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# Safety of long-distance transfers of patients on acute mechanical circulatory support

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ABSTRACT

*Background:* Acute mechanical circulatory support (aMCS) can be a lifesaving therapy for patients with refractory cardiogenic shock. As device safety and technology improve, so will the ability to extend aMCS to patients at remote hospitals. The Intermountain West is unique because of the large geographical area, making transport of critically ill patients a logistical challenge.

*Methods:* We reviewed our experience of transporting patients in cardiogenic shock over long distances who had already been placed on aMCS: Impella and extracorporeal membrane oxygenator devices. Survival data was compared to international benchmark data published by the Extracorporeal Life Support Organization.

*Results:* A total of 11 patients (91% male; mean age 56 ± 5.4 y) were transported via fixed-wing aircraft to our center. The etiology of cardiogenic shock was ST-elevation myocardial infarction ($n = 4$), acutely decompensated chronic systolic heart failure ($n = 4$), post-cardiotomy shock ($n = 2$), and acute myocarditis ($n = 1$). Average transport distance was 364 ± 139 miles (585 ± 264 km) and flight time was 170 ± 29 min. All patients were safely transported with no in-transit adverse events. The average duration of aMCS was 6.4 ± 3.3 d. Six patients (54.5%) survived to device explantation and 3 (27.2%) survived to hospital discharge. For comparison, Extracorporeal Life Support Organization benchmark data for adult cardiogenic shock patients report 56% survival to device explantation and 41% to hospital discharge.

*Conclusions:* Patient transport with aMCS over long distances can be done safely without serious adverse events using good protocols and well-trained personnel. Although survival data are slightly below benchmark data, they appear reasonable, given the severity of illness and challenges of transferring critically ill patients to an expert center.



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## Introduction

Refractory cardiogenic shock (RCS) consists of circulatory collapse which is unresponsive to conventional medical therapies that results in hypoperfusion to end organs.[1] Despite improvements in acute mechanical circulatory support (aMCS) technology, current outcomes remain very poor with benchmark data of 40% survival.[2,3] For patients with RCS, aMCS can be a lifesaving therapy to facilitate bridge to recovery, bridge to transplantation, or implantation of a long-term ventricular assist device (VAD) as destination therapy.[4] In treating patients with time-sensitive cardiogenic shock, early access to aMCS and management in experienced centers are critically important.

Unfortunately, many patients do not live in close proximity to potentially lifesaving aMCS technologies and expertise. For example, in our geographic region of the Intermountain West, there are several medically sophisticated metropolitan areas surrounded by hundreds of miles of remote and rural areas without access to robust heart failure/shock technologies or expertise. As both device safety and technology improve, the ability to extend aMCS to patients at remote sites is now possible, but the best way to care for these patients is poorly understood.[5] Some controversy exists as to whether aMCS patients are best treated locally or transferred to experienced centers. Additional controversy exists about whether implementation of aMCS at the referring center by the local (less experienced) team or traveling team (more experienced but inherently delays in implementing aMCS) provides better outcomes. Finally, controversy also exists regarding the composition of the traveling team (via ground or air) required for aMCS transports. Traditionally, transport teams have had at least one physician and frequently both a physician and perfusionist. There are no data about transport outcomes using less resource-intensive teams (i.e., no physician or perfusionist). This likely reflects strongly held opinions of experts within the field. An additional gap in our understanding of aMCS transfers relates to long distances as most published data come from large, dense metropolitan areas in which the traveling aMCS team travels by ground.

With this study, we aim to both address the gaps in our understanding about the safety of long-distance, fixed-wing aMCS transfers and to challenge the traditional composition of the aMCS flight team. Using the Intermountain West's uniquely large geographical area, we report our initial patient outcomes and processes for long-distance, fixed-wing transportation of RCS patients on aMCS devices.

## Methods

We reviewed our institutional experience of all patients in RCS transferred to the University of Utah while being supported by aMCS devices implanted at referring hospitals between January 2013 and June 2016. Institutional review board approval from the University of Utah was obtained for this study. To explore the outcomes of long-distance transports, we limited our analysis to patients who were transported via fixed-wing aircraft and excluded local helicopter and ground transfers. All these patients had aMCS devices placed by physicians at the referring center consistent with our "if you cannulate, we will come" philosophy. The aMCS devices used in this study were Impella (ABIOMED Inc, Danvers, MA) 2.5, CP, and RP devices and extracorporeal membrane oxygenator (ECMO) (CentriMag, Thoratec, Pleasanton, CA; ROTAFLOW, Maquet, Rastatt, Germany). Transportation was performed using fixed-wing aircraft by the University of Utah AirMed flight teams consisting of a trained flight nurse, a flight paramedic, a flight respiratory therapist, and either an intensive care unit (ICU) nurse trained in mechanical circulatory support (MCS) or a VAD coordinator, in addition to the pilot crew. Specifically, these ICU nurses have received additional comprehensive device and cardiopulmonary support training. Of note, no physician or perfusionist traveled on any of these transports, as per our protocols.

The ECMO equipment used for air transport was the same as that used in our hospital, which occasionally required tubing splicing at the referring center from their system to ours before transfer. Patient management protocols are essentially the same during transport as in our ICU but without as much advanced monitoring. The flight crew had available to it invasive blood pressure monitoring, central venous pressure, pulse oximetry, and continuous electrocardiogram monitoring (Fig. 1).

Given that no physician or perfusionist accompanies these patients during transport, our ICU nurses and VAD coordinators have received extensive training on all forms of aMCS and have been empowered in managing all forms of aMCS used at our center. Since our program uses both CentriMag and ROTAFLOW technologies for ECMO support, all ICU nurses are required to maintain certification for both of these as well as for the Impella consoles. In addition to the traditional ICU training and certification, we have identified a core

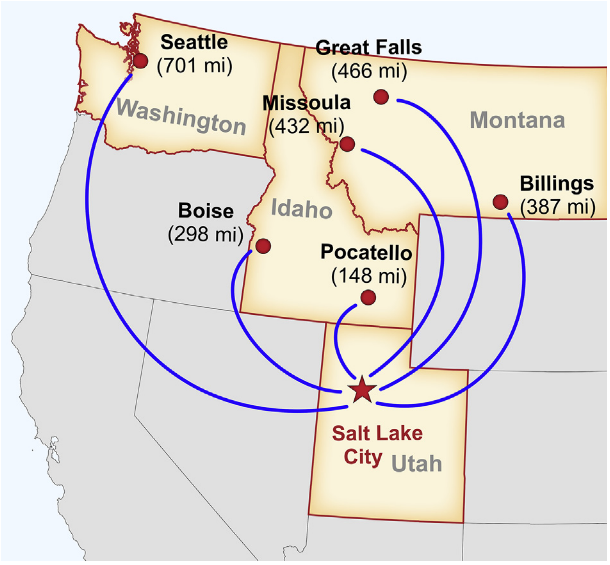


**Fig. 1 – Representative photograph of a patient on ECMO during a fixed-wing transport. (Color version of figure is available online.)**