problems, indications, complications, and clinical course of the patients enrolled.

The Cardio-Thoracic Surgery Service of the J.W. Goethe University Hospital, Frankfurt, Germany, established a Distance Cardiac Care Unit to provide ECMO circulatory support for institutions in the Hessen area lacking this therapeutic resource. The unit was created in December 2011 and consists of a perfusionist and a heart surgeon permanently on call and in direct contact with the secondary hospitals' critical care units.

Veno-arterial ECMO support implantation was indicated in cases of cardiogenic shock refractory to conventional critical care treatment (systolic blood pressure under 80 mmHg, administration of at least two inotropic agents, and/or counterpulsation balloon and signs of inadequate perfusion).^{1,2} Veno-venous support was indicated in cases of hypoxic-hypercapnic respiratory failure refractory to advanced ventilation strategies (respiratory distress syndrome).^{1,6}

We used the PLS extracorporeal system (Maquet AG; Germany), consisting of a closed polyvinyl circuit, membrane oxygenator and centrifugal pump. The patient was intubated using percutaneous venous cannulas (17–25 Fr) and arterial cannulas (18–21 Fr). In patients with respiratory failure only, veno-venous ECMO support was established by using the Seldinger technique of inserting cannulas in both femoral veins, lodging one in the right atrium (outflow) and the other in the inferior vena cava (inflow). In cases of cardiogenic shock, veno-arterial ECMO support was surgically implanted in the deltopectoral groove giving access to the axillary artery to connect the arterial line and a venous cannula inserted percutaneously in the inferior vena cava. Procedures were performed under general anesthetic in the patient's intensive care unit bed, after administering 10 000 U heparin.

Table 1

Demographic Characteristics of Patients Enrolled. Causes of Cardiorespiratory Failure. Indications for ECMO and ECMO Support Type

Patient	Sex	Age	Etiology	Indication for support	Type of support
1	W	18	Drowning; immersion syndrome	CS + RDS	V-A
2	M	36	Attempted suicide by drug overdose; pneumonia due to aspiration	RDS	V-V
3	M	58	Acute myocarditis	CS	V-A
4	M	46	Pneumonia caused by <i>Influenza A</i>	RDS	V-V
5	M	43	Pneumonia caused by staphylococcus; right heart failure	CS + RDS	V-A
6	M	61	Acute myocardial infarction	CS	V-A
7	W	46	Pneumonia caused by <i>Influenza</i>	RDS	V-V
8	M	60	Pneumonia caused by <i>Influenza A</i>	RDS	V-V
9	M	55	Pneumonia caused by aspiration	RDS	V-V
10	M	52	Pneumonia caused by <i>Influenza</i>	RDS	V-V

CS, cardiogenic shock; ECMO, extracorporeal membrane oxygenator; M, man; RDS, respiratory distress syndrome; V-A, veno-arterial ECMO; V-V, veno-venous ECMO; W, woman.

Table 2

Inter-hospital Distances and Transport Times for Critical Patients With ECMO Support. Type of ECMO Support Implanted and Support Duration. Patient Postoperative Clinical Course

	Patient										Summary
	1	2	3	4	5	6	7	8	9	10	
Transfer											
Distance, km	15	25	15	80	15	15	10	8	15	15	Mean SD, 21.3 (21.1)
Time, min	31	45	29	90	32	34	28	25	31	30	Mean SD, 37.5 (19.2)
ECMO support											
Type	V-A	V-V	V-A	V-V	V-A	V-A	V-V	V-V	V-V	V-V	
Time, h	216	258	264	456	265	99	143	155	161	201	Mean SD, 221.8 (99.8)
Explantation	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	70
Survival	Yes	Yes	No	Yes	Yes	No	Yes	No	No	No	50

ECMO, extracorporeal membrane oxygenator; SD, standard deviation; V-A, veno-arterial ECMO; V-V, veno-venous ECMO.

Data are expressed as % or mean (standard deviation).

From December 2011 to April 2013, 10 patients in critical condition (8 men, 2 women), with mean age 46.7 (standard deviation, 15.3) (range, 18–61) years, required ECMO support in secondary hospitals in Hessen; inter-hospital transfer to our center took place post-implantation. In all cases, transfer was by road, in a mobile intensive care unit. The heart support team's preparation time was 25 minutes and time from call-out to implantation, 90 minutes.

The demographic characteristics of patients and underlying causes of their need for cardiopulmonary support are in Table 1. Six patients presented with severe pulmonary failure only and received veno-venous ECMO implants; 2 in cardiopulmonary failure and 2 in cardiogenic shock had veno-arterial ECMO implantations. Once the indication for support and support type had been established, patients were connected to the ECMO circuit. There were no complications due to percutaneous venous cannulation. A surgical approach using axillary artery access was needed in 4 patients, with no complications.

Table 2 shows the mean transfer distance was 21 (8–80) km and unit-to-unit transport time, 37 (25–90) min. No device-related logistical or technical complications arose during implantation or transfer. None of the patients had transfer-related complications, morbidity, or mortality.

Table 2 shows the patients' postoperative clinical course. The ECMO systems were explanted after a mean 9.7 (4–19) days on support. Explantation was successful in 70% of patients (7/10) and survival to discharge was 50%. In-hospital mortality was similar to that of 119 patients receiving ECMO support in our center during the same period (51%).

We conclude that, in our experience, emergency implantation of ECMO-type cardiopulmonary support in external institutions and subsequent transfers of patients to regional referral centers are feasible in practice, with reasonable mid-term results.

María José Dalmau,^{a,*} Andrés Beiras-Fernández,^a Harald Keller,^b Tobias Bingold,^c Anton Moritz,^a and Ulrich Stock^a

^aKlinik für Thorax- Herz-und Thorakale Gefäßchirurgie, Klinikum der Johann Wolfgang Goethe Universität, Frankfurt am Main, Germany

^bKardiotechnik Abteilung, Maquet Vertrieb und Service, Klinikum der Johann Wolfgang Goethe Universität, Frankfurt am Main, Germany

^cKlinik für Anästhesiologie, Intensivmedizin und Schmerztherapie, Klinikum der Johann Wolfgang Goethe Universität, Frankfurt am Main, Germany

*Corresponding author:

E-mail address: dalmau_mjo@gva.es (M.J. Dalmau).

Available online 16 February 2014

REFERENCES

- Allen S, Holena D, McCunn M, Kohl B, Sarani B. A review of the fundamental principles and evidence base in the use of extracorporeal membrane oxygenation (ECMO) in critically ill adult patients. *J Intens Care Med*. 2011;26:13–26.
- Marasco SF, Lukas G, McDonald M, McMillan J, Ihle B. Review of ECMO (extra corporeal membrane oxygenation) support in critically ill adult patients. *Heart Lung Circ*. 2008;17 Suppl 4:41–7.
- Beurthelet S, Mordant P, Paoletti X, Marijon E, Celermajer DS, Léger P, et al. Emergency circulatory support in refractory cardiogenic shock patients in remote institutions: a pilot study (the cardiac-RESCUE program). *Eur Heart J*. 2013;34:112–20.
- Gariboldi V, Grisoli D, Tarmiz A, Jaussaud N, Chavignac V, Kerbaul F, et al. Mobile extracorporeal membrane oxygenation unit expands cardiac assist surgical programs. *Ann Thorac Surg*. 2010;90:1548–52.
- Haneya A, Philipp A, Foltan M, Mueller T, Camboni D, Rupprecht L, et al. Extracorporeal circulatory systems in the interhospital transfer of critically ill patients: experience of a single institution. *Ann Saudi Med*. 2009;29:110–4.
- Papadopoulos N, Ahmad Ael-S, Marinos S, Moritz A, Zierer A. Extracorporeal membrane oxygenation for influenza-associated acute respiratory distress syndrome. *Thorac Cardiovasc Surg*. 2013;61:516–21.

<http://dx.doi.org/10.1016/j.rec.2013.10.010>