Role of Extracorporeal Membrane Oxygenation in Pediatric and Adult Cardiac Patients

Essay

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Mostafa Rashad

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List of Abbreviations

Abb.	Full term
ACT	*Activated Clotting Time*
AFM	*Acute Fulminant Myocarditis*
AKI	*Acute Kidney Injury*
APTT	*Activated Partial Thromboplastin Time*
ARDS	*Adult Respiratory Distress Syndrome*
avECCO2-R	*Arteriovenous Extracorporeal Membrane Carbon Dioxide Removal*
AV-ECMO	*Arteriovenous ECMO*
CA	*Cardiac Arrest*
CA	*Catheter Ablation*
CF-LVADs	*Continuous Flow Left Ventricular Assist Devices*
CPB	*Cardiopulmonary Bypass*
CPR ECPR	*Ongoing Refractory*
CS	*Cardiogenic Shock*
ECGE	*Extracorporeal Gas Exchange*
ECMO	*Extracorporeal Membrane Oxygenation*
ECSL	*Extracorporeal Life Support*
HTx	*Heart Transplantation*
IABP	*Intraaortic Balloon Counter Pulsation*
iLA	*Interventional Lung Assist*
IVC	*Inferior Vena Cava*
MOF	*Multiorgan Failure*
PCCS	*Post-Cardiotomy Cardiogenic Shock*
pECLA	*Pumpless Extracorporeal Lung Assist*
PGD	*Primary Graft Dysfunction*
PI VSD	*Post-Infarct Ventricular Septal Defect*
PVR	*Pulmonary Vascular Resistance*
SBP	*Systolic Blood Pressure*

List of Abbreviations (Cont...)

Abb.	Full term
SIRS	*Systemic Inflammatory Response Syndrome*
SNHL	*Sensorineural Hearing Loss*
SVC	*Superior Vena Cava*
TAPVC	*Total Anomalous Pulmonary Venous Connection*
TAVI	*Transcatheter Aortic Valve Implantation*
TPN	*Total Parenteral Nutrition*
VA	*Veno-Arterial*
VADs	*Ventricular Assist Devices*
VAPa	*Veno-Arterio-Pulmonary-Arterial Cannulation*
VAV	*Follows Venoarterio-Venous*
VT	*Ventricular Tachycardia*
VV	*Veno Venous*

Abstract

Introduction:

Extracorporeal membrane oxygenation (ECMO) is a rescue therapy to support severe cardiac and/or pulmonary failure. Both veno venous (VV) and veno-arterial (VA) ECMO {or extracorporeal life support (ECSL)} are increasingly being used.

Methods:

A systematic review of studies that reported data about the effect of ECMO and its indications in different centers serving and treating the cardiac patients around the world with illustrating the benefits of its usage and outcomes.

Conclusion:

ECMO is currently being used in ICUs worldwide for neonatal, pediatric, and adult respiratory and cardiac failure. Evidence to support its use is strongest in the neonatal population, but treatment in the pediatric population is also generally accepted.

INTRODUCTION

Critical illness with severe pulmonary or cardiac failure is associated with high mortality. Advances in lung-protective strategies and cardiac assist devices [1, 2] have helped to improve survival for patients with lung or heart failure. However, even if evidenced-based best practices are followed, mortality rates can still be as high as 30 to 40% for patients with ARDS and 50% for patients with cardiac failure. [3]

Although initially introduced for the support of infants with severe respiratory failure, (ECMO) has gradually become the standard of care for the support of patients with complications of many forms of congenital heart disease. The ability to support both a patient's circulation and gas exchange has allowed many patients with transient cardiopulmonary failure to survive after complex repairs or with severe physiologic derangement such as pulmonary hypertension. [4]

It has become essential tool in the care of adults and children with severe cardiac and pulmonary dysfunction refractory to conventional management. [5, 6] Nowadays ECMO has become more reliable with improvement in equipment, and increased experience, which is reflected in improving results. [7]

AIM OF THE WORK

The aim of the study is to go through the literature to evaluate the outcome of the use of extracorporeal membrane oxygenation in pediatric and adult patients with aiming to introduce this modality in our Egyptian cardiac surgical centers.

REVIEW OF LITERATURE

Definition:

Extracorporeal membrane oxygenation (ECMO) is the general term used to define a technique that allows gas exchange to be performed outside of the body in order to support the failing heart and/or lungs. Despite being the most commonly used term, 'ECMO' is not entirely correct. Indeed, extracorporeal membrane lungs do add oxygen (O2) and remove carbon dioxide (CO2) from the blood so the term extracorporeal gas exchange (ECGE) would therefore be more appropriate.[8]

Extracorporeal membrane oxygenation (ECMO) is a technique for providing life support for patients experiencing both pulmonary and cardiac failure by maintaining oxygenation and perfusion until native organ function is restored. [3]

Another term *extracorporeal life support* (ECLS) refers to devices used to support the heart and lungs, and includes extracorporeal membrane oxygenation (ECMO) and ventricular assist devices (VADs). [9]

Other external gas exchange systems provide similar functions without the pump component of VV- or VA-ECMO. These arteriovenous extracorporeal lung assist devices bypass the lungs, but not the heart, and use the patient's blood pressure in order to sustain circulation of externally oxygenated blood. [10]

Because of the requirement for adequate cardiac function in candidate patients, these systems have more limited application. These devices are known by a variety of names, including pumpless extracorporeal lung assist (pECLA), arteriovenous extracorporeal membrane carbon dioxide removal (avECCO2-R), or interventional lung assist (iLA). In this report, we refer to these devices by the name used by their clinical investigators, although it is our understanding that these devices are functionally equivalent. [10]

When using the "heart–lung machine" to completely bypass the cardiopulmonary circulation, it is referred to as cardiopulmonary bypass. When ECLS is used in the intensive care unit (ICU) or emergency department (ED) to augment oxygenation, ventilation, or cardiac output it is generally referred to as extracorporeal membrane oxygenation (ECMO). [11]

History:

Kolff and Berk [12] in 1944 noted that blood became oxygenated as it passed through the cellophane chambers of their artificial kidney. This concept was applied in 1953 by Gibbon who used artificial oxygenation and perfusion support for the first successful open heart operation.13 In 1965, Rashkind and colleagues were the first to use a bubble oxygenator as support in a neonate dying of respiratory failure.[14] In ***1969, Dorson et al.*** reported the use of a membrane oxygenator for cardiopulmonary bypass in infants. 15 In 1970, ***Baffes et al.*** reported the successful use of extracorporeal membrane oxygenation as support in infants with congenital heart defects undergoing cardiac surgery. [16]

The first case report appeared in 1972 and described a 24-year-old who had sustained blunt thoracic trauma that was successfully treated using ECMO, Thereafter; the first randomized, prospective study of ECMO in severe acute respiratory failure was published in 1979. [17]

Bartlett and colleagues reported the first case series of 28 patients (14 children, 14 adults) who were treated with ECMO in 1977.[18] Although only 5 of 28 patients were long-term survivors, the early successes in near-moribund patients led to the first randomized trials of ECMO therapy for respiratory failure in neonates. [19]

During the same years, Kolobow was developing a new membrane lung optimized for carbon dioxide (CO2) removal as a possible application in patients with chronic obstructive pulmonary disease. While testing this new device in spontaneously breathing animals, however, we observed when part of the metabolically produced CO2was removed by the membrane lung that the ventilation of the animals proportionally decreased to maintain a constant blood partial pressure of CO2. [20]

The first applications in humans of the concept of lung rest were reported in 1980.[21] However, a small randomized trial conducted in the United States at the beginning of the 1990s failed to show an outcome advantage of additional extracorporeal support as compared with conventional mechanical ventilatory support. [22]