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Primary transport on extracorporeal membrane oxygenation: Two Indian center experience

Sandip Gupta, Arpan Chakraborty, Kunal Sarkar, Dipanjan Chatterjee, Pranay Oza

ABSTRACT

Aims: Extracorporeal membrane oxygenation (ECMO) can be a lifesaving modality for patients with severe reversible pulmonary and/or cardiac failure, but its use remains restricted to a few highly equipped referral centers. Conventional transports to an ECMO center can be hazardous. Transport teams are usually trained to transfer stable patients across hospitals. As ECMO patients are extremely sick, specially trained critical care teams to deal with all possible complications in these critically ill patients will be required. Therefore, many ECMO centers have developed transport programs with the mobile ECMO team. In this study, we aim to present a brief account of the two-center experience of ECMO transport from India.

Methods: Retrospective observational study is depicting the data of two mobile ECMO teams over 4 years, where 21 patients (16–74 years) were evaluated. Analysis was done for the transport arrangements, different characteristics of ECMO retrieval patients, their outcomes, and predictors of mortality of a total of 21 patients from two different referral centers of India. As it is a retrospective observational study, hence institutional ethical committee approval was waived off.

Results: The mean distance of travel was 87.24±104.5 km (range 2–250 km) and transportation was by road in all cases. About 38% (n=8/21), patients had suffered from complications during transport like hypotension, cardiac arrest. There were no deaths in connection with transportation. The overall mortality rate was 33.3% with no difference over gender, age, duration of pre-ECMO ventilation, or duration of transport. The most common indication associated with ECMO transport was H1N1 infection.

Conclusion: We found that patient transfer if done with proper protocols by a prepared team with full knowledge of problem areas to a referral institution while on ECMO support seems to be safe and adds no significant risk of mortality to ECMO patients.

Keywords: Acute respiratory failure, Extracorporeal membrane oxygenation, Mobile ECMO team, Retrieval, Transport

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INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) has become more and more recognized as a treatment modality for the treatment of refractory respiratory and/or cardiac failure [1, 2]. As only a few designated centers with expertise can provide ECMO support, hence the patients

who require ECMO therapy need to be transported to these hospitals. Moreover, the critical nature of the illness makes conventional transport risky and susceptible to adverse events so often there is a need for cannulation at referring hospitals and then transporting patients on ECMO [3–5]. In the developed world, most specialized centers have a dedicated transport team for ECMO retrieval, thus ensuring the safety of the patients [6, 7]. In developing nations, like India, there has been a rapid rise in the use of ECMO in recent years, but data regarding ECMO transport is scarce. This study aims at describing a brief account of different characteristics of ECMO retrieval patients, their outcomes, and predictor of mortality of a total of 21 patients from two different centers in India, Medica Hospital, Kolkata, and Ridhivinayak Critical Care & Cardiac Center (RVCC), Mumbai.

MATERIALS AND METHODS

Data from both the hospitals were retrospectively collected from patient's hospital charts, which are biometrically protected and stored in hospital servers. The additional data were obtained from the patient's ambulance charts. We collected the following data: age group, gender, diagnosis, type of ECMO, time taken to transport, and distance traveled. As it is a retrospective observational study, hence institutional ethical committee approval was waived off.

Logistics

All 21 patients with pulmonary (n=18) or cardiac failure (n=3) were transported by ambulance by road from the local center to referral hospitals. All the transports from 2015 to September 2019 were included in this study.

The study population consisted of patients from the age range of 16–74 years, with a mean age of 46.29±16.6. There were 10 females and 11 males. Diagnoses leading to initiation of ECMO were acute respiratory distress syndrome (ARDS) post-infectious/sepsis (n=15, 71.4%) ARDS post-trauma (n=1), cardiac failure (n=3, 14.3%) chloramphenicol poisoning (n=1), ventilator-associated pneumonia (n=1) as shown in Table 1.

The severity of illness of the patients was estimated using the SOFA scoring system at Medica Hospital, Kolkata, and APACHE II score at RVCC, Mumbai.

All the transport was done by ground ambulance. Upon receiving a retrieval request, the lead anesthetist/intensivist in the unit decided to accept or not, after collecting details candidacy for transport based on primary diagnosis, ventilator parameters, hemodynamic support of primary disease process, and neurological state and ruling out the exclusion criteria. If the patient was eligible, then the referring hospital was asked to do the counseling about the potential risk associated with both transport and ECMO support.

Percutaneous cannulation with the Seldinger technique was used by the intensivist to insert the catheter by both teams. Ultrasonography was routinely used to verify the patency of the blood vessels and the insertion of the cannula.

ECMO team

We did have a special transport team dedicated to ECMO retrievals at both centers. At Medica, two senior intensivists, a perfusionist, and an ECMO nurse specialist were part of the team. At RVCC, the transport team included a single senior intensivist, two nursing staff, and a perfusionist. Upon reaching the ECMO center, on-site re-evaluation of the patient was done and, the need for ECMO, mode of ECMO, and cannulation approach was decided. Then after brief reinforced counseling, the retrieval team had performed the cannulation, started on ECMO support, and transported back to the referral center.

Transport equipment

ECMO transport is an emergency, hence all the required equipment was packed and kept ready in a storage section of ICU, with additional backup equipment such as circuits and cannula for safety in case of any adverse events. Table 2 summarizes the transport types of equipment used in the ambulances of both centers.

Data collection and analysis

Transport services were started in Medica, Kolkata on 03/02/2015 and in RVCC, Mumbai on 02/05/2012. Data collected here summarizes the transports done in both centers till August 2019. Data were obtained from our database and patients' records and ambulance charts. We collected the following data: age, group, gender, diagnosis, types of ECMO.

Statistical methods

SPSS 16 software (copyright 2007, SPSS Inc., Chicago, IL, USA) was used for data analysis. For frequency percentages, an independent *t*-test for continuous variables and the chi-square test/Fisher's exact test for categorical variables were applied. A p-value < 0.05 was considered significant.

RESULTS

The characteristics of the study population have been depicted in Table 1. The average distance of travel was 87.24 km (median: 30 km; range 2–250 km) and transportation was by road in all cases. There were no deaths in connection with transportation. Veno-venous (VV) ECMO was used in 17/21 (80.95%) patients whereas veno-arteria (VA) ECMO was required in 4/21 (19.05%).

As shown in Table 3, after an average of 11.9 days (median: 7 days; range 1–64 days), 14 patients (67%)

could be weaned from ECMO, while 7 patients (33%) died on ECMO. Mean ECMO time for those who died was 10.7 (median: 7) versus 12.5 days (median: 7) for survivors, p=0.78. There were no differences in early mortality related to gender. In the male 8 out of 11 survived, whereas in females 6 out of 10 had survived, p=0.87.

The mean age for survivors was 46 (median: 48.5; range: 19–74) versus 46.8 (median: 47; range: 16–67) years in fatal cases, p=0.91. The average duration of the transportation time on ECMO back to the hospital was 123 minutes (median: 120 min; range: 14–240 minutes) in survivors and 89.2 minutes (median: 33; range: 14–240 minutes) in non-survivors, p=0.70. The average distance of the transportation on ECMO by ambulance was 91.63 kilometers (km) (median: 34.5; range: 2.9–250 km) in survivors and 81.37 km (median: 14.5 and range: 2.4–250 km) in non-survivors, p=1.0 with no statistical significance of the difference between the two groups.

Duration of mechanical ventilation before ECMO was 4.71 days (median: 3 days; range: 1–16 days) hours in survivors and 4 days (median: 2 days and range: 1–13 days) in the non-survivors p=0.744. Among the etiologies, the most common cause was H1N1 infection which was present in 8/21 (38%), sepsis in 3/21, and malaria in 2/21 patients.

As shown in Table 4, out of a total of 20 patients, 8 (38%) patients had suffered from complications during transport like hypotension (n=3/21), cardiac arrest (n=2/21), cannulation site bleeding (n=2/21), tracheostomy bleeding (n=1/21), ambulance breakdown (n=1/21), power failure (n=1/21), hand cranking (n=1/21), lack of space in the lift (n=1/21). Complications during transport were not associated with ICU mortality.

Table 1: Summarizing the demographics, primary and secondary diagnosis, type of ECMO support, distance and duration of transport, and APACHE/ SOFA score of severity of illness of individual patients.

No.	Age	Sex	Primary diagnosis	Secondary diagnosis	Type	Duration of transport (min)	Distance of transport (km)	APACHE/ SOFA score
1	54	F	ARDS	H1N1 pneumonia	VV	180	35	APACHE-12
2	74	M	ARDS	Polytrauma	VV	35	5	APACHE-16
3	60	M	ARDS	H1N1	VV	240	250	APACHE-14
4	67	F	ARDS	Interstitial pneumonia with BOOP	VV	60	42	APACHE-21
5	28	F	ARDS	H1N1 pneumonia	VV	120	55	APACHE-16
6	16	M	ARDS	Leptospirosis	VV	20	4	APACHE-21
7	47	M	ARDS	H1N1 pneumonia	VV	240	210	APACHE-12
8	21	F	ARDS	Malaria	VV	240	220	APACHE-6
9	50	M	Pneumonia	VAP	VV	240	250	APACHE-8
10	47	M	ARDS	H1N1 pneumonia	VV	240	250	APACHE-6
11	53	M	ARDS	Viral myocarditis	VV	240	250	APACHE-11
12	55	F	ARDS	H1N1 pneumonia	VV	180	168	APACHE-4
13	46	M	ARDS	H1N1 pneumonia	VV	22	5	SOFA-15
14	19	F	Chloramphenicol poisoning	Arrhythmia	VV	22	2.9	SOFA-17
15	33	F	ARDS	H1N1 pneumonia	VV	14	6.7	SOFA-15
16	33	F	ARDS	Unknown	VV	33	14.5	SOFA-17
17	38	F	ARDS	Malaria	VV	14	2.4	SOFA-17
18	67	M	Cardiogenic shock	RV failure	VA	44	34	SOFA-19
19	67	F	Cardiogenic shock	Bacterial sepsis	VV	18	6.7	SOFA-18
20	49	M	ARDS	Unknown	VA	32	11.3	SOFA-11
21	48	M	Cardiogenic shock	Mitral regurgitation	VA	120	30	SOFA-17

ARDS: acute respiratory distress syndrome, BOOP: bronchiolitis obliterans organizing pneumonia, VAP: ventilator associated pneumonia, RV: right ventricle, VV: veno-venous, VA: veno-arterial, APACHE: Acute Physiology and Chronic Health Evaluation, SOFA: Sequential Organ Failure Assessment Score.

Table 2: Equipment used in both the centers during the study period

Equipment	RVCC, Mumbai	Medica, Kolkata
Oxygenator	MedosHilite, Sorin, Quadrox	Quadrox
Pump	Medtronic, Sorin	Maquet/GettingeRotaflow
Console	Medtronic, Sorin	Maquet/Gettinge
Transport ventilator	Horus	Philips Vm6
Monitor	Larsen & Toubro Star 50 monitor	Philips portable cardiac monitor
Heater	Maquet Hu 40	Maquet Hu 35
Stretcher	Customized stretcher	Customized stretcher
Circuit	Custom made circuit	MaquetPls kit
Catheter	Medtronic Biomedicus Venous Cannula 27, 29	Edwards Drainage 18, 20, 22, 24, 28 Fr
	Medtronic Biomedicus Arterial Cannula	Edwards Return
		16, 18, 20, 22, 24 Fr
Oxygen cylinder	2 cylinder, regular size	2 cylinder, regular size

Table 3: Transport-related predictors of ICU mortality

Variables	Non survivor (n=7)	Survivors (n=14)	p-value
Mean duration of the transportation time on ECMO	89.2	123	0.7
Mean distance of the transportation on ECMO	90	81.92	1
Mean duration of mechanical ventilation	4.71	4	0.744
Mean age for survivors	46	46.	0.91

Table 4: Details of total duration of ECMO, pre-ECMO ventilation, outcome, cause of death, and transport complications.

	Duration of ECMO (days)	Pre-ECMO ventilation	Outcome	Cause of death	Transport complications
1.	27	1	Survived		Hypotension, cardiac arrest
2.	4	15	Survived		None
3		4	Death	Sepsis, MOF	Cannula site bleeding
4	12	2	Death	DNR (BOOP)	None
5	64	16	Survived		Ambulance crack down
6	4	2	Death	DNR	None
7	20	6	Survived		Power failure
8	3	5	Survived		Cannula site bleeding, lift too small, hand cranking
9	5	4	Survived		None
10	18	11	Death	Sepsis	Tracheostomy site bleeding
11	10	1	Survived		None
12	5	4	Survived		None
13	7	2	Survived		None
14	5	1	Survived		None
15	14	2	Survived		Hypotension, cardiac arrest
16	3	1	Death	ICH	None
17	1	1	Death	ICH	Hypotension
18	7	1	Survived		None
19	12	7	Death	Sepsis	None
20	11	2	Survived		None
21	1	6	Survived		None

ICH: Intra cranial hemorrhage, BOOP: Bronchiolitis obliterans organizing pneumonia, MOF: Multi-organ failure.

DISCUSSION

ECMO is a lifesaving procedure for patients with refractory respiratory and/or cardiac failure, with only specialized centers providing ECMO, hence patients need to be shifted to these designated ECMO centers. Patients needing ECMO, in general, are too critical to be transported even on maximum ventilator settings and other intensive care support. Hence, there has been an increasing trend of cannulating the patient in the referring center and then transporting them on ECMO with the help of a mobile ECMO team [2–4].

Moreover, data from extracorporeal life support organization (ELSO) registry suggests that centers doing high volume ECMO experience have significantly lower mortality than units with lesser experience [8, 9]. This volume-mortality association has favored the development of the policy of developing centralize ECMO treatment rather than starting the ECMO program in multiple centers, the classical example being the current National ECMO service provision in England, where each of the five specialist ECMO centers supports a large number of regional hospitals, 24×7 with help of a well-equipped mobile ECMO team [10, 11].

The development of specialized ECMO teams and retrieval in developing countries like ours is in the nascent stage. In this study, we described the recent experience of ECMO transport from two high-volume ECMO centers in India. Patients were referred to both hospitals due to serious lung or heart failure. So far, in India, the majority of transportations on ECMO support are by road in the ambulance. All transports were performed without any deaths reported during transportation. This is in agreement with other reports [12–15]. None of the later deaths were related to transportation.

Overall survival till discharge in patients transported on ECMO was 66.7% and is comparable to the overall ECMO survival rate of 55% in ELSO data [16]. It is also comparable to the Swedish study by Lindén et al. [17], and Norway study by Wagner et al. [18], showing a survival rate of 72% and 66.7% respectively in patients needing transportation on ECMO. There was no difference in mean age, distance traveled and time of transport, pre-ECMO ventilation, and the total duration of ECMO support among the survivors and non-survivors (Table 3). In our study, 38% (8/21) of the patients had developed complications during transport which was similar to 28% as observed in a Swedish study by Fletcher-Sandersjöö et al. [12].

Limitations of our study include the retrospective nature of data and small sample size for statistical analysis, as well as the use of different scoring systems in the studies, which makes it difficult to compare expected mortality with final results. However, as previously described, the overall mortality rate was compatible with the expected mortality previously published in the ELSO registry.

CONCLUSION

Our limited data tends to support the growing evidence, in favor of transportation of patients with refractory respiratory and/or cardiac failure on ECMO by cannulating them at the referring center. Life-threatening situations can occur during mobile ECMO transport, needing immediate intervention by highly skilled and experienced personnel and transport needs to be organized accordingly. Overall, the availability of a mobile ECMO team makes transport to a referral institution while on ECMO support safe and adds no significant risk of mortality to ECMO patients.

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Author Contributions

Sandip Gupta – Conception of the work, Design of the work, Analysis of data, Interpretation of data, Drafting the work, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Arpan Chakraborty – Acquisition of data, Analysis of data, Interpretation of data, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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Conflict of Interest

Authors declare no conflict of interest.

Data Availability

All relevant data are within the paper and its Supporting Information files.

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