# IJECMO

# Indian Journal of ECMO

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# Indian Journal of ECMO

## 1. Aims and Scope

Indian Journal of ECMO, the official publication of ECMO Society of India (ESOI) (https://www.ecmosocietyofindia.com), is a peer-reviewed print + online Quarterly journal. The *Indian Journal of ECMO* aims to publish Extracorporeal Membrane Oxygenation (ECMO) is an evolving branch in the critical care specialty. Recognizing the increasing need to consolidate the field and to promote awareness, continuing education, and research in this field, the "ECMO Society of India (ESOI)" was formed in September 2010 with the headquarters in Mumbai, India. Which will include editorials, original articles, case reports, review articles and a quiz.

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# From the Editors' Desk

Dear friends,

On behalf of the *Indian Journal of ECMO (IJECMO)*—the editorial board and the editorial team—we would like to wish all authors, patrons, and readers a wonderful and prosperous new year.

The year 2023 was a great year for IJECMO. Our journal has made a pan India reach and also has made international presence. For this, we would like to congratulate all the members of the editorial team and authors. Journal is continuing to innovate in response to the changing environment of science and technology in the complex field of extracorporeal therapy. We are sure that IJECMO is continuing to become a platform with the aim to assist researchers to grow at all levels the research scholars, post-docs and students who are seeking publishing opportunities for their work.

## Extracorporeal Life Support (ECLS) in the Indian Subcontinent…13 Years on

Though ECMO was practiced in India at a few centers prior to 2010, efforts to add the respiratory ECMO as an available modality to the therapeutic armamentarium of critical care practice started from this period. Prior to this date, ECMO was mainly practiced as extended cardiopulmonary bypass when the patients couldn't come off following prolonged cardiac surgeries. Last 13 years have seen tremendous growth of the specialty as a result of the mutual cooperation of interested ECMO physicians, the exchange of knowledge from centers abroad, close relationship with the Central Extracorporeal Life Support Organization (ELSO), Ann Arbor, Michigan, USA. Genesis of ECMO Society of India (ESOI) and South Asia, West Asia, Africa Chapter (SWAAC) of ELSO has contributed significantly to the growth and proliferation of ECMO knowledge bases and practicing centers in our country. Besides our team from ECMO Society of India, Riddhi Vinayak, Mumbai, we would like to pay our gratitude to Dr Robert Bartlett, Dr Steve Conrad and Peter Rycus on this historical occasion. We interacted with subsequent ESLO chairmen who made their impact through their contributions to the growth of ECMO all over the world through its five subchapters including ours.

We saw the growth of subspecialty which evolved facing challenges in the last decade. We lived through two pandemics, H1N1 and COVID-19. More and more institutions have incorporated ECMO as part of the care. Obviously, the workforce has to be trained as well. ECMO Society of India took the opportunity and stood by the clinicians by organizing training programs and keeping education going. Besides respiratory ECMO, cardiac ECMO has been growing too. Other centers in the country contributed to ECMO training too. This has been a team effort, demonstrating the success of bringing a relatively new life science into practice, in a short period. ECMO practice needs dedication, persuasion and teamwork validating the true sense of working together. Needless to say, ECMO team has to work like a closely knit family.

We had successes. We had failures. Nearly 50 to 55% of the sickest people, who would have died otherwise were saved. Unlike much of the West, our ECMO service is mostly family funded with further extended help from insurance, charities, and crowdfunding. In the West as well as in some of our Middle East countries (part of the SWAAC region), ECMO program is funded by the governments as well as insurance programs. There is a need to enhance the insurance programs and bring down the cost of ECMO to a moderate level. There is a need to control infection, which has been a major cause of mortality worldwide. There is a need for thorough introspection of infection control policies and putting them into practice in true spirit.

We are glad to see the growth of pediatric ECMO which deserves more attention. Raising the awareness among obstetricians/perinatologists/neonatologists/pediatricians/pediatric cardiac surgeons and cardiac anaesthesiologists will go a long way in making this situation WIN–WIN to the mother as well as the newborn baby. Training of the critical care nurses and the involved subspecialties in the art of neonatal and pediatric cannulation and further management cannot be overemphasized. Efforts are on in this direction.

We are very pleased to share the growth of some of our ECMO centers as the best centers by the central ELSO by careful consideration and a rigorous inspection process. Riddhi Vinayak Hospital, Mumbai, has been awarded Platinum award, which is a pride for us.

The growth of ECMO Society of India in the past 13 years has been very satisfactory with more than 500 ECMO practitioners. Though more centers are practicing ECMO, so far 23 centers are registered with ELSO. The numbers need to grow. We brought simulation into practice by inculcating innovative methods, which has received accolades from all over the world.

There are a lot of academic feasts in the next couple of months. It is our pleasure to see Yashoda Hospital, Hyderabad, hosting the 13$^{th}$ Annual Conference of India with National and International experts participating in the exchange of deliberations, starting from January 2024. Besides the conference, workshops have been planned for pediatric and adult ECMO groups individually, which is a new feature starting with this conference. Our 17$^{th}$ annual training program of ECMO (ELSO endorsed) will be held in Mumbai soon after that. South Asia, West Asia, and Africa Chapter of ELSO will be held between 14$^{th}$ and 17$^{th}$ February 2024 at Kuwait.

We would like to end this note with a reminder that ECMO is a science which requires learning and relearning with a need to continuously update ourselves for the benefit of our patients.

Happy Learning and Happy New Year!

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# Greetings from the Desk of Journal Coordinator!

Greetings from the Desk of Journal Coordinator!

I am honored and thrilled to announce the release of this issue of the Indian Journal of ECMO (IJECMO).

The publication stands as the foundational bedrock upon which academic endeavors flourish, serving as the established pathway for the dissemination of knowledge, the presentation of groundbreaking research discoveries, and the conveyance of innovative concepts and technological breakthroughs. It embodies the collective efforts of scholars, researchers, and experts to not only showcase their findings but also to contribute to the ever-expanding reservoir of human understanding. Through the medium of publication, information transcends boundaries, fostering collaboration, sparking intellectual discourse, and propelling the evolution of various fields. It not only captures the essence of scholarly achievements but also signifies the continuous pursuit of excellence in advancing human knowledge and societal progress.

Our objective is to establish a worldwide platform for sharing comprehensive work and research within the continuously expanding realm of ECMO. This encompasses its evolution, physiology, equipment, continuously expanding applications, successful implementations, and its limitations. I extend a warm invitation to each of you to contribute your valuable experiences, thereby fortifying and enriching our community with knowledge.

In this current issue, we feature the third instalment of our series on the evolution of ECMO, an original research article, insightful case reports, a comprehensive survey, and abstracts chosen for presentation at the upcoming annual conference.

The full text of each article will be available online at https://www.ijecmo.com/journalDetails/IJECMO, where one can access the previous published issues of the journal as well as submit articles.

I strongly encourage all of us to make consistent use of this invaluable resource, integrating it into our daily clinical routines. I envision this journal playing a pivotal role as a driving force, igniting a deeper and more profound understanding of ECMO within the scientific community. My hope is that through the information and insights gained from this journal, we collectively enhance our knowledge base, refine our practices, and push the boundaries of our understanding in the realm of ECMO, ultimately leading to improved patient outcomes and advancements in the field of critical care medicine.

I want to express my gratitude to the editors, associate editors, and the reviewers for their diligent efforts and tremendous support in ensuring the timely release of this issue. Additionally, I extend my heartfelt appreciation to the authors who have contributed their valuable articles to our journal.

I would like to share a quote by Abraham Lincoln–

"*Next to creating a life, the finest thing a man can do is to preserve one.*"

This quote holds a profound significance for both the medical community and society at large. It honors the immeasurable value of preserving and safeguarding life, emphasizing the noble and crucial role of healthcare professionals in saving and enhancing lives.

Happy Reading, Happy Learning!

**Saurabh Taneja**
Journal Coordinator, Indian Journal of ECMO
Senior Consultant, Institute of Critical Care Medicine
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Indian Journal of ECMO

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# Contents

ORIGINAL RESEARCH

# Prone Positioning in Venovenous Extracorporeal Membrane Oxygenation (VV-ECMO) in COVID-19 Acute Respiratory Distress Syndrome (ARDS)

Rahul Dixit[1], Arpan Chakraborty[2]

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## Abstract

**Background:** There is a lack of scientific evidence on the beneficial effects of proning in COVID-19 ARDS patients on venovenous extracorporeal membrane oxygenation (VV-ECMO). This is the first original article from India that compared the effects of prone positioning in patients in VV-ECMO, the indication of ECMO being COIVD-19-associated acute respiratory distress syndrome (ARDS).

**Methodology:** In this single-center retrospective observational study, we divided the COVID-19-associated ARDS patients on VV-ECMO into 2 groups, the supine group, and the prone group. The primary outcome parameter was 30 days mortality. Secondary outcome parameters were the length of ICU stay, days on VV-ECMO, and duration of mechanical ventilation.

**Results:** There was no statistical difference in mortality ($p = 0.9$) between the supine and prone groups. There were no statistically significant findings in the secondary outcome parameters too.

**Conclusion:** Prone positioning did not show a statistically significant benefit in mortality in COVID-19 ARDS patients on VV-ECMO. Although, there was a numerically lower percentage of mortality in prone patients. Additionally in numerical terms, patients had shorter ICU stays, fewer days on VV-ECMO, and shorter duration of mechanical ventilation who were proned.


**Keywords:** Acute respiratory distress syndrome, Coronavirus disease of 2019, Proning, Prone positioning, Venovenous ECMO.

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## Introduction

Extracorporeal membrane oxygenation (ECMO) is a technique for providing prolonged support to human cardiac and/or respiratory systems when the human heart and lungs are incapable of meeting blood supply and/or gas exchange to sustain life.[1] Advent of SARS CoV-1 in 2002–2004 and SARS CoV-2 in the early 2020s, have led to the increased application and acceptance of ECMO worldwide. Extracorporeal membrane oxygenation consists of a circuit of drainage cannula, a centrifugal pump, a membrane gas exchanger (oxygenator), and a return cannula. The aim of ECMO is to bypass the heart and/or the lungs to provide them rest and time to adequately recuperate. Venovenous ECMO (VV-ECMO) supports the lungs, return cannula being placed in the venous system.[2]

Acute respiratory distress syndrome (ARDS) is characterized by acute respiratory hypoxemia, bilateral chest infiltrates unexplained by cardiac issues, or fluid overload. Acute respiratory distress syndrome is a result of dysregulated inflammation resulting in abnormal cytokine release in response to pulmonary or extra-pulmonary insult. The injury causes alveolar epithelial–endothelial barrier disruption leading to lung exudates, surfactant dysfunction, compromised gas exchange, impaired pulmonary compliance, increased shunting and physiological dead space, alveolar hyalinization, and alveolar hemorrhages in varying orders.[3]

Multiple studies have shown the beneficial effects of prone ventilation in ARDS.[4] Proning reduces the difference between dorsal and ventral transpulmonary pressure, reduces alveolar distension, increases recruitment potential, reduces shunting, and improves oxygenation and ventilation that is sustained when the patients are positioned supine.[5]

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**Conflict of interest:** Dr Arpan Chakraborty is associated as the Associate Editorial Board member of this journal and this manuscript was subjected to this journal's standard review procedures, with this peer review handled independently of this editorial board member and his research group.

There is a lack of scientific evidence on the beneficial effects of prone positioning in VV-ECMO done on ARDS associated with COVID-19 Infection. This is the first original article from India that compared the impact of prone positioning in patients on VV-ECMO, the indication of ECMO being COIVD-19-associated

## Methodology

The study was an observational and analytical, cross-sectional, retrospective study a conducted in single tertiary-level hospital

**Table 1:** Baseline patient characteristics

| *Parameters* | *Supine group n = 20* | *Prone group n = 22* | *p-value* |
|---|---|---|---|
| Median age (years) | 57.1 | 59.3 | $p = 0.8$ |
| Female sex (%) | 47.2% | 45.5% | $p = 0.9$ |
| Comorbidities | | | |
| Diabetes mellitus ($n = 13$) | 5 | 8 | $p < 0.01$ |
| Hypertension ($n = 11$) | 6 | 5 | $p = 0.9$ |
| Chronic kidney disease ($n = 4$) | 2 | 2 | $p = 1$ |
| Morbid obesity ($n = 6$) | 4 | 2 | $p < 0.01$ |
| Hypothyroidism ($n = 7$) | 3 | 4 | $p = 0.8$ |
| Coronary artery disease ($n = 6$) | 3 | 3 | $p = 1$ |
| Organ dysfunction | | | |
| Acute kidney injury | 11 | 13 | $p = 0.9$ |
| Hepatic dysfunction | 4 | 5 | $p = 0.9$ |

in Kolkata (India). This study included patients who were put on venovenous ECMO from 1st April to 30th June in year 2021 during the second Indian wave of COVID-19. The study population comprised adults (age years: 18–60) with severe ARDS (PF ratio <150) associated with COVID-19, not clinically improving within the first 7 days on invasive mechanical ventilation. Exclusion criteria were underlying chronic lung disease, significant neurological injury, pregnancy, coagulopathy, cardiogenic shock, and non-responsive ARDS with more than 7 days of invasive mechanical ventilation. Necessary approvals and consents were obtained before commencing the study.

The patients ($n = 42$) were sorted into two groups. The first (supine group) of patients on VV-ECMO were kept in the supine position ($n = 20$) and the second (prone group) of VV-ECMO patients ($n = 22$) were prone as per ARDS proning protocol. The primary outcome parameter was 30 days of mortality between the two groups. Secondary outcomes were the duration of VV-ECMO, duration of ICU stay, and weaning from invasive mechanical ventilation.

Statistical analysis was done to compare these groups to evaluate the beneficial effects of proning in patients who were put on VV-ECMO due to severe ARDS associated with COVID-19. The *p*-value of < 0.01 was taken as statistically significant.

## Results

As per inclusion and exclusion criteria, 42 patients were included in the study. The baseline characteristics of the two groups are mentioned in Table 1. Only the incidences of diabetes and obesity were statistically different in the two groups.

The study's primary outcome, 30 days mortality was statistically analyzed between the supine and prone patients who were on VV-ECMO. There was no statistical difference ($p = 0.9$) documented in 30-days mortality in the two groups (Table 2). Although, the mortality was numerically less in the VV-ECMO patients who were prone as per ARDS proning protocol.

In the secondary outcomes, it has been found that the prone group of patients had less VV-ECMO duration, shorter ICU stay, and less number of ventilator days. However, there were no statistically significant differences in the secondary outcome parameters in both groups (Table 2).

**Table 2:** Outcome parameters

| *Parameters* *Primary* | *Supine group n = 20* | *Prone group n = 22* | *p-value* |
|---|---|---|---|
| 30 days mortality (%) | 13 (65%) | 14 (63.6%) | $p = 0.9$ |
| Secondary | | | |
| Median days of VV-ECMO (days) | 33.3 | 29.5 | $p = 0.8$ |
| Duration of ICU stay (days) | 35.4 | 31.7 | $p = 0.8$ |
| Duration of ventilation (days) | 37.8 | 33.1 | $p = 0.7$ |

## Discussion

In this observational, retrospective study done in a single center, we tried to evaluate the beneficial effects of proning in VV-ECMO in patients of ARDS associated with COVID-19. The effect of proning in ECMO patients had been published earlier. A systematic review analyzing six clinical studies documented no mortality benefits of prone positioning in ECMO patients.[6] In this study too, there was no difference in mortality attributed to proning in ARDS patients associated with COVID-19 on VV-ECMO.

There are a smaller number of studies on the effects of proning in ARDS patients with COVID-19 on VV-ECMO. In a study from the United States, Zaaqoq et al. had shown that hospital discharge was 33% in the ECMO-prone group against 22% in the ECMO supine group with a mortality hazard ratio of 0.31; 95% CI: 0.14–0.68.[7] In contrast to this study, there was no statistically significant survival advantage found in our Indian patients who were prone during VV-ECMO. However, we observed a lesser percentage of mortality in patients in the prone group. In another study from France, Laghlam et al. found that proning helped in improved oxygenation and respiratory mechanical parameters in patients of COVID-19 ARDS and improvements persisted after patients were positioned supine.[8]

The second wave of COVID-19 in India claimed millions of lives in our homeland. The Indian ICUs were overwhelmed by the exponential rise of COVID-19 associated ARDS cases during the peak of the second wave of the pandemic. Our ICU was one of the few ICUs in India equipped with VV-ECMO facilities, running over a decade. The exhausted and overwhelmed medical facilities in India explain the lack of clinical studies during the COVID-19 pandemic. This is the only Indian study on proning in VV-ECMO of ARDS patients associated with COVID-19 performed till to date.

There are a few limitations in this study. This is a retrospective observational study performed in a single center in India. The sample size was taken as per convenience and there were minor statistically significant differences in the baseline characteristics of the two groups of patients. Therefore, the findings of this study cannot be considered representative of different patient groups. The results of this study are yet to be compared with prospective multicentric randomized controlled trials.

## Conclusion

Prone positioning is a reliable clinical technique in ARDS patients to improve patient outcomes. We studied the effect of proning in ARDS patients associated with COVID-19 on VV-ECMO. Prone positioning did not contribute to a statistically significant difference in terms of mortality. Though, we found a numerically lower percentage of mortality in prone patients. Additionally, patients had shorter ICU stays, lesser days on VV-ECMO, and shorter

duration of mechanical ventilation who were prone as per ARDS proning protocol.

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REVIEW PAPER

# Evolution of Extracorporeal Membrane Oxygenation: Part 3 – The Stepping Stones to Success in the History of Cardiopulmonary Bypass

Suneel Kumar Pooboni

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## Abstract

The story of the "Evolution of Extracorporeal Membrane Oxygenation (ECMO)" continues after the previous edition. In the 17th century, Robert Hooke was the first to conceptualize a process similar to ECMO. Many researchers and clinicians worked hard throughout the 19th and 20th centuries to build systems supporting gas exchange over a thin film of blood. Brukhonenko from Russia is worth mentioning as the system he built, called an "autojector" came close to the expectations of replacing the lung with a mechanical gas exchange system. All the experiments so far were on animals till Dr John Gibbon, in 1953, first used the heart–lung machine he made on a case of the atrial septal defect (ASD) for cardiac bypass. In 1954, Dr Walton Lillehei introduced the practice of controlled cross-circulation using a child with his biological parents.


**Keywords:** Brunkhonencko, Cardiopulmonary bypass, Evolution, Extracorporeal membrane oxygenation, History, John Gibbon, Walton Lillehei.

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## In continuation of Part 2

Besides the development of further inventions leading to the development of cardiopulmonary bypass machinery in the early part of the 20th century, it is equally important to pay tribute to the inventors of heparin, without which, there would have been no progress in the implementation of the circulation of blood in the cardiopulmonary bypass tubing and oxygenator in the anticoagulated state during bypass procedures.

## Discovery of Heparin

Although the discovery of heparin took place two to three decades before the advent of cardiopulmonary bypass circuits, its inclusion in keeping the blood in circulation *via* artificial tubing took some time. The importance of developing a methodology to finetune controlling the extent of anticoagulation was recognized. It was first discovered in 1916 but did not enter into formal clinical trials until 1935.

Heparin is a biologically available product in the human body, which is tightly regulated to control the homeostasis of anticoagulation. Antithrombin III (AT III) is an important component in this process as Heparin acts by augmenting the action of AT III by 1,000-fold.

In the early 1990s, it was difficult to imagine the hardships faced by brilliant pioneers such as Jay McLean, the discoverer of Heparin, for obtaining medical education. In his formative years, Jay was determined to join the Johns Hopkins Medical School to study the science of Medicine. As he did not have enough support from his domestic background following the demise of his father and his stepfather refusing to support him for studies at John Hopkins, initially Jay worked part time in goldmines as a mucker to earn money for his college education. His spare time was devoted to various part-time jobs such as working at a recorder's office, working in labs doing blood counts, in the Museum of Invertebrate Zoology, scrubbing the decks of ferry boats in San Francisco, etc., to earn enough money to pay for the college fees and other essential expenses. At first, he was rejected at the Johns Hopkins Medical School as his Dean from the University of California stated in the evaluation of his career "He was not the kind of person Johns Hopkins would like to have." He persisted with his efforts and was successful in securing a seat in the second year of Medicine. Although he was refused a seat in the first instance, he was offered a seat as an unexpected vacancy became available. Historically, this opportunity opened up the future of mankind in finding a valuable substance that made further advances in open heart surgery/extracorporeal membrane oxygenation (ECMO) possible. He joined Dr Howell's physiology laboratory and started working on the research projects. One such hypothesis Howell was working on discovering the procoagulant properties of a substance "Cephalin" extracted from the brain. Jay also experimented on extracts of the heart and liver and concluded the extract of the liver was superior. Howell as his supervisor, acknowledged the work of Jay McLean in 1917 but took the credit of discovery of

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**Conflict of interest:** None

**Fig. 1:** Willian Henry Howell and Jay McLean
*Courtesy:* Wikipedia

**Fig. 2:** Johan Erk Jorpes
*Courtesy:* Wikipedia

heparin for himself in subsequent claims for discovery of heparin. As per the claims by Dr William Henry Howell, he was credited with the honor of discovery of Heparin. Although Jay McLean was the primary person who extracted and isolated Heparin in the lab of Dr Howell, out of profound respect for his former mentor, Jay McLean remained silent till the death of Dr Howell in the year 1945. Jay published his recollection of the earlier evidence regarding his work leading to the extraction of Heparin and claimed ownership for the discovery of Heparin. The scientific community admitted this evidence (Fig. 1).[37–39]

Though one of them discovered Heparin, Howell and McLean's pioneering work opened up many avenues for extracting, purifying, and using it in clinical trials for maintaining anticoagulation.[40] It is interesting to note Dr Charles Herbert Best from Toronto was working on extraction of a pure compound of heparin for incorporation of heparin into clinical practice. Best, who was also responsible for the discovery of insulin, utilized heparin as an anticoagulant and tested it in vitro experiments in the United Kingdom[41] Dr Best moved to Toronto in 1929. At the time of establishment in 1914, Connaught Laboratories was a not-for-profit organization in Toronto, meant to take medical advances forward. Researchers at Connaught Laboratories were responsible for the development of Diphtheria antitoxin, polio vaccine, and purification of Heparin. Dr Best and his team did further studies to establish the role of Heparin as an anticoagulant.[42] It was amazing teamwork.

After confirming the activity of Heparin, further researchers continued with studies to test its efficacy. In 1936, Johan Erk Jorpes, a Finnish-born Swedish clinician and biochemist, worked hard leading to the identification of the chemical structure of heparin. Johan was born into a poor fisherman's family. As a result of the World War I and entering Sweden as a refugee, he faced many hardships in life. He visited New York and Toronto. He became a millionaire but gave away his property to charity and developing academics. Jorpes published his experience on the utility of heparin in the treatment of venous thrombosis in 1946. Since the 1940s, he took part in studies on factors of coagulation mechanism such as fibrinogen, factor VIII, plasminogen, prothrombin, and thrombin. He participated in studies on von Willebrand disease along with von Willebrand (Fig. 2).

Connaught Medical Laboratories and the pharmaceutical company Vitrum AB took up the task of preparation and mass-scale production of safe heparin solution that can be used in human subjects. Its incorporation into trials designed for the circulation of blood in an anticoagulated state through artificial surfaces led to further progress in the search for cardiopulmonary bypass circuits.[43]

## Progress of Research on Cardiac Surgery Beyond 1940s

In the 1940s, enthusiastic cardiac surgeons started operating on heart conditions that did not need the assistance of bypass such as closure of a patent ductus arteriosus,[44] repair of coarctation of the aorta,[45,46] the Blalock–Taussig shunt[47] performing mitral commissurotomy[48] Lewis FJ and Taufic M successfully used hypothermia in 1953 for the surgical closure of atrial septal defect (ASD).[49] Researchers felt the need for an ideal heart–lung machine to deal with the complexity and procure more time for safely performing the majority of cardiac anomalies manifesting in the neonatal period. The management of structural abnormalities of heart valves also needed advanced support system.

The initial experiments including animal studies with attempts at cardiopulmonary bypass were disappointing as the survival rates were not high. Dr Walton Lillehei was credited with reviewing the cardiac surgical procedures published in journals over a five-year period starting from 1951. As stated in his review, 18 patients were operated on cardiopulmonary bypass at 6 institutions during this period. There were 17 mortalities and only 1 survivor. The type of oxygenators used were film (8 patients), bubble (4 patients), monkey lung (5 patients), and autologous lung (1 patient).[50]

As per the historical records, five medical centers contributed to the efforts in the development of a heart–lung bypass machine during the period 1950–1955. Although the basic similarities existed in the construction of these cardiopulmonary bypass machines, there were variations in the functionality. It is interesting to note the works of Toronto researchers such as Dr William Mustard who was working on using isolated monkey lungs as the oxygenator in designing a cardiopulmonary bypass machine. Dr Forest Dodrill was another pioneer at Detroit at Wayne State Medical School, who contributed to the development of a heart pump at General Motors culminating in the design of the Dodrill-General Motors Research (GMR) heart machine. Simultaneously, Dr John Gibbon in

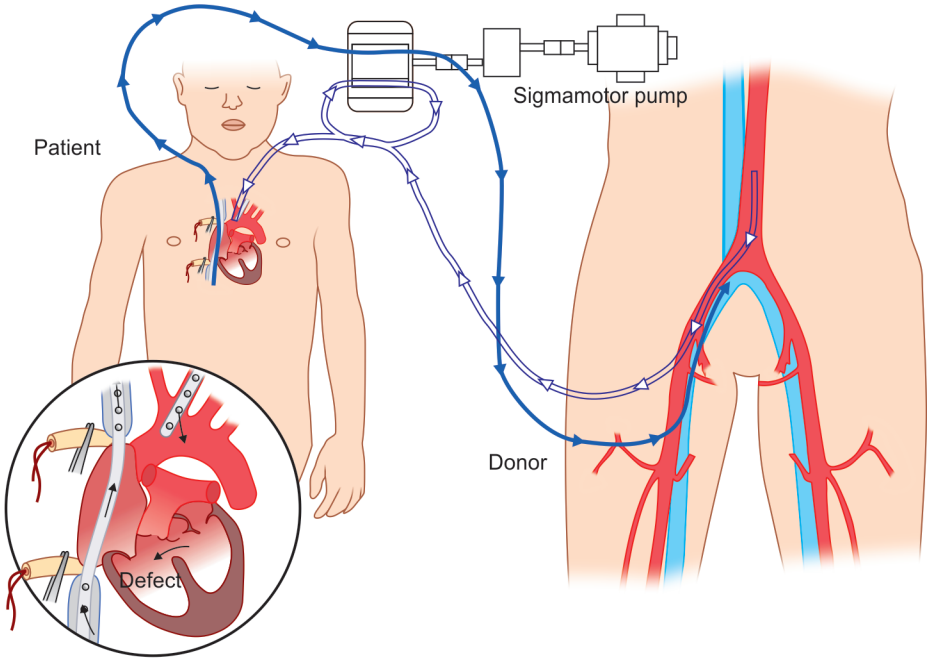


**Fig. 3:** Controlled cross-circulation—either father or mother were the donors[51]

Philadelphia had been working on his dream project of developing heart–lung bypass machine since the 1930s along with his assistant and partner Mary Gibbon. His machine used DeBakey roller pumps and a film oxygenator.

Another cardiac surgeon, Dr Clarence Dennis at the University of Minnesota Medical School, had developed a rotating disc oxygenator. His design was based on earlier concepts proposed by Viking Björk and Clarence Crafoord. Dr C Walton Lillehei, based at the same center, conducted a clinical trial in which the function of gas exchange and circulatory support would be carried out by cannulating the blood vessels of the biological parent of the patient. This procedure was labeled as cross-circulation. In addition, John Kirklin and his colleagues at Mayo Clinic were working on redesigning a heart-lung machine based on Gibbon's prototype that used a vertical film oxygenator and roller pumps. It was called the Mayo–Gibbon heart–lung machine. It is exciting to see how multiple researchers across the centers were involved in a healthy competition, trying to find a solution to overcome the problems of establishing a safe cardiopulmonary bypass system.[43]

Meanwhile, at Toronto, Dr William T Mustard founded a cardiac surgical service with surgeries for conditions such as coarctation of the aorta, patent ductus arteriosus, and procedures such as Blalock–Taussig shunt (BT shunt) for increasing pulmonary blood flow. Dr Mustard was an exceptional surgeon blessed with the expertise for operating on small babies with congenital cardiac disorders. His experimental studies were based on canine species. His cardiopulmonary bypass pump used four rubber bulbs. During these experiments, his laboratory oxygenator was the isolated lung of another dog. However, his initial seven open-heart surgeries using this method ended with high mortality. All seven patients died. Mustard finally reported operating on another 21 children between 1951 and 1956 using a monkey lung oxygenator, with only 3 survivors.[43]

In 1952, John Lewis used experimental hypothermia on a patient with ASD by reducing the body temperature to 30°C and closing the defect within 5–7 minutes. This patient survived. The same technique on a patient with Ventricular septal defect was a failure.[50]

Dr C Walton Lillehei Minnesota contributed to a significant extent to the genesis of cardiopulmonary bypass. In the early 1950s, Lillehei used the procedure of controlled cross-circulation to successfully close a ventricular septal defect. He was a pioneer in a total repair of the tetralogy of Fallot. He was also credited with the distinction of repairing a persistent common atrioventricular canal for the first time. He demonstrated his abilities by operating on 45 children using his principle of cross-circulation and had 28 survivors (Fig. 3).

In 1954, Richard DeWall returned to the University of Minnesota from military service. The association between Dr Lillehei and Dewall led to further advances in the field of open-heart surgery. Dewall was entrusted with the responsibility of looking after the cardiopulmonary circuit setup and managing the patient during the cross-circulation operations. He will be remembered as the first open-heart surgery perfusionist.

Lillehei gave two guidelines to Dewall: "First of all, do not go to bubble oxygenator systems because they have a very poor history of success. Second, avoid libraries and avoid literature searches, as I want you to keep an open mind and not be prejudiced by the mistakes of others."[43] Lillehei advised DeWall to investigate the use of novel material such as polyvinyl tubing for manufacturing cardiopulmonary bypass circuits.

Dewall continued with the designs of a bubble oxygenator, using hyperbaric oxygen first. He ended up developing a vertical chamber of long vinyl tubing woven in a circular fashion as a helix, with blood running in the column and oxygen through the 22G needles connected to a rubber stopper inserted in the base. It was put to use for the first time in 1955. It became so popular that in no time it replaced the old technique of cross-circulation. It is interesting to note that Silicon antifoam and Mayon polyethylene tubing as the two important components of this Lillehei–DeWall

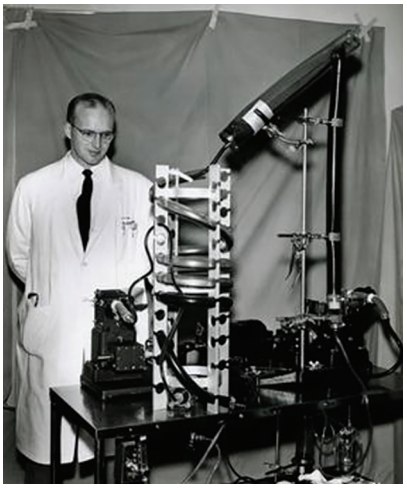

**Fig. 4:** Dewall bubble oxygenator source wikepedia[52]

bubble oxygenator. By using this oxygenator, nearly 350 cardiac surgical bypass surgeries were performed at the University of Minnesota within the next couple of years. At a ripe age, Dewaal died in 2016 (Fig. 4).

Another decorated clinician of those times was Dr John W Kirklin. As one of his colleagues said, "His lifetime ambition was to see the risk of death from cardiac surgery reduced to zero." Following the initial mortality of using the heart–lung bypass machine, Dr John Gibbon was discouraged and avoided using his machine. When the Mayo team under the leadership of Dr Kirklin approached him, Dr Gibbon willingly shared the blueprints of his machine developed as a result of his dedicated research work lasting for a couple of decades.[53] In 1955, Kirklin began clinical trials using the vertical screen oxygenator of Mayo Gibbon.[53]

Since 1960, with the advent of technologies and improvements in opportunities for performing more cardiac surgeries, many manufacturing companies came forward resulting in an increase in the production of heart–lung machines. Further advances in oxygenator design in this era led to the emergence of bubble oxygenators that contained a defoaming chamber and a heat exchanger.

During the decade after the 1950s, the survival figures following open heart surgery improved each year. With better oxygenators, better surgical techniques with advances in imaging technology such as echo machines, the mortality numbers came down to single-digit levels. Although it had been the dream of all clinicians to put their efforts into the development of safe cardiopulmonary bypass technology, they would not have predicted that many cardiac surgical procedures today are done with a mortality risk of below 1 in 100.

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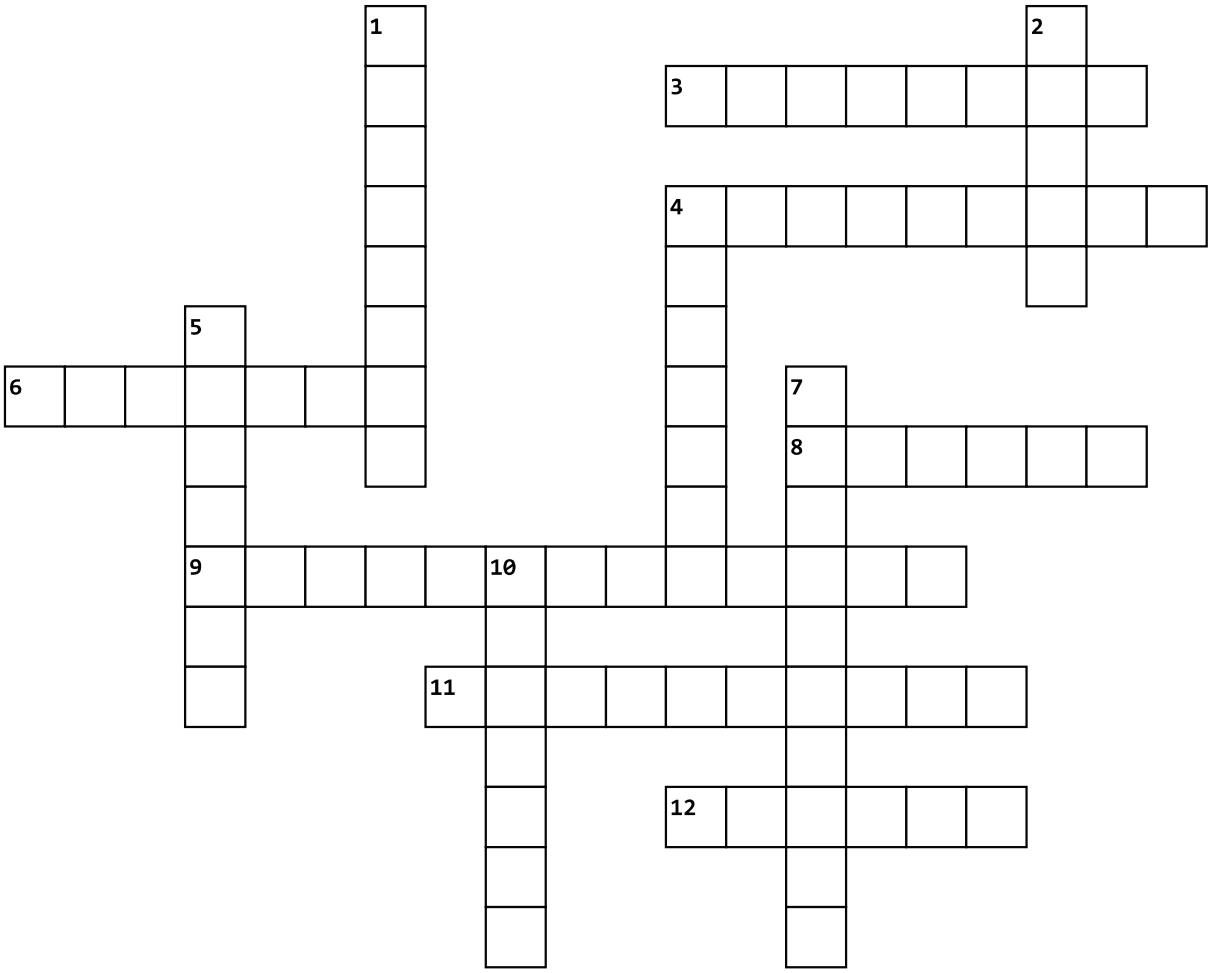
Continues as Evolution of ECMO-Part 4 in next issue

## CROSSWORD




| ACROSS | DOWN |
|---|---|
| 3. Cannula inserted during VA ECMO to avoid distal limb ischemia | 1. CO2 removal in the membrane oxygenator is primarily dependent on |
| 4. Antidote for heparin | 2. Trial which did not show mortality benefit of ECMO in severe ARDS |
| 6. LVAD for short term mechanical circulatory support | 4. Landmark trial in ARDS which shows mortality benefit in proning |
| 8. Bicaval dual lumen ECMO cannula | 5. Anticoagulation of choice in ECMO |
| 9. Phenomenon in which oxygenated blood is withdrawn from the drainage cannula without passing the systemic circulation | 7. Which commonly used NOAC has majorly renal excretion |
| 11. 1st human lung transplant done by | 10. How to identify that the patient on ECMO is hypovolemic |
| 12. What is the name of 2012 Definition of ARDS | |

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CASE REPORT

# Harnessing the Potential of ECMO: A Game-changer for Tracheal Stenting

Manda Ravi Krishna[1], Rakesh Venuturumilli[2], Chukka Bharath[3], Malla Venkata Hariprasad[4]

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## Abstract

The use of extracorporeal membrane oxygenation (ECMO) can be beneficial when conventional ventilation methods are unsuccessful. Here, we successfully managed a patient with advanced tracheal malignancy and impending airway obstruction by implementing venovenous ECMO (VV-ECMO) before performing a critical endotracheal procedure. The VV-ECMO was securely established through the right jugular vein and the left femoral vein, under local anesthesia. The placement of a tracheal stent was then performed under the guidance of a rigid bronchoscope and fluoroscopy. Extracorporeal membrane oxygenation effectively maintained adequate oxygenation and ventilation. Venovenous extracorporeal membrane oxygenation serves as a valuable tool in supporting airway interventions for complex tracheal pathologies, especially when conventional ventilation may not be sufficient or feasible.

**Keywords:** Awake extracorporeal membrane oxygenation, Case report, Respiratory failure, Tracheal stenting, Venovenous extracorporeal membrane oxygenation.

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## Key Points

The application of venovenous extracorporeal membrane oxygenation (VV-ECMO) represents a cutting-edge approach to treating individuals with severe and complicated airway problems.

This approach offers the most effective ventilatory support in situations where conventional methods are not feasible.

By utilizing ECMO, patients can undergo complex airway interventions in a safe environment, with acceptable rates of complications.

We suggest taking into account the preoperative initiation of ECMO in particular high-risk patients who may face the potential of disastrous airway obstruction during airway procedures, particularly in cases of high-grade tracheal stenosis where complete airway obstruction is a potential worry.

## Introduction

Extracorporeal life support is utilized to treat patients with refractory cardiac and/or respiratory failure when conventional treatments have been ineffective. Venovenous extracorporeal membrane oxygenation is a life-saving technique that offers ventilatory support to patients with severe hypoxia and/or hypercapnia. It has demonstrated its effectiveness in several other situations, including severe upper central airway obstruction.

This case study highlights the successful management of advanced tracheal malignancy with the use of pre-emptive VV-ECMO to avoid impending airway obstruction during critical endotracheal procedures.

## Case Description

A woman, aged 56, was admitted to the hospital's intensive care unit. She had a known case of carcinoma of the left lung (T4N2M0) that was diagnosed 4 months ago and was receiving palliative chemotherapy. The patient experienced gradually worsening shortness of breath, blood-stained sputum, and stridor, beginning two weeks prior to the presentation.

She exhibited tachypnea and stridor at rest during the presentation. The patient displayed tachycardia with a heart rate of 130 beats per minute, accompanied by labored breathing. The physical examination revealed inspiratory stridor and decreased breath sounds in the right hemithorax. X-ray/CT chest and bronchoscopy showed extrinsic compression of both the left and right main bronchi along with the distal trachea with near complete opacification of the right hemithorax due to collapse/consolidation (Fig. 1). Arterial blood gas (ABG) results indicated severe hypoxia and mild hypercapnia. Electrocardiogram (ECG) and 2D echocardiography suggested ACS-STEMI involving the LAD territory with an ejection fraction of 40%. A multidisciplinary team meeting was held, and therein it was planned that the patient would undergo tracheobronchial stenting after cardiac evaluation for ACS. The intensivists who participated in the meeting expressed their belief that the utilization of standard airway management techniques during the endotracheal procedure would carry a considerable level of risk, citing low tracheal stenosis and involvement of both main bronchi. The patient had a poor cardiopulmonary reserve. Initiation of VV-ECMO prior to coronary angiography was considered, but the

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**Conflict of interest:** None

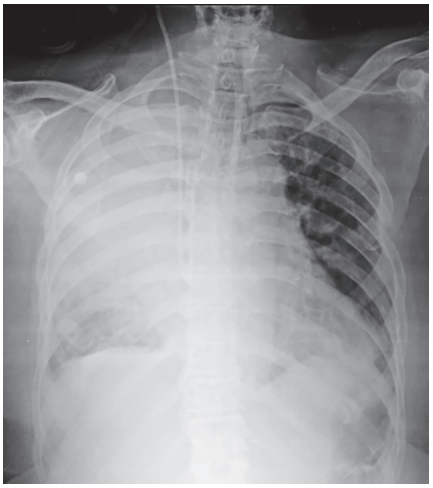

**Fig. 1:** Pre-ECMO cannulation

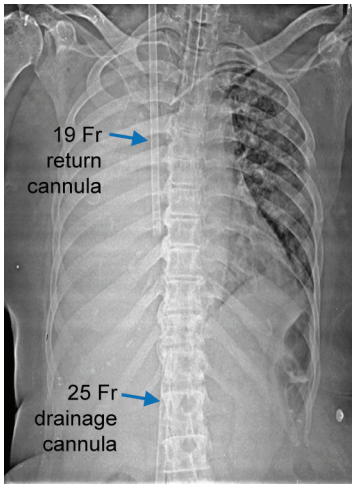


**Fig. 2:** Upper arrow showing 19Fr return cannula, lower arrow showing 25 Fr venous cannula

family's opinion was to defer tracheal stenting in case of significant coronary artery disease.

The patient was electively intubated and underwent coronary angiography, which showed normal coronaries. It was then decided to initiate VV-ECMO to assist with tracheobronchial stenting and mitigate intraprocedure hypoxia. Venovenous ECMO was initiated by percutaneously placing a 19 French return cannula in the right internal jugular vein and a 25 French multistage drainage cannula in the right femoral vein. This procedure was performed under ultrasound guidance (Fig. 2). At the time of cannulation, a dosage of 5000 IU of heparin was administered, and a heparin drip was initiated at a rate of 10 units per kilogram per hour. The following protocol was implemented to achieve a target A.C.T. of approximately 160–180s through heparin infusion.

*ACT (i-STAT Kaolin) Titration*

| *ACT (seconds)* | *Bolus units/kg* | *Action* |
|---|---|---|
| ≥20 below range | 15 | Increase heparin infusion by 4 units/kg/hr |
| 6–19 below range | | Increase heparin infusion by 4 units/kg/hr |
| 1–5 below range | | No change |
| Within ordered range | | No change |
| 1–5 above range | | No change |
| 6–40 above range | | Decrease heparin infusion rate by 2–4 units/kg/hr |
| >40 above range | | Decrease heparin infusion rate by 6 units/kg/hr and notify MD |

The rota flow ECMO system was employed for the initiation of ECMO. The ECMO clinical settings remained stable throughout, with flows of 4 lpm delivered at an RPM set at 2850/min, venous pressure recorded at –32 mm Hg, and $SvO_2$ maintained at 56%. After ECMO insertion, the patient's pH was 7.43, $PaCO_2$ was 33, $PaO_2$ was 226, and lactate was 2.1 with $FiO_2$ of 0.3 PEEP of 6, and PS of 12 cm/s. The procedure was uneventful, and after instituting ECMO, her dyspnea significantly reduced. 16 hours after initiation of ECMO patient was extubated and was safely shifted to the interventional pulmonology room. Anticoagulation was stopped 6 hours prior to initiation of

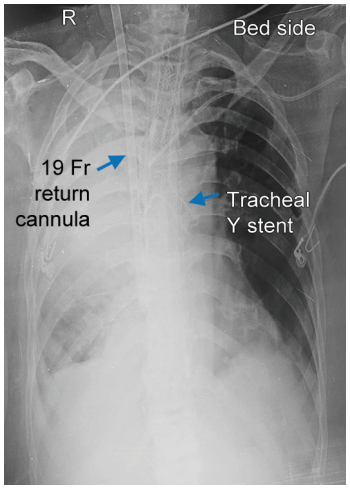


**Fig. 3:** Left arrow showing 19Fr return cannula, right arrow showing tracheal Y stent

tracheal stenting. During the heparin-free run, the membrane lung and the pump head were visually monitored for any new clots along with monitoring of delta P for new onset membrane lung dysfunction. A combination of flexible and rigid bronchoscopy was used during the procedure. BF-MP190F flexible bronchoscope was used for surveillance before and after stent placement. Karl Storz rigid bronchoscopes were used for deploying the stent under fluoroscopic guidance. BF-XT190 was used for clearance of airways before stent deployment. JAVASTENT® Tracheal covered Y-Stent stent (40 mm × 12 mm) was placed using a 14 rigid bronchoscope for Y-stent placement (Fig. 3). In the course of the Y-stent placement procedure, the patient's oxygenation was exclusively supported by VV-ECMO. Anesthesia was administered exclusively for the purpose of providing patient comfort during airway manipulation. Extracorporeal life support (ECLS) allowed for stable oxygenation of the patient, enabling the tracheal procedure to be performed. Propofol and fentanyl were utilized for the induction of general anesthesia, followed by maintenance through a propofol infusion. Bleeding during the procedure was controlled using a cryoprobe. The patient was intubated poststenting as the pulmonologist said he needed a conduit for bronchoscopy as she requires repeated

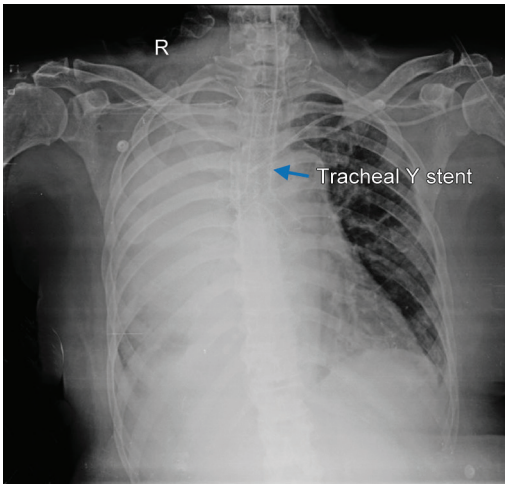


**Fig. 4:** Arrow showing tracheal Y stent

therapeutic airway suctioning poststenting because of purulent tracheal secretions.

Following the procedure, the patient remained hemodynamically stable and required minimal oxygen support, leading to the swift weaning and removal of VV-ECMO the next day (Fig. 4).

## Discussion

In our case, ECMO insertion was preemptively performed before the clinical worsening of the patient, both ventilatory and hemodynamically in view of ACS. Furthermore, it was performed preemptively in anticipation of ventilation difficulties that may arise during stent placement.

Deployment of VV-ECMO should be considered prior to the induction of anesthesia in patients with severe airway obstruction and where the advancement of a rigid bronchoscope into the distal airway or ventilation through a rigid bronchoscope is anticipated to be technically difficult.[1]

In 1986, Hicks reported the first use of pre-emptive ECMO in patients with impossible airways.[2] With the rising number of individuals suffering from lung cancer and tracheal malignancies, there is a corresponding increase in the probability of occurrence and the risk of central airway obstruction, particularly among the elderly population. Thus, the potential indication for preventive use of ECMO in such a situation will also increase.[3]

Hong et al. preemptively initiated VV-ECMO in 18 cases to facilitate ventilation in severe airway obstruction.[4] According to Kim et al., it is recommended that pre-emptive ECMO support be made available if the tracheal lumen measures less than 5 mm on a computed tomography scan prior to any airway procedures.[5] Park et al. examined the use of VV-ECMO for tracheal stent placement.[6] Of 17 patients, 13 had an endotracheal tube placed prior to ECMO. Additionally, its usage is becoming more prevalent in cases that involve complex tracheal surgeries, including carinal resection and reconstruction, or the resection of tracheal tumors spanning long segments.[7]

The utilization of ECMO also provides enhanced visualization of the surgical site in comparison to conventional ventilation techniques such as maintenance of spontaneous ventilation, intermittent positive pressure ventilation via the side port of rigid bronchoscope, and low-frequency or high-frequency jet ventilation.[8]

Extracorporeal membrane oxygenation serves the dual purpose of preventing perioperative mortality during the induction of general anesthesia in complex airways and improving intraoperative stability and safety. However, it does not come without inherent complications. The most common complication is bleeding secondary to the use of anticoagulation and the presence of coagulopathy, resulting from prolonged exposure of the blood to the foreign external circuit.

However, we recommend that the preemptive utilization of VV-ECMO in an awake patient who is breathing spontaneously is potentially a safer course of action compared to deploying ECMO after inducing anesthesia in patients with benign diseases. The continuous stability provided by intraoperative ECMO can provide clinicians more time to maneuver the stent into the optimal location in these difficult patients, resulting in fewer procedural problems.[6] Initiation of VV-ECMO in a stage IV lung cancer for respiratory failure would be considered as an absolute contraindication under conventional standards of care but it can still be considered as an adjunct for assisting other palliative therapies aimed at reducing discomfort. However, if the therapeutic procedure fails, weaning ECMO would present an ethical and moral dilemma for the parties concerned. The use of ECMO as a "bridge to nowhere" for these patients can be detrimental, as it prolongs their pain and raises the chances of complications such as neurological catastrophe or exsanguination. This can be distressing for patients, families, and medical personnel.

While discussing the possibility of a time-limited trial as part of the informed consent process can help prepare for the withdrawal of ECMO in case a patient cannot be successfully weaned off it, this pursuit poses a challenge. Informed consent discussions for ECMO are typically brief, and even if patients have previously agreed to a time-limited trial, they retain the right to change their decision at any point during ECMO treatment.[9] If this situation arises, medical professionals should respect the preferences of patients to the best of their capabilities. Furthermore, there is apprehension that patients might feel pressured, either directly or indirectly, to agree to a clinician's suggestion of a time-limited trial. This pressure could stem from the belief that agreeing to the trial is essential in order to receive potentially life-extending care with ECMO.

We believe that it is of utmost importance to prudently select appropriate cases for treatment through multidisciplinary discussions involving interventional pulmonologists, surgical oncologists, ECMO specialists, intensivists, and anesthesia teams. It is crucial to take into account variables including the suitability, affordability, availability, and expertise of ECMO services in order to maximize results in these circumstances. Moreover, we recommend maintaining a database of relevant ECMO cases for future reference. Despite the benefits of ECMO in our patient's treatment, most cases of malignant central airway obstruction can be effectively treated without it and hence ECMO should not be seen as the sole strategy for managing malignant central airway obstruction.

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CASE REPORT

# Awake Venoarterial Extracorporeal Membrane Oxygenation: Saving Lives in Aluminum Phosphide-induced Myocarditis

Nishanth Selvaraj[1], Venkatesh Kumar[2], Prabu G[3], Sathya Praksash[4]

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## Abstract

Venoarterial extracorporeal membrane oxygenation (VA-ECMO) has emerged as a crucial intervention for severe myocarditis, particularly when the causative factors are reversible, such as viral infections or toxins. This report details a case of toxic myocarditis resulting from aluminum phosphide poisoning, successfully treated with VA-ECMO support. Notably, the ECMO was initiated while the patient was conscious. In the absence of effective treatments for this lethal toxin, VA-ECMO effectively maintained circulation despite severe arrhythmias. The patient recovered within 84 hours and was discharged without any lingering health issues.

**Keywords:** Awake extracorporeal membrane oxygenation, Case report, Toxic myocarditis, Venoarterial extracorporeal membrane oxygenation.

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## Case Description

A 52-year-old female presented to the emergency room in a state of shock, having ingested two tablets of aluminum phosphide 2 hours prior. Initial evaluation revealed a reduced left ventricular ejection fraction (LVEF) and metabolic acidosis, admission ECG is shown in Figure 1. She was categorized as SCAI shock stage D and scored (–3) on the survival after venoarterial ECMO (SAVE)

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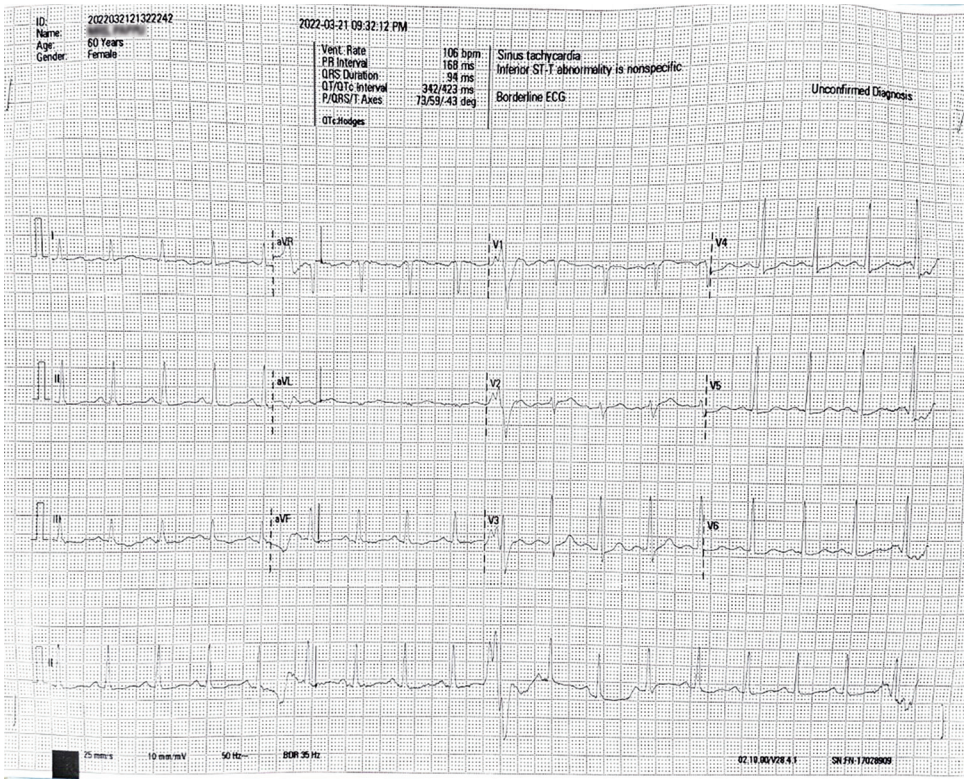


**Fig. 1:** ECG at admission–Sinus tachycardia

score, indicating a high-risk status (risk class III) with a 42% in-hospital mortality rate. The venoarterial extracorporeal membrane oxygenation (VA-ECMO) was initiated within 6 hours of poisoning using a USG-guided Seldinger technique. A 25Fr drainage cannula was employed in the right femoral vein, a 19Fr return in the left femoral artery, and a 7Fr distal perfusion cannula to sustain perfusion in the left lower limb. X-rays confirmed the appropriate placement of the drainage cannula in the intrahepatic IVC (Fig. 2). Remarkably, the patient was on room air during the ECMO initiation.

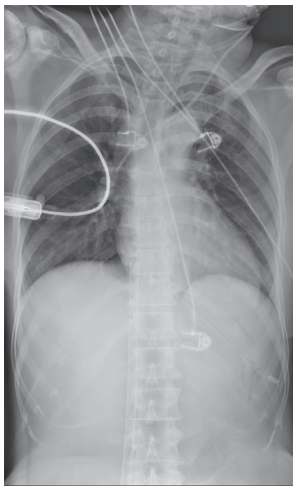

**Fig. 2:** X-ray—the drainage venous cannula in intra hepatic portion of IVC

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**Source of support:** Nil

**Conflict of interest:** None

Within hours, the patient experienced episodes of ventricular fibrillation and tachycardia (Fig. 3), necessitating cardioversion and amiodarone treatment. Despite these challenges, ECMO support effectively maintained tissue perfusion. Lactate levels began to stabilize within a few hours of ECMO initiation, as evidenced by serial ABG analyses indicating a progressive improvement in acidosis and decreasing lactate levels (Table 1). At the 48-hour mark, severe myocardial depression led to pulmonary edema, requiring invasive positive-pressure ventilation. Careful management of fluid balance and diuretics effectively addressed the pulmonary complications.

By the 72-hour mark, signs of cardiac function recovery were evident. Consequently, a gradual reduction in ECMO blood flow commenced to alleviate the recovering heart's afterload. Serial echocardiography over the subsequent 3 days (Video clip on journal's website) demonstrated a progressive improvement in left ventricular function. The ECMO support was systematically withdrawn, and after 84 hours, decannulation with the assistance of a vascular surgeon was performed. The patient was liberated from the ventilator the following day. Subsequent doppler scans ruled out lower limb vessel thrombosis, and the patient was discharged without any complications by the 7th day.

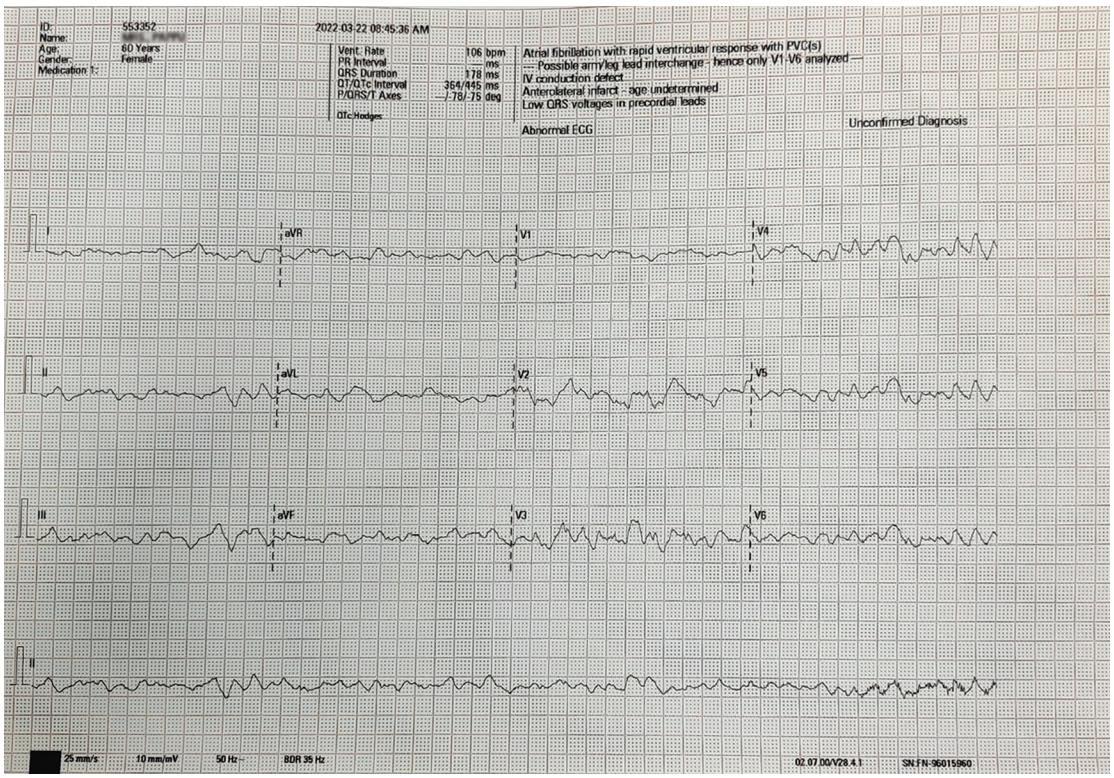


**Fig. 3:** ECG—6th hour after ECMO – showing ventricular fibrillation

**Table 1:** Serial bicarbonate and lactate values

| *Timeline* | *Bicarbonate (mmol/L)* | *Lactate (mmol/L)* |
|---|---|---|
| Pre ECMO | | |
| 6th hour post ingestion – At admission | 9.1 | 13.4 |
| 10th hour | 9.0 | 19 |
| Post ECMO—ECMO initiated at 4th hour since admission | | |
| 1st hour | 13.4 | 23 |
| 3rd hour | 12.7 | 27 |
| 6th hour | 20 | 17 |
| 12th hour | 17.6 | 13 |
| 18th hour | 18.6 | 9.7 |
| 24th hour | 18.6 | 6 |
| 32nd hour | 20.2 | 3.5 |
| 44th hour | 32.3 | 2.1 |
| 56th hour | 29 | 4 |
| 68th hour | 29.3 | 4.2 |
| 70th hour | 29.9 | 3.8 |
| 80th hour | 31.9 | 2.8 |
| 83rd hour–30 minutes with ECMO flow @1.5 L | 31 | 2.3 |
| 84th hour–30 minutes with ECMO flow @ 1 L | 31.2 | 2.2 |
| Post decannulation 1 hour | 29.3 | 2.3 |

## Discussion

Aluminum phosphide ingestion is associated with high mortality rates.[1] Typically used as a rodenticide and grain storage fumigant, it releases phosphine gas upon ingestion, inhibiting cytochrome oxidase and causing cellular respiration disruption, oxidative stress, myocardial depression, circulatory collapse, metabolic acidosis, and multiorgan dysfunction syndrome (MODS).[2,3] Unfortunately, there is no specific antidote for this compound.[4]

Recent case series have highlighted the potential efficacy of VA-ECMO in patients with specific high-risk features following aluminum phosphide poisoning. These features include severe metabolic acidosis (pH $\leq$ 7.0), refractory shock despite maximum vasopressor and inotrope support, and a LVEF of <35%.[5] Our case exhibited refractory shock and a low ejection fraction, warranting the use of ECMO support.

While VA-ECMO proved instrumental in this case, it is not without complications. Early detection and management of complications, such as left ventricular distension to prevent complications like aortic root thrombus, are crucial.[6] Options for managing LV distension include vasopressor and inotrope titration, adjusting ECMO flows, utilizing IABP, and surgical venting of the left ventricle or left atrium when conservative measures fail.

The practice of initiating VA-ECMO in conscious patients is gaining traction due to its potential to reduce hospital-acquired infections, enhance patient comfort, and minimize nosocomial infections.[7] In our case, the patient was successfully supported on awake ECMO for the initial 36 hours before necessitating mechanical ventilation due to pulmonary edema. Surgical decannulation at the arterial site followed by doppler scans to detect thrombosis is imperative.

## Conclusion

The VA-ECMO stands as a viable life-saving intervention for severe myocarditis with reversible causes, such as viral infections or toxins like aluminum phosphide. Key factors for successful outcomes include early initiation of extracorporeal life support (ECLS) before the onset of MODS and robust multidisciplinary team support.

## Supplementary Material

Supplementary videos to this article are available online on the website of https://youtu.be/oFiyIVLoS8E.

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SURVEY

# Sedation Practices during VV-ECMO in Indian Scenario: A Retrospective Survey

Vikrant Shamrao Pawar

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## Abstract

**Aim and background:** There has been an exponential rise in the use of venovenous extracorporeal membrane (VV-ECMO) in patients who develop acute respiratory distress syndrome (ARDS), as observed in Indian hospitals. In spite of the ever-increasing cases of patients being treated with VV-ECMO, there is scarcity of literature about sedation management in this patient group. This retrospective, online questionnaire-based survey was undertaken with an aim of gaining an overview of what majority institutes in India are practicing with respect to sedation during VV-ECMO, so that it can contribute to the smallest extent in forming policies and protocols.

**Materials and methods:** This survey was formulated on SurveyMonkey application and shared with members of ECMO society of India (ESOI) through WhatsApp. Their responses were recorded and analyzed through SurveyMonkey application.

**Results:** Fentanyl was found to be the most widely used drug followed by midazolam and fentanyl plus midazolam was the most commonly used combination. Majority of participants (83.33%) use Richmond Agitation-Sedation Scale (RASS) for monitoring agitation. Only other scale being used is the Ramsay scale. Incidence of delirium was less than 10% in most intensive care units (ICUs). Majority of participants (54.17%) required deep sedation for less than 5 days to keep their patients calm and comfortable. Physiotherapy was given during both deep and light sedation in most of the units (60%).

**Conclusion:** We found substantial uniformity with respect to choice of agitation scales used, initiation of physiotherapy, incidence of delirium and number of days on deep sedation among the centers across India.

**Clinical significance:** Although this survey gives a glimpse of sedation practices in VV-ECMO in many centers across India, more surveys and studies are required on this topic.


**Keywords:** Sedation, Survey, Venovenous extracorporeal membrane oxygenation.

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## Introduction

John Gibbon invented cardiopulmonary bypass circuit leading development of extracorporeal life support devices used in current era.[1]

Extracorporeal life support encompasses various modalities including extracorporeal membrane oxygenation (ECMO), which provides temporary cardiopulmonary assistance in failing heart and/or lung.[2]

Early bubble oxygenators had limitation of having higher chances of hemolysis.[3] In 1957, it was found that silicone efficiently allows gas exchange with lesser hemolysis. "Membrane oxygenator" was thus discovered and paved the way in coining the term ECMO. Prolonged extracorporeal support had become a possibility due to development of efficient oxygenators and use of continuous anticoagulation.[4]

Extracorporeal membrane oxygenation technology has seen a lot of evolution since then. The pump in ECMO functions like a heart, as it receives and propels the blood. An oxygenator does functions like that of a lung, by oxygenating the blood.

Venovenous extracorporeal membrane (VV-ECMO) provides respiratory support, whereas venoarterial ECMO (VA-ECMO) provides cardio-respiratory support.[5] There are various indications of VV-ECMO (e.g., bridge to lung transplant, status asthmaticus, bronchopleural fistula, acute lung injury, and viral/bacterial pneumonia); however, it is most commonly used worldwide for treating severe acute respiratory distress syndrome (ARDS).[6] The primary goal of supporting a patient with VV-ECMO is to promote lung rest via lung-protective ventilation.[7] Therefore, sedation forms important and integral part of management in patients on VV-ECMO.

Severe hypoxemia, ventilator dyssynchrony and fear of patient-initiated cannula removal are crucial challenges in VV-ECMO patients necessitating deep sedation and restricting mobility.[8] There are no widely accepted guidelines for the management of sedation and analgesia in patients on VV-ECMO, leading to diversity in sedation practices worldwide for this patient population.[9]

Last few years, especially since COVID-19 pandemic there is exponential rise in the number of patients being treated

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**Source of support:** Nil

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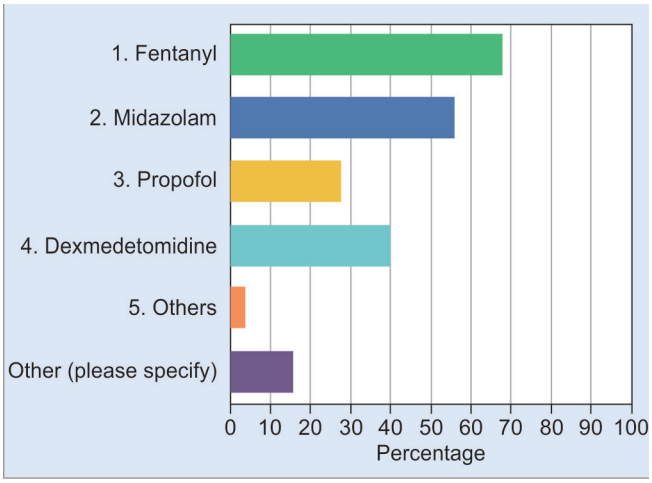


**Fig. 1:** Responses to question 'which drugs are used in your ICU for sedation in patients on VV-ECMO'

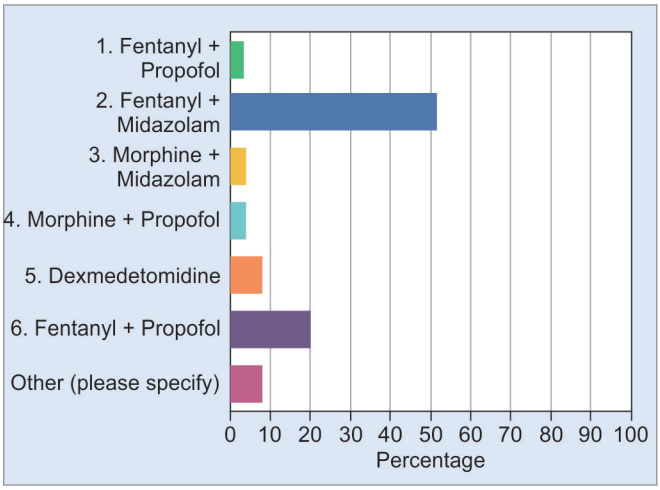


**Fig. 2:** Responses to question 'drug combination preferred in your ICU for sedation in VV-ECMO'

**Table 1:** Percentage wise demonstration of responses to question 'which drugs are used in your ICU for sedation in patients on VV-ECMO'

| *Answer choices* | *Responses* | |
|---|---|---|
| 1. Fentanyl | 68.00% | 17 |
| 2. Midazolam | 56.00% | 14 |
| 3. Propofol | 28.00% | 7 |
| 4. Dexmedetomidine | 40.00% | 10 |
| 5. Others | 4.00% | 1 |
| Other (please specify) | 16.00% | 4 |
| Total respondents: 25 | | |

with VV-ECMO in the Indian scenario. Our survey focuses on understanding sedation practices in various institutes across India while managing patients on VV-ECMO.

## Materials and Methods

In this retrospective survey, we collected data from intensivists and anesthetists managing patients on VV-ECMO in their respective institutes. The survey was created on SurveyMonkey application, which is available on android and apple devices. Survey link was shared with members of ECMO society of India (ESOI) through WhatsApp group. Responses received could be directly tracked and analyzed in the application. The survey was conducted in two parts, where 1st part had seven questions and 2nd part had two questions. The questions in both the parts had multiple choices and scope to mention any particular deviation. It was not mandatory to mention name of the unit or the respondent. Out of 412 members of ESOI, 25 responses were received for both the parts of the survey. The survey was conducted in December 2023.

## Results

The drugs used for sedation in patients on VV-ECMO in Indian intensive care units (ICUs) were fentanyl, midazolam, dexmedetomidine, propofol, morphine, and ketamine. The most commonly used drug is fentanyl followed by midazolam. Dexmedetomidine was the third most commonly used drug indicating its rising popularity (Fig. 1, Table 1).

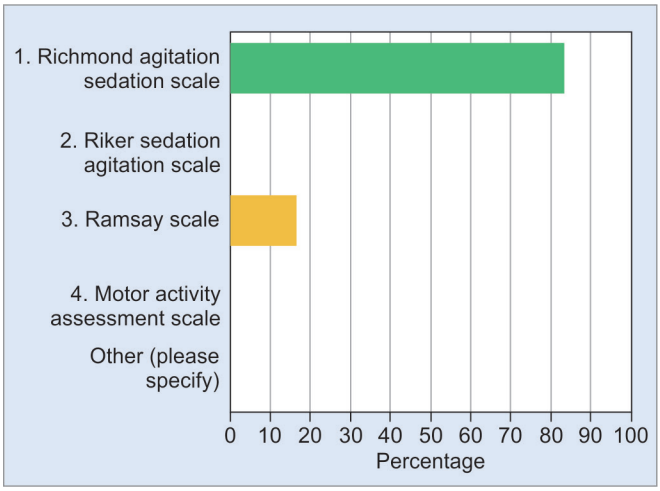


**Fig. 3:** Responses to question 'which agitation sedation scale is used in your ICU'

Fentanyl and midazolam was the most commonly used combination followed by a combination of fentanyl, midazolam, and propofol. Interestingly, some centers use dexmedetomidine and ketamine combination (Fig. 2). One of the participant mentioned about use of combination dexmedetomidine infusion and fentanyl boluses in their unit.

Majority participants (83.33%) use Richmond Agitation-Sedation Scale (RASS) for monitoring agitation. Only other scale being used is the Ramsay scale (Fig. 3).

Incidence of delirium was less than 10% in most ICUs. Approximately, 28% ICUs reported incidence of 11–20% and only 4% of ICUs had delirium percentage 21–30% (Fig. 4).

Majority of participants (54.17%) required deep sedation for less than 5 days to keep their patients calm and comfortable. Deep sedation was required in the patients for 6–10 days as per 45.83% of the respondents (Table 2).

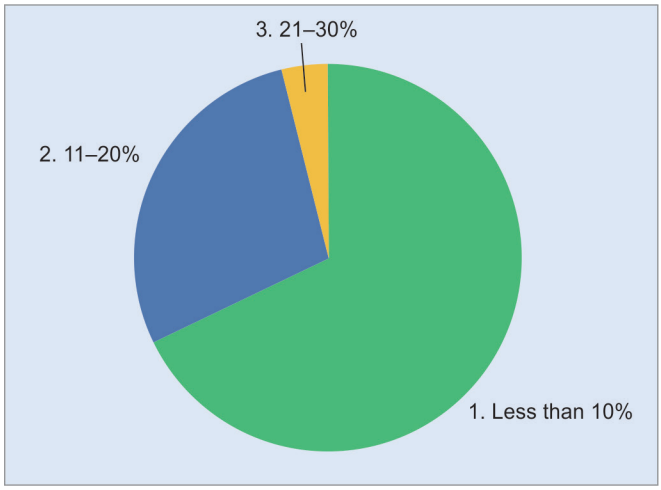


**Fig. 4:** Responses to question 'Incidence of delirium in patients on VV-ECMO in your ICU'

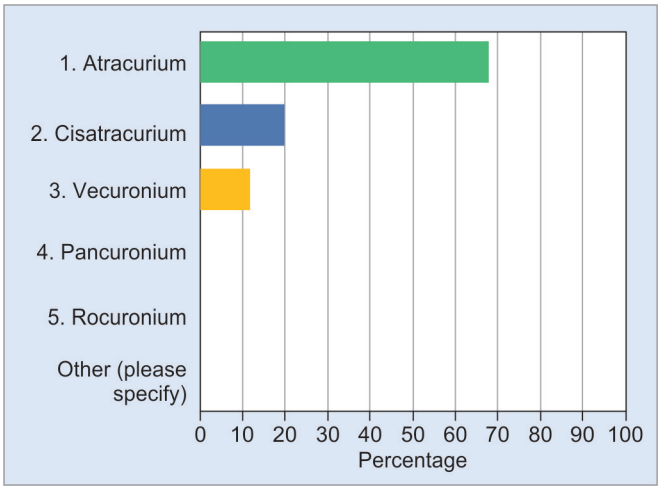


**Fig. 5:** Responses to question 'which NMBAs preferred in your ICU, for patient on VV-ECMO'

**Table 2:** Percentage wise responses to question 'As an average for how many days most patients are deeply sedated when on VV-ECMO in your ICU'

| *Answer choices* | *Responses* | |
|---|---|---|
| 1. Less than 5 days | 54.17% | 13 |
| 2. 6–10 days | 45.83% | 11 |
| 3.11–14 days | 0.00% | 0 |
| 4. >14 days | 0.00% | 0 |
| Other (please specify) | 0.00% | 0 |
| Total | | 24 |

**Table 3:** Percentage wise responses to question 'how many patients required deep sedation when on VV-ECMO'

| *Answer choices* | *Responses* | |
|---|---|---|
| 1. <25% | 32.00% | 8 |
| 2. 25–50% | 56.00% | 14 |
| Other (please specify) | 12.00% | 3 |
| Total | | 25 |

Approximately, 25–50% patients required deep sedation even after putting on VV-ECMO as per 56% of respondents. While one respondent reported that >50% cases required deep sedation, only one reported the requirement of deep sedation in all their cases (Table 3).

Atracurium is the most widely used neuromuscular blocking agent (NMBA) by 68% of respondents in patients on VV-ECMO. Cis-atracurium (20%) and vecuronium (12%) are the only other agents used for the said purpose in the Indian scenario (Fig. 5).

Need of NMBAs for more than 48 hours in up to 25% patients was reported by 88% of participants; however, only 12% reported use of NMBAs in excess of 48 hours for more than 25% patients (Fig. 6).

Most ICUs start physiotherapy when a patient is in deep and/or light sedation. Approximately, 36% ICUs allow physiotherapy only when the patient is in light sedation (Fig. 7).

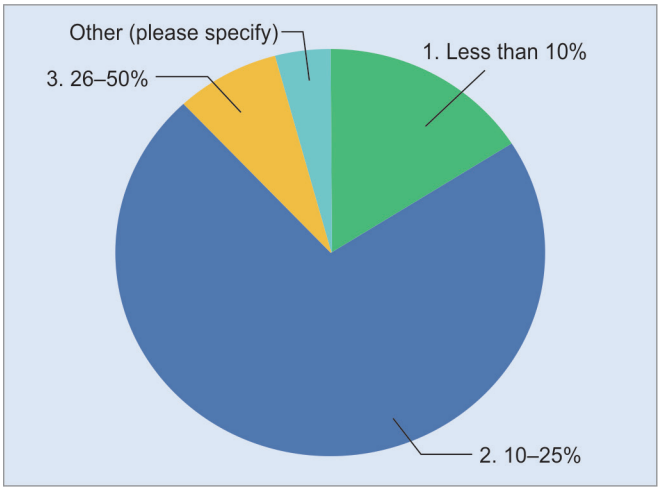


**Fig. 6:** Responses to question 'What percentage of patient required NMBA for more than 48 hours when on VV-ECMO'

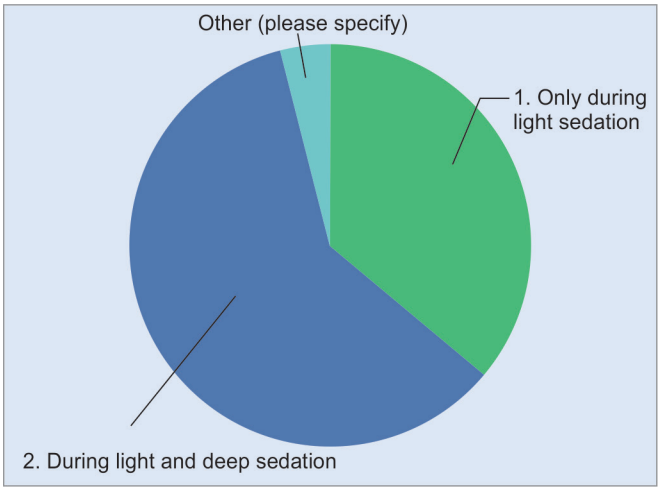


**Fig. 7:** responses to question 'Is physiotherapy continued in your ICU during sedation in patients on VV-ECMO'

## Discussion

Rising use of ECMO technology has imparted light on the supportive care which includes sedation management, pain management, delirium management, and physiotherapy.

In patients who are on life support but are not on ECMO, these areas are well researched and there are evidence-based guidelines available for the purpose.[10] Patients who had received daily interruption or light sedation showed a decreased in-hospital mortality rate, in comparison to those on deep sedation.[11] Delirium in ventilated patients causes longer stay on mechanical ventilator, prolonged hospitalization, and increased mortality.[12] Initiation of physiotherapy early in the course of mechanically ventilated patients has shown improved outcomes.[13] However, there is scarcity of data and practice guidelines in sedation management in patients on ECMO and there is substantial variation in daily practice from one center to another.[9,14,15]

Significant pharmacokinetic alterations happen in patients on ECMO, affecting drug dosing of the sedative agents.[16]

The most important reasons are as follows:

- Drug sequestration or adsorption to the circuit. It is observed more with highly lipophilic drugs like fentanyl. Circuit may act as reservoir prolonging the sedoanalgesia effect.[16–18]
- Higher volume of distribution due to drug adsorption and fluid resuscitation.[16–18]
- Drug clearance variabilities due to organ dysfunction.[19]
  This increased demand, sequestration, and reduced clearance leads to patients remaining sedated for considerably higher time than desired.

In our survey, we found that up to 32% participants reported the need of deep sedation in a quarter of their patients on VV-ECMO. Approximately, 56% participants felt the need of deep sedation in up to half of their patient population when on VV-ECMO. A multinational study involving more than 300 centers found that three out of every four patients on VV-ECMO required deeper sedation and one out of every four could be managed with minimal sedation.[20] Considerable difference is seen here if compared with findings in our survey.

The Extracorporeal Life Support Organization (ELSO) guidelines suggest light sedation to be preferred in patients receiving ECMO.[21] A single center retrospective study conducted at Toronto general hospital between year 2012 and 2015 by showed that patients on VV-ECMO required deep sedation for an average of 6 days.[8] In our study, we found that 54.17% respondents reported the need for deep sedation for <5 days for most of the patients. Deep sedation requirements for 6–10 days were reported by 45.83% respondents. None reported deep sedation beyond 10 days.

Extracorporeal Life Support Organization suggests to use of NMBAs during intravenous cannulation to avoid air embolism due to breathing efforts by the patient. The use of NMBAs may be considered when the ECMO flow optimization is in process and is not to be preferred during other times.[21] In our survey, we noticed that only 8% respondents reported the use of NMBAs beyond 48 hours in more than a quarter of patients. That indicates 92% of units had less than 25% patients who required NMBAs for more than 48 hours, which seems compliant with ELSO guidelines.

A single center observation study done over 8 years reported that physiotherapy if initiated in first week of ECMO support leads to lesser time on ECMO and shorter stay in ICU.[22] Munshi et al. conducted a study between year 2010 and 2015 concluded that early physiotherapy can be initiated in patients on VV-ECMO and it may lead to reduction in mortality.[23] In our survey, 60% respondents conveyed that physiotherapy is initiated in their unit even when patient is deeply sedated while on VV-ECMO and it is continued during light sedation. Only 36% respondents stated that they initiate physiotherapy only when the patient is in light sedation. This is a buoyant trend in Indian ICUs that as majority of centers prefer early physiotherapy even when the patient is deeply sedated.

Meta-analysis done by Ho et al. included 10 studies and 8580 patients to assess prevalence of delirium in patients on ECMO. It found that 51.84% patients on VV-ECMO had delirium.[24]

As per our survey, 68% respondents reported that incidence of delirium was <10% in their unit when the patients were on VV-ECMO. Approximately, 28% reported incidence to be between 11 and 20%. Considerable difference between results of meta-analysis and our study indicates more research is needed in this area.

Multiple scales and scoring systems are used to assess agitation sedation in critically ill patients, including Ramsay scale, RASS, Riker sedation agitation scale (SAS), and motor activity assessment scale (MASS) to name a few.[14] Study done by deBacker et al. used SAS, while survey conducted by Buscher et al. used Ramsay scale for assessing agitation-sedation in patients on VV-ECMO.[8,9] In India, RASS seems to be the most widely used scale followed by Ramsay scale as per results of our survey.

There is wide variety in choice in the use of sedatives and analgesics at global level for patients on VV-ECMO. An international survey done by Minnen et al. across 48 centers found the most commonly used drugs for the purpose as propofol, midazolam, dexmedetomidine, fentanyl, morphine, and ketamine in reducing order.[25] International survey done by Buscher et al. found that midazolam was the most frequently used drug (79%), followed by morphine and fentanyl. While propofol was used in (36%), alpha-2 agonist was administered frequently in up to 66% cases on VV-ECMO. Neuromuscular blocking agents most commonly used were vecuronium (40), followed by cis-atracurium (21%).[9] Pan-American and Iberian Federation guidelines on sedation and analgesia 2020, suggests the use of opioids like morphine along with ketamine. Morphine is preferred due to its lower lipophilicity.[14] Our study found that fentanyl (68%) was commonly used drug, followed by midazolam (56%), dexmedetomidine (40%), propofol (28%), and morphine (12%). Fentanyl and midazolam were the most widely used sedative combination (52%) as per our survey. There was a unique combination used at some centers in the form of dexmedetomidine and ketamine (8%). Approximately, 20% centers used fentanyl, propofol, and midazolam combination for deeper sedation. Atracurium was the preferred NMBA (68%), followed by cis-atracurium (20%) and vecuronium (12%). There is paucity of data on choices of sedatives, their combinations and NMBAs used in patients on VV-ECMO. Moreover, there are no widely accepted guidelines for sedation protocol in patients on VV-ECMO. More surveys, trials, and evidence-based guidelines are the need of the hour in this context.

## Conclusion

Our study highlighted a trend in choices of sedatives, NMBAs and their combinations used in centers across India in the treatment of patients on VV-ECMO. Findings like choices of drugs used for sedation also corroborated with international surveys. The survey

found substantial uniformity among the responses about the agitation scales used, initiation of physiotherapy, incidence of delirium, and number of days deep sedation were required.

### Clinical Significance

This survey gives a glimpse of sedation practices in VV-ECMO in many centers across India, though more surveys and studies are required on this topic.

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### VV ECMO Assisted Tracheal Stenting

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DOI: 10.5005/jaypee-journals-11011-0018.1

**Keywords:** VV ECMO, Tracheal stenting, Respiratory failure

The use of extracorporeal membrane oxygenation (ECMO) can be beneficial when conventional ventilation methods are unsuccessful. Here, we successfully managed a patient with advanced tracheal malignancy and impending airway obstruction by implementing veno-venous ECMO (VV-ECMO) before performing a critical endotracheal procedure. The VV-ECMO was securely established through the right jugular vein and the left femoral vein, under local anesthesia. The placement of a tracheal stent was then performed under the guidance of a rigid bronchoscope and fluoroscopy. ECMO effectively maintained adequate oxygenation and ventilation. VV-ECMO serves as a valuable tool in supporting airway interventions for complex tracheal pathologies, especially when conventional ventilation may not be sufficient or feasible.

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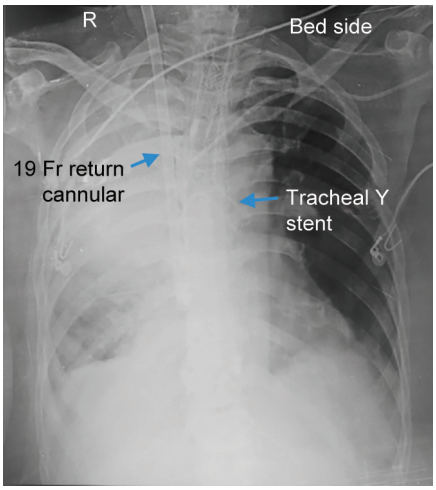


### Multi-slice Contrast – Enhanced CT Imaginig in Periphrral VA ECMO: How I Do It?

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DOI: 10.5005/jaypee-journals-11011-0018.2

**Keywords:** Computed tomography, ECMO, Contrast

**Introduction:** Extracorporeal membrane oxygenation (ECMO) is a modified cardiopulmonary bypass to support life, permitting further treatment and recovery during severe cardiac or pulmonary failure. Computed tomography (CT) is widely applied in the assessment of critical conditions, such as clinical suspicion of complications or an unexplained delay in improvement on ECMO. **Methods:** Specific hemodynamic changes associated with patients on ECMO determine the patterns and the route of contrast use in CT(computed tomography). Different possible venous route for contrast delivery were used on VA-ECMO patient to get proper coronary view as used in non ECMO patients which encountered complication for proper imaging. **Results:** If a CT angiogram is being performed on these type of VA-ECMO patients to evaluate the coronary status, an optimal image can be obtained by lowering the flow rate of the ECMO circuit or by disabling the circuit for the duration of image acquisition. **Conclusion:** Therefore it is important that in ECMO centers perfusionists are well aware of the imaging pitfalls associated with the use of CT in ECMO cases.It is also important to apply well-designed imaging protocols in ECMO centers and familiarize themselves with post-contrast CT imaging findings in patients on ECMO.

### Reviving the Unrecoverable: Outcomes of Veno-arterial ECMO In 14 Severe Celphos Poisoning Cases, Highlighting The Role of Multidisciplinary Management and Future Implications

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**Introduction:** Celphos poisoning, common and often fatal in North India, lacks a specific antidote, with cardiogenic shock as the primary cause of death.[1] This case series examines 14 high-risk Celphos poisoning cases treated with VA-ECMO at our hospital (October 2021-August 2023), resulting in a 78.5% survival rate. Establishing a new ECMO center presented challenges, and post-liberation, some patients needed prolonged care, emphasizing the need for comprehensive, long-term management. Despite hurdles, the successful outcomes demonstrates VA-ECMO's efficacy in severe Celphos poisoning. **Case series:** Patients who met the inclusion criteria for high-risk Celphos poisoning, includes left ventricular myocardial dysfunction with an ejection fraction of ≤35% or severe metabolic acidosis with a pH ≤ 7.0 and/or refractory shock with a systolic blood pressure <80 mmHg despite conventional medical therapies, were considered for VA-ECMO therapy.[2] **Discussions:** In 23 high-risk Celphos poisoning cases, average presentation time was 7 hours, with 6 grams ingestion on average. 14 patients received VA ECMO. All cannulation was done ultrasound guidance. VA-ECMO recipients showed a 78.5% survival rate. Mechanical ventilation, renal replacement therapy, bleeding, and thrombosis were observed in varying cases. Limb ischemia occurred in two, psychiatric symptoms in

one, and four developed sepsis. The average door to cannulation time was 40 minutes. VA-ECMO duration averaged 48 hour, contributing to reduced vascular access complications, blood transfusions, and overall cost-effectiveness and safety. **Conclusion:** VA-ECMO therapy may be a promising intervention for severe Celphos poisoning cases with cardiogenic shock. Multidisciplinary management is crucial for the successful management of these patients in a new center. Our experience highlights the importance of collaborative management and may have important implications for future management.

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### A Successful Case of VA-ECMO For an Antenatal Woman with Aluminium Phosphide Poisoning

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DOI: 10.5005/jaypee-journals-11011-0018.4

**Introduction:** Aluminium phosphide poisoning has high mortality of 80-100% which causes refractory cardiogenic shock and multiorgan dysfunction syndrome. Maternal mortality has always been a major medical concern. The effects of aluminium phosphide toxicity on both mother and fetus should be treated and the classical treatment may be controversial at certain circumstances. Among population who were ingested aluminium phosphide tablets, antenatal women were rare and have higher risks. **Case presentation:** We present a case of 21-year-old antenatal woman who was consumed aluminium phosphide tablets (3g) in suicidal intent. On primary survey, her airway was patent, blood pressure was 100/60 mm Hg with heart rate of 105/min. Routine investigations and POCUS were done. POCUS revealed reduced LVEF-25%. As the time progressed her blood pressure started falling (90/60 mm Hg) and lactate levels were raising (10.5 mmol/L). Hence, she was started on inotropes. Inspite of increasing her vasopressor and inotropic support her hemodynamics remained unstable. In view of refractory cardiogenic shock secondary to lactic acidosis due to aluminium phosphide poisoning, VA ECMO was planned. Elective intubation was done. Obstetrician opinion was obtained regarding morbidity and mortality of the fetus. After obtaining high risk consent, peripheral VA ECMO was initiated. Gradually after 4 hours of initiation her lactate levels started decreasing and her hemodynamics were improved. Serial POCUS monitoring was done. After 62 hours, her cardiac function improved and the fetal viability remained intact. Hence, she was successfully weaned off from ECMO. **Discussion:** This case illustrates the prompt and appropriate choice of treatment in an antenatal woman with aluminium phosphide poisoning will increase the survival rate of both mother and fetus.

### ASuccessful Case of VV ECMO Complicated by Membrane Thrombosis and Airway Haemorrhage

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DOI: 10.5005/jaypee-journals-11011-0018.5

**Objective:** Despite increasing use and promising outcomes Veno-Venous ECMO introduces the risk of a number of complications across the spectrum of ECMO care. This describe the variety of complication that can occur during treatment with ECMO and how patient selection and management decisions may influence the risk of these complication. ECMO has emergedasapromising intervention that may provide more efficacious supportive care to these patients. Improvements in technology have made ECMO safer and easier to use, allowing for the potential of more widespread application in patients with Acute Respiratory Failure. **Methods**: Femoral-IJV cannulation with adequate flows was used to perform a Veno-Venous ECMOon a 60-year-old male patient who had been diagnosed with ARDS and developed pneumonia. From there, we faced numerous challenges for almost 36 days of ECMO, including a coagulation factor, failure of the oxygenator, an active internal bleed at the lung, aspirations from the Ryles tube, regular lab work, X-rays, ACT for hourly sometimes. **Conclusion:** VVECMO is the treatment of choice for patient with respiratory failure refractory to optimal mechanical ventilation and conventional medical treatment. A baseline echo evaluation of paramount importance in such critically ill patient to rule out the presence of concomitant cardiac dysfunction. Technological advances have improved the safety and simplicity of ECMO for patients with Acute Respiratory Failure and may represent an important advance in the management of these patient. VV-ECMO is a form of mechanical circulatory support that has been shown to be effective in temporarily managing patients with profound respiratory failure.

### Role of Respiratory Therapist is Essential during VV-ECMO

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Role of Respiratory therapist is essential during VV-ECMO, because mechanical ventilation is still required due to reasons that are:

(1) ECMO blood flow rate is usually not enough and in hyperdynamic status a substantial proportion of blood still passed via native lung, not having gone through the artificial lung first;
(2) lung should be mildly ventilated and kept open.

### Role of VA-ECMO in Dengue Myocarditis

***Girish IR***

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Dengue is an acute viral illness caused by a RNA virus of the family Flaviviridae and spread by the Aedes mosquito. Cardiac manifestations of Dengue fever vary from mildly raised cardiac enzymes to severe myocarditis, congestive heart failure, arrhythmia's, cardiogenic shock and death. We present a case of 19 year old female who presented to us with cardiogenic shock and was found to be NS1 and IG M positive. She had a Mobitz type II block on her electrocardiogram (ECG) with bradycardia on arrival to the emergency room and a temporary pacemaker was placed via a femoral vein approach. She was initiated on central veno-arterial extracorporeal membrane oxygenation (VA-ECMO) with an apical left ventricular (LV) vent as a bridge to recovery. A myocardial biopsy was done at this stage. Apart from thrombocytopenia needing platelet transfusion her stay in intensive care was unremarkable. She passed the RAMP test on VA-ECMO day 5 and eventually weaned off VA-ECMO on day 7 and was successfully decannulated. Her abnormal ECG rhythm persisted and she was reviewed by the electro-physiology team. The ECG

finding was deemed a conginental block, not needing a permanent pacemaker insertion. The myocardial biopsy which was done while initiating VA-ECMO showed evidence of necrotic myocardial tissue with lymphoid infiltration which cemented the diagnosis of viral myocarditis. In this case report we highlight the successful usage of VA-ECMO as a bridge to recovery in a patient with cardiogenic shock caused by viral myocarditis.

### Victorious VV-ECMO in a Post Cardiac Arrest Pediatric Patient with ARDS and Bilateral Pneumothorax

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A 12 years boy admitted with fever, dry cough for 3 days and breathlessness 1 day managed in pediatric IPD discharged on 7th day. On next day patient readmitted with breathlessness, shifted to ICU in view of hypoxic with arterial oxygen tension (PaO2) of 58mm Hg on 15L/min of oxygen via mask with a reservoir, requiring non-invasive positive pressure mode of ventilation to maintain arterial oxygen saturation. HRCT thorax showed diffuse bilateral ground glass opacities with extensive consolidation, RTPCR for covid 19 negative. The patient received empirical antibiotics, steroids for 2 days but there is no improvement in respiratory status so we took on mechanical ventilator support with intubation. Unfortunately developed bilateral pneumothorax on 5th day, managed with bilateral intercostal drains. On 7th day patient developed hypoxemia refractory to mechanical ventilation, ABG analysis showed persistent hypoxemia (PaO2 of 48mm Hg, pCO2 79, Ph7.1, lactate 3) on 100% fraction of inspired oxygen (FiO2) with positive end expiratory pressure (PEEP) of 12 cm H2O in spite of proning. On 8th day patient had cardiac arrest, ROSC achieved after 3 minutes of CPR, due to hemodynamically stable and refractory hypoxemia with respiratory acidosis (po2-33, pco2 98, Ph 7, lactate 7) decision was made to treat the patient with venous-venous ECMO. He was subsequently initiated with circuit flow of 1.2L/min and sweep gas of 4.0L/min of oxygen (FiO2 of 100%,3000RPM) with lung protective ventilation and antibiotics based on cultures. On day 13th patient shifted to KIMS Hospitals Secunderabad on ECMO in view of lung transplant, Patient weaned successfully on day 60th and discharged on 90th day of admission without need of lung transplantation. To the best of our knowledge, this is the first pediatric case report of the successful use of prolonged VV-ECMO for bilateral pneumothorax with post CPR survivor from refractory ARDS.

### Haemoperfusion in Parquat Posioning

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DOI: 10.5005/jaypee-journals-11011-0018.9

**Keywords:** Paraquat, Hemoperfusion, Urine dithionite, Resin-based cartridges

**Background:** Paraquat (PQ) is a highly toxic weedicide when ingested causes multiple organ dysfunction followed by death if treatment is delayed. Interventions to reduce mortality were less beneficial in many case series and only a few studies have documented the use of urine dithionite tests (UDT) with hemoperfusion in prognosticating the outcomes. We aimed to determine the outcomes of hemoperfusion (HA 230) guided by UDT in patients with PQ poisoning in terms of presentation time. **Methods:** This retrospective observational study involved 15 patients presented with paraquat ingestion. UDT was performed to confirm paraquat severity in all patients. Data on the ingested quantity, presentation time, complications developed, diagnostic results and treatment prognosis were collected and analysed. **Results:** Of the 15 patients treated, hemoperfusion (HP) (with HA 230) was performed in 12 patients who tested positive for paraquat on UDT. The overall mortality rate was 40%. All patients presented early. (<4h) (n=6) were successfully managed. Seventy-five percent (n=3) of late presenters succumbed to death despite HP therapy. The UDT was strongly positive (+++) in all non-survivors ($p<0.05$). Non-survivors had higher serum creatinine and bilirubin levels at postfinal HP compared to survivors. Complications like respiratory dysfunction, hepatic failure and multiorgan dysfunction syndrome (MODS) were significantly higher in the non-survivors ($p<0.05$). The survival rate in patients treated with HP was higher 66.7%. **Conclusion:** Early presentation and timely hemoperfusion (with HA 230) with diagnostic UDT guidance increases survival with fewer complications in cases with paraquat intoxication.

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### Intraoperative ECMO and Anesthesia Management in Challenging Airway Cases: A Comprehensive Case Series

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DOI: 10.5005/jaypee-journals-11011-0018.10

**Introduction:** This case series investigates the application of intraoperative extracorporeal membrane oxygenation (ECMO) and anesthesia management in three challenging airway scenarios: a) tracheal stenosis requiring resection and anastomosis, b) pulmonary alveolar proteinosis necessitating bronchoalveolar lavage, and c) intratracheal tumor leading to intratracheal stenosis managed with stenting. **Methods:** A retrospective analysis was conducted on patients undergoing these intricate airway procedures between Jan 2023 and Dec 2023. The study focuses on delineating the unique challenges encountered during surgery, outlining perioperative complications, and evaluating critical care outcomes associated with using ECMO and tailored anesthesia approaches. **Results:** In tracheal stenosis cases, the study underscores the nuances of resection and anastomosis, emphasizing the role of ECMO in ensuring adequate oxygenation during airway reconstruction. Pulmonary alveolar proteinosis cases highlight the significance of ECMO support in maintaining hemodynamic stability, and gas exchange during bronchoalveolar lavage. Intratracheal tumor cases with stenting explore the complexities of managing intratracheal stenosis, showcasing the critical role of ECMO in facilitating surgery and mitigating complications. **Conclusion:** This case series offers valuable insights into the multifaceted challenges of intraoperative ECMO and anesthesia management in diverse airway pathologies. By addressing the specific intricacies of tracheal stenosis, pulmonary alveolar proteinosis, and intratracheal tumor with stenting, the

| | Descriptive Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *N* | *Mean* | *SD* | *Minimum* | *Maxmimum* | *Q1* | *Median* | *Q3* | *IQR* |
| Age | 37 | 43.05 | 12.099 | 16 | 62 | 33.50 | 40.00 | 54.00 | 20.5 |
| Time on ECMO (days) | 37 | 15.86 | 12.687 | 2 | 58 | 7.50 | 13.00 | 19.50 | 12 |
| res score | 37 | –1.43 | 4.240 | –6 | 6 | –4.00 | –3.00 | 3.50 | 7.5 |
| TRJV (m/s) | 37 | 3.168 | 0.4802 | 2.6 | 4.2 | 2.800 | 3.000 | 3.400 | 0.6 |
| EF (%) | 37 | 58.11 | 4.067 | 50 | 64 | 55.00 | 60.00 | 60.00 | 5 |
| RVSP (mm. of Hg.) | 37 | 48.43 | 7.809 | 38 | 60 | 41.00 | 48.00 | 56.50 | 15.5 |

study contributes to the evolving understanding of perioperative strategies, complications, and critical care outcomes. The findings provide practical insights for clinicians navigating complex airway interventions, guiding future approaches, and enhancing overall patient care in similar challenging scenarios.

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## Prevalence and Outcomes of RV Dysfunction in VV ECMO


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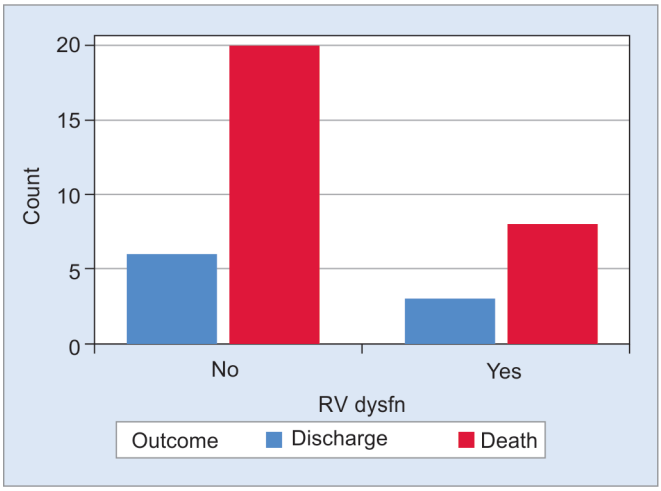
**Background:** Extracorporeal membrane oxygenation (ECMO), also known as extracorporeal life support, was initially developed to extend the support provided by the cardiopulmonary bypass machine. Its use in adults has increased due to the H1N1 ARDS pandemic in 2009 and the COVID-19 ARDS pandemic in 2020. Severe acute respiratory distress syndrome can lead to acute right ventricular (RV) dysfunction, which occurs in 22 to 50% of cases. Many factors contributing to RV dysfunction in ARDS can be improved with better oxygenation and VV-ECMO implementation. However, the presence and impact of RV dysfunction after VV-ECMO cannulation are not well understood. **Aims and Objectives:** To determine the prevalence and prognostic value of post-cannulation RV dysfunction, as measured by transthoracic echocardiography, in patients treated with VV-ECMO for severe ARDS. **Materials and Methods:** A retrospective cohort study design was used to include consecutive patients treated with VV-ECMO between January 2013 and December 2021 at a single quaternary medical center. The institutional electronic medical record was used to identify clinical variables, comorbidities. Clinical




test results, and outcomes. **Results:** Out of the 37 patients, 9 patients (24.3%) survived to discharge. In terms of RV dysfunction, out of the 37 patients, 26 (70.27%) did not have RV dysfunction. Among them, 6 patients were discharged (23.1%) and 20 patients died (76.9%). On the other hand, 11 patients had RV dysfunction, with 3 patients being discharged (27.3%) and 8 patients dying (72.7%). The mortality was similar in both groups although not statistically significant (P-value 0.786). **Conclusion:** RV dysfunction is prevalent even after initiation of VV ECMO (29.7%). The temporal sequence of RV function and its effects on outcomes should be evaluated with further studies in this population. Prospective multicenter studies are needed to validate alternative forms of temporary.


## Transportation on ECMO: Challenges, Strategies, and Best Practices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The transportation of patients supported with Extracorporeal Membrane Oxygenation (ECMO) poses unique challenges that demand careful coordination, specialized equipment, and a skilled transport team. This review traces the historical evolution of ECMO transportation since the pioneering work of Dr. Robert Bartlett in the 1970s and highlights the exponential growth in ECMO indications over the years. the heightened complexity associated with transporting critically ill patients on ECMO support, whether for interhospital transfers or rescues at outside facilities. The necessity for meticulous risk assessment and consideration of potential benefits is crucial during the selection of ground or air transportation methods. Ground and air transport involve adaptations of in-house ECMO support circuits and equipment, with a focus on addressing

the distinctive aspects of mobile care.[1] While limited evidence guides ECMO-supported patient transport, recommendations stress the importance of well-prepared teams familiar with mobile transport. The need for ECMO transport arises from the hazards associated with conventional transfers of mechanically ventilated patients to ECMO centers, with recent studies indicating improved outcomes in centers with higher annual ECMO treatment volumes.[2] The means of transport, whether ground or air, introduces various advantages and challenges. Air transport, especially fixed-wing flights, offers shorter travel times but requires careful consideration of logistical challenges such as airport accessibility. Ground transport, facilitated by specialized ECMO ambulances, ensures stability in diverse weather conditions but may have limitations on maximum distance coverage.[3] The composition of ECMO transport teams to be build in such a way that emphasizing the flexibility needed to handle the high complexity task with time constraints, and environmental pressures involved. Team members, including a lead, cannulating provider, ECMO specialist, and medical transport professionals, play specific roles to ensure safe and effective ECMO transport.[4] The definition and systems of ECMO transport, as outlined by the Extracorporeal Life Support Organization (ELSO), include primary, secondary, tertiary, and intra-facility scenarios. Each scenario demands unique considerations and coordination between referring and accepting institutions. Cannulation and equipment strategies have changed widely drawing data from recent studies during the COVID-19 pandemic. A preferred cannulation strategy, utilizing specific cannula sizes and configurations, is discussed to enhance simplicity during transport and daily ICU management. In conclusion, the challenges, strategies, and best practices associated with ECMO transport are evolving greatly offering valuable insights for healthcare professionals involved in the critical task of transporting patients on ECMO support.

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## Challenges Faced by an ECMO Patient – A Case Report


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**Keywords:** ECMO, COVID, cell free hemoglobin,hemolysis,CMV, CANDIDA AURIS



**Objective :** To Elaborate the challenges faced by an ECMO Patient and the issues to be overcome and how to address them and combat with the help of a multidisciplinary team. **Introduction:** Severe ARDS is associated with very high mortality leads to death in 46% of cases. VV ECMO has become a frequent modality in recent years if all other rescue therapies fail. Therapy with ECMO buys time for lung recovery/transplantation and delivers lung protective ventilation meanwhile. During VV ECMO therapy venous blood is drained through a large bore cannula into an extracorporeal circuit. A pump drives the blood through a membrane oxygenator and finally oxygenated and decarboxylated blood is infused back in to a large vein of the circulation. Intravascular hemolysis is side effect of blood circulating through extracorporeal systems and membrane oxygenator. Current literature reports an incidence of 18% in patients treated with ECMO. Evidence suggests role of hemolysis in sepsis and ARDS where increased concentration of cell free hemoglobin might be associated with increased mortality. Plasma hemoglobin scavenges endothelial derived nitric oxide inducing vasoconstriction and hypertension. It also triggers proinflammatory signaling pathways. Patients receiving ECMO are at highest risk of developing nosocomial infections including fungal and viral infections due to underlying immune dysregulation and prolonged hospitalisations. Management of these infections is very challenging due to the potential for microorganisms colonization of devices, unpredictable antibiotic pharmacokinetics and challenges in removing cannulas for source control, we lose our patients to refractory sepsis most of the times. Here we present a case scenario of a young patient who witnessed all the forementioned complications and had long hospitalization stay and came out of all odds due to prompt detection and treatment and holistic approach. **Case presentation:** This is a case of 34 year old male patient without any comorbidities tested positive for covid on 08/07/21 who was on home quarantine for for 8 days and reported to hospital on 16/07 in view of breathlessness, was started on oxygen, bipap and tried on remdesevir, steroids and tocilizumab and baricitinib. Patient was not maintaining saturations and was intubated on 26/07/21 and as there was refractory hypoxaemia was initiated on ECMO on the next day. Patient was started on ceftazidime and levoflox along with voricanozole as serum galactomann was positive and ET cultures showed strephonomonas maltophilia. Patient was tracheostomized on 01/08 and was keeping well till 12/08 when there were episodes of desaturation and tachypnoea and blood culture showed candida auris and BAL culture showed chryseobacterium and MDR klebsiella with NDM, OXA -48 AND VIM + Patient developed septic shock and required dual vasopressors. BAL galactomann had titres of 4.5 and patient was initiated on a mixture of ceftazidime -avibactum, aztreonam, voriconazole and anidulafungin suspecting MDR bacterial and dual fungal infection. Patient started having hemoglobinuria, high coloured urine and was quantified using plasma concentrations of cell free hemoglobin and plasma LDH. Subsequently acute kidney injury secondary to this and required 3 sessions of dialysis and the whole ECMO circuit was changed. Improvement in the parameters followed with normalization of cell free hemoglobin, blood pressure and urine output. When there was a sigh of relief as the things were getting normal patient started having heavy bouts of tracheal bleeding and bronchoscopy done again with endobronchial biopsy showing CMV endobronchitis with focal ulceration and was started on ganciclovir. Patient had high viral loads more than 1,00,000 copies. There were maleana episodes too which normalized after initiation of antivirals and CMV enterocolitis was suspected to be the cause. Patient

responded to the treatment and was decannulated after multiple hurdles and events. **Conclusion:** Initiating ECMO triggers a number of hematologic and inflammatory consequences. Forecasting those complications and treating them pragmatically would reverse the potential devastating consequences and improve outcomes despite numerous challenges in the journey.

### Veno-venous Extracorporeal Membrane Oxygenation in Bronchopleural Fistula – A Case Report

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**Keywords:** Bronchopleural Fistula, Differential lung ventilation, VV-ECMO.

**Introduction:** The use of Veno-venous Extracorporeal Membrane Oxygenation in severe pneumonia is very well known when lungs are extensively damaged and conventional management has failed. In this case report, we demonstrate successful use of VV-ECMO in a patient with severe necrotizing MRSA pneumonia with Bronchopleural Fistula. **Case presentation:** 42 years old man with flu like symptoms for 7 days presented to the hospital with lower respiratory tract infection with sepsis initially managed on noninvasive ventilation for a day, later required endotracheal intubation and mechanical ventilation. Respiratory biofire grew influenza and MRSA – treated with inj. Ceftaroline, inj. Linezolid, fluvir and other supportive treatment. Course complicated with spontaneous pneumothorax with bronchopleural fistula on left side required intercostal drain insertion. Bronchoscopy with instillation of glue was done for broncho pleural fistula, but leak persisted. Double lumen endotracheal tube inserted, and differential lung ventilation attempted for 12 hours but peak pressures worsened, with severe type 2 respiratory failure. Considering worsened lung mechanics-not responding to conventional treatment, VV ECMO was initiated on day 7 th of hospital admission. Complete lung rest with minimum PEEP strategy for mechanical ventilation was used. Course complicated with XDR pseudomonas ventilator associated pneumonia -treated with cefepime -zidebactum. In view of anticipated prolonged ventilation, tracheostomy was performed. blood gases and patient condition gradually improved so ECMO support weaned after 14 days. Pneumothorax and leak through ICD persisted-so patient underwent thoracoscopic decortication. There was gradual improvement and tracheostomy was decannulated on 43rd day of admission. Patient was shifted to stepdown unit and then discharged on 65 th day of admission. **Conclusion:** In this case report we report the successful use of VV ECMO in 42-yrars old man with severe MRSA necrotizing pneumonia with bronchopleural fistula, given high mortality rate of necrotizing pneumonia with BPF, this case report provided evidence for use of VV ECMO as supportive care in such patients.

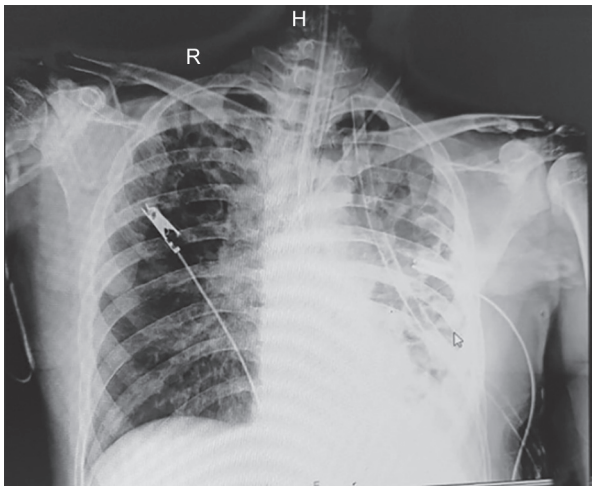


**Fig. 1:** Chest X-Ray prior to ECMO- canulation

### Successful Management of 1gm Amlodipine Poisoning with the Combination of VA-ECMO and Plasmapheresis

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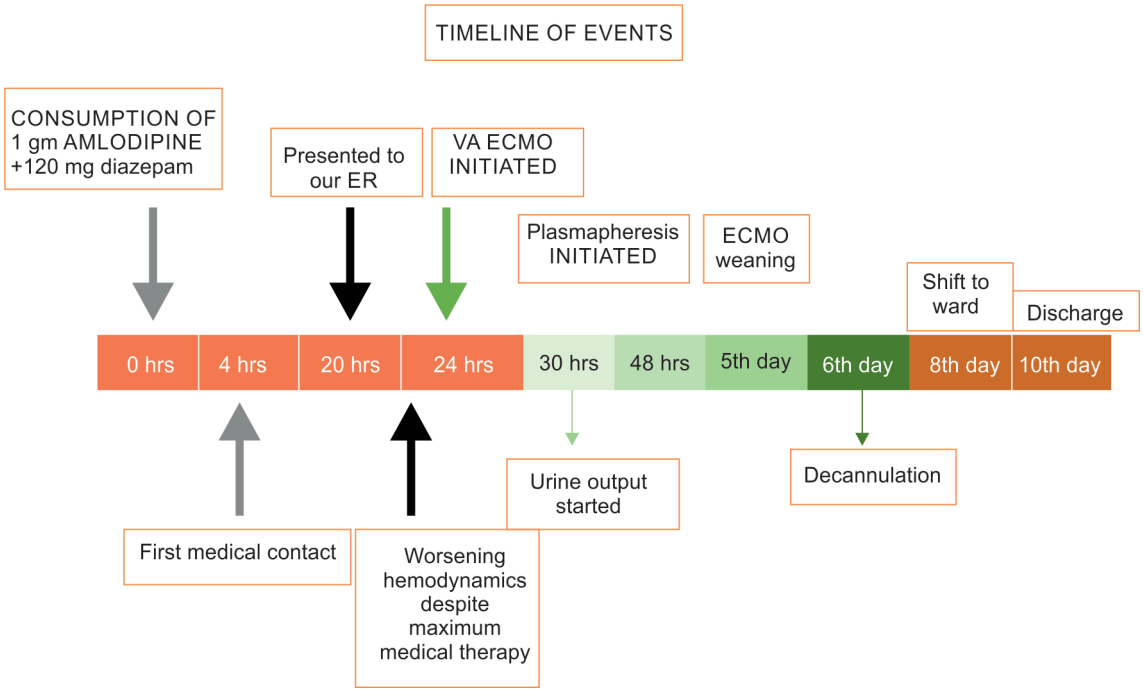
**Keywords:** Amlodipine overdose, VA ECMO,Plasmapheresis.

**Introduction:** As per the 2022 *Annual Report of the National Poison Data System® the first-ranked substance was pharmaceutical in 2,250 (85.8%) of the 2,622 fatalities and of the 2,250 first-ranked pharmaceuticals 266 were cardiovascular drugs and among them, 105 were of amlodipine* overdose.[1] ***High efficacy, low metabolic clearance, high volume of distribution, and long half-life*** make amlodipine a highly toxic substance if ingested in high amounts. **Case report:** A 28-year-old Pediatric resident from Pondicherry presented to our emergency with a history of ingestion of 100 tablets of 10 mg of amlodipine {1000mg} along with 60 tablets of 2 mg diazepam 20 hours before presenting to our hospital. He was taken to a nearby nursing home within 4hrs of suspicion of consumption where he was intubated and was started on vasopressors and inotropes for worsening shock and oliguria. His initial ABG revealed metabolic acidosis {HCO3- 12 mmol/L and lactates of 8mmol/L. ECG showed sinus tachycardia. He was rushed to our centre because of worsening hemodynamics. On arrival, he was tachycardic(122/min) and hypotensive 84/38 mm Hg on noradrenaline infusion of 0.5 ug/kg/min. Spo2 was 90 % on fio2 of 100%. His blood gas revealed worsening metabolic acidosis with lactates of 16 and a Pa02/Fio2 ratio of 122. His Systemic vascular resistance index was 544 dynes-sec/cm$^2$, Extravascular lung water was 1260 and Cardiac index of 1.8. His screening 2D ECHO revealed global LV hypokinesia with an EF of 20% and lung USG showed B profiling. He was started on IV glucagon, High dose insulin -euglycemia therapy {HIET}and IV lipid emulsion but despite these aggressive measures his hemodynamics continued to worsen drastically over the next few hours requiring supranormal doses of vasopressors (noradrenaline 3.33 ug/kg/min, adrenaline 1.88 ug/kg/min vasopressin 0.04Units/min and phenylephrine 0.42 ug/kg/min) respectively just to maintain a MAP target of 65 mmHg and progressively became anuric. Given his worsening clinical condition, he was initiated on Vf-Af ECMO 21 fr arterial cannula and 29 fr venous cannula. distal perfusion with 8 fr sheath distal perfusion cannula surgically placed. The blood flow rate was 3.5 L/min, the sweep gas flow rate was 3.0 L/min and the fraction of delivered oxygen was 1.0. he received one session of plasmapheresis for 4 hours exchanging one and a half times plasma volume. Within a few hours of starting ECMO, arterial blood gas variables began improving lactates trended down to 5.8 mmol/l. Pao2 238mmhg. After 6 hours on the ECMO, the patient started to produce




urine which reached normal levels after about 12 hours. Patient hemodynamics gradually improved with the progressive decline of vasopressors and inotropes and were completely stopped on the 5th day. On the 5th day he was started on ECMO weaning trial and on the 6th day he was successfully decannulated. He was found to have a floating thrombus in the right proximal femoral vein and was started on rivaroxaban Patient was shifted out of ICU after 8 days to the ward and was subsequently discharged. Wienberg et al[2] in similar circumstances were able to wean the patient ECMO after 8 days which could be due to the persistence of the drug in the system. Amlodipine is a highly protein-binding drug and therefore not dialyzable. On the other hand, the same property can be utilized to remove it from the system by plasma exchange. A significant amount of drug can be removed from the body by one plasma volume exchange.[3] This very likely allowed for rapid return of vasomotor tone and rapid weaning of the ECMO compared to Wienberg et al who had to use ECMO for 8 days with half the amount of drug consumed which is 500 mg compared to 1000mg as in our case. **Conclusion:** We like to report this case as it is probably the first instance where both ECMO and Plasmapheresis were successfully combined to revive a near-fatal amlodipine overdose.

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## Extracorporeal Cardiopulmonary Resuscitation (ECPR): Are We There Yet?" – Challenges Faced by a Tertiary Care Center— A Case Series Analysis

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**Keywords:** Code Blue/Cardiac Arrest, CPR, ACLS, ECPR.

**Introduction:** Extracorporeal Cardiopulmonary Resuscitation (ECPR) is a revolutionary approach utilizing extracorporeal life support (ECLS) for circulatory and respiratory support during cardiac arrest. Unlike traditional CPR, ECPR extends resuscitative efforts, acting as a potential bridge to definitive treatment and significantly improving survival rates. Rapid extracorporeal membrane oxygenation (ECMO) initiation is crucial for sustaining vital organ perfusion, making ECPR a dynamic intervention that revolutionizes outcomes for patients in cardiac arrest.[1–2] **Objectives:** This case series explores the application of ECPR across diverse cases, aiming to identify specific challenges inherent to ECPR for refining protocols and improving patient outcomes.[3] **Materials and Methods:** A retrospective analysis was conducted on 328 code blue activated in a busy 1000-bed tertiary care public sector teaching hospital in Northern India from January to December 2023. Challenges faced were a) lack of knowledge in patient selection for ECPR among the postgraduate residents trained in ACLS, the right time to activate ECPR b) patient age, number of comorbidities, location of code blue event (ward vs emergency unit), CPR duration, peri-arrest cardiac rhythms, availability of trained manpower, resource limitations e.g., PLS kits, and end-of-life care. ECMO parameters considered were circuit priming, the need for an automated CPR device, initiation and maintenance, cannulation

**Table 1:** Outcomes of ECPR

| | | | | | *Complications* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Age* | *Sex* | *Diagnosis* | *Indication for ECPR* | *No. of days on ECMO* | *Cannulation problems* | *Distal limb ischemia* | *Sepsis* | *AKI requiring CRRT* | *Liver dysfunction* | *Hypoxic Brain Injury resulting in brain death* | *Bleeding* | *Outcomes* |
| 35 | M | CAD AWMI | Cardiac arrest with refractory VT | 4 | YES | YES | YES | YES | YES | NO | YES | Died |
| 68 | M | CAD, Aortic stenosis posted for TAVR. | Cardiogenic shock and cardiac arrest | 2 | YES | NO | YES | YES | YES | NO | YES | Died |
| 29 | F | Myocarditis | Myocarditis with cardiac arrest | 5 | YES | YES | NO | NO | NO | YES | YES | Died |

complexities and complications, imaging choices, post-ECPR patient transport to the cardiac Cath lab on ECMO, the futility of care, and ethical considerations. **Results:** Of the 328-code blues, only 3 (0.92%) were converted to ECPR. The mean duration on VA-ECMO was 3.67 days. One patient presented to the emergency department after 20 min of cardiac arrest with refractory Ventricular tachycardia following anterior wall MI, the remaining two were admitted to the cardiology unit, with a patient posted for transcatheter aortic valve replacement (TAVR) presented with cardiac arrest and the third was a female patient presented with cardiac arrest following severe myocarditis 03 days post illness, both within 20-30 minutes after the activation of the code. The complications and outcomes are shown in Table 1. **Conclusions:** The study highlights the need for comprehensive training, meticulous logistics support, resource augmentation, futility of care, and continuous refinement of institutional protocols impacting ECPR success and safety for future implementation.[4]

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## Extracorporeal Toxin Removal (ECTR) in Paraquat Poisoning – The Broad Spectrum Use of Extracorporeal Life Support in Developing Countries


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**Keywords:** Paraquat, hemoperfusion, urine dithionite, resin-based cartridges


**Background:** Paraquat (PQ) is a highly toxic weedicide when ingested causes multiple organ dysfunction followed by death if treatment is delayed.[1] Interventions to reduce mortality were less beneficial in many case series and only a few studies have documented the use of urine dithionite tests (UDT) with hemoperfusion in prognosticating the outcomes.[2–3] We aimed to determine the outcomes of hemoperfusion (HA 230) guided by UDT in patients with PQ poisoning in terms of presentation time. **Methods:** This retrospective observational study involved 15 patients presented with paraquat ingestion. UDT was performed to confirm paraquat severity in all patients.[4–5] Data on the ingested quantity, presentation time, complications developed, diagnostic results and treatment prognosis were collected and analysed. **Results:** Of the 15 patients treated, hemoperfusion (HP) (with HA 230) was performed in 12 patients who tested positive for paraquat on UDT. The overall mortality rate was 40%. All patients presented early. (<4h) (n = 6) were successfully managed. Seventy-five percent ($n$ = 3) of late (Table 1) presenters succumbed to death despite HP therapy. The UDT was strongly positive (+++) in all non-survivors ($p < 0.05$). Non-survivors had higher serum creatinine and bilirubin levels at postfinal HP compared to survivors. Complications like respiratory dysfunction, hepatic failure and multiorgan dysfunction syndrome (MODS) were significantly higher in the non-survivors (p<0.05). The survival rate in patients treated with HP was higher 66.7%. **Conclusion:** Early presentation and timely hemoperfusion (with HA 230) with diagnostic UDT guidance increases survival with fewer complications in cases with paraquat intoxication.


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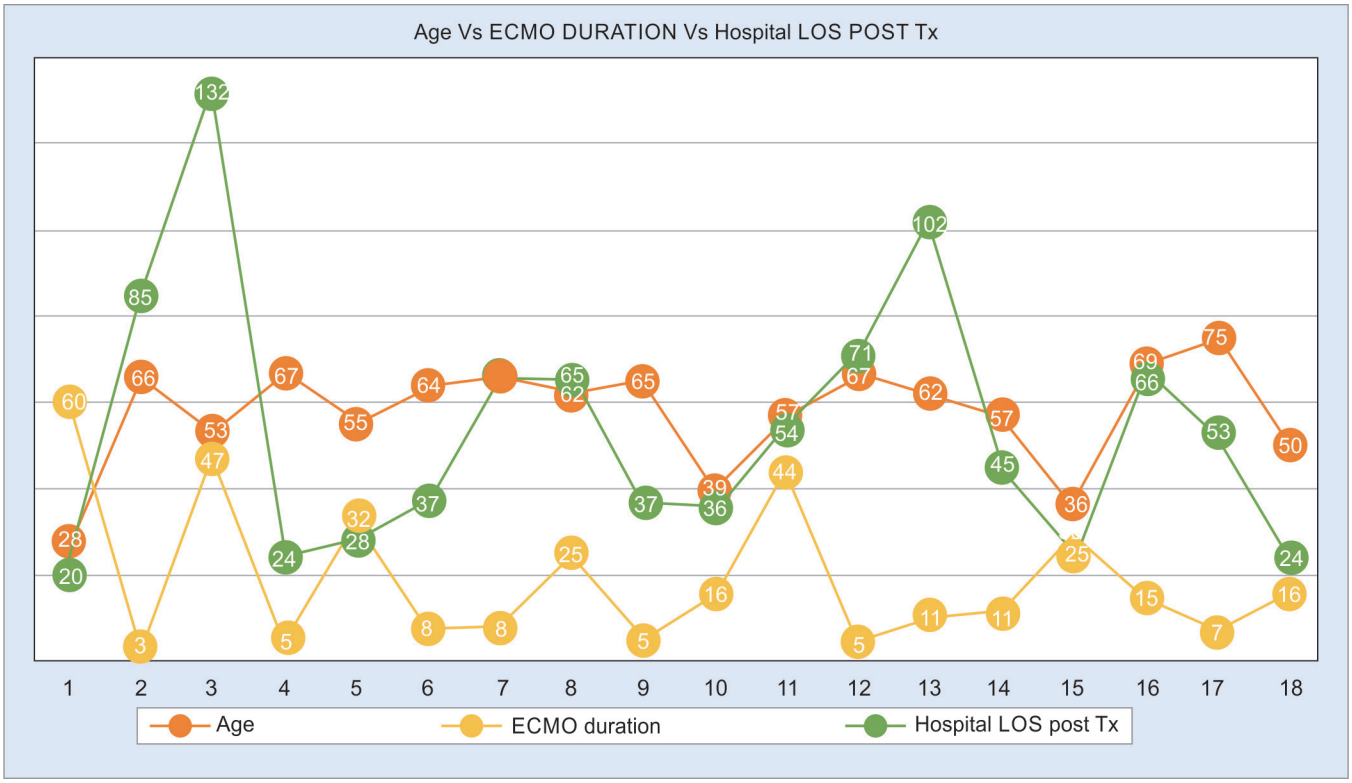
**Table 1:** Demographics, presentation and outcome data of Paraquat poisoning patients who underwent hemoperfusion

| | | | | | | | | | | | | Peak level | | | Number of HP+HD, (final values) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Case* | *Age/Sex* | *Quantity of PQ ingested (on approx)* | *Ingestion to door time* | *Arrival* | *4-6 hrs* | *8-10 hrs* | *24 hrs* | *48 hrs* | *72 hrs* | *Treatment provided* | *Complications developed* | *Sr. creatinine (mg/dl)* | *Bilirubin(mg/dl)* | *Number of HP+HD, sessions* | *Sr. Creatinine* | *Bilirubin(mg/dl)* | *Hospital stay* | *Status* |
| 1 | 17y/M | PO 20-30 ml + Carbofuran | 2 h 30 mins | +++ | – | – | – | – | – | SW, EHD + HP, NAC, ST, Atropinisation, PAO, Ab, MV | Shock, RD, Leukocytosis | 0.6 | 0.6 | 1 | 0.6 | 0.3 | 15 days | Survived |
| 2 | 26y/M | 70-100 ml | 2 h 10 mins | +++ | – | – | – | – | – | SW, EHD + HP, NAC, ST, Ab | AKI, Leukocytosis | 2 | 0.4 | 2 | 1.3 | 0.4 | 9 days | Survived |
| 3 | 35y/M | 20 ml | > 24 h | UDT not performed as the ingestion to door time exceeded the required time. | | | | | | SW, NaHCO3, Ab, NAC, MV | Hyperkalemia, Leukocytosis, Metabolic acidosis + AKI, RD, LD, MODS | 6.2 | 7.5 | - | 7.5 | 6.2 | 1 day | DAMA-Expired |
| 4 | 37y/M | 40 ml | > 8 h | ++ | – | – | – | – | – | SW, NAC, ST, Ab | Dysphagia, AKI | 3.2 | 1.1 | 1 | 2.2 | 1.1 | 5 days | Survived |
| 5 | 24y/M | 100 ml | > 8 h | ++++ | ++ | + | + | + | + | SW, HP, ST, NAC, Ab | RD, Leukocytosis, AKI, LD, MODS | 7.3 | 5.9 | 5 | 4.8 | 5.9 | 7 days | DAMA-Expired |
| 6 | 31y/M | 80 ml | < 8 h | +++ | – | – | – | – | – | SW, HP, HD, ST, NAC, Ab, MV | Hematuria, Leukocytosis | 1 | 1 | 1 | 0.9 | 0.5 | 8 days | Survived |
| 7 | 27y/M | 100 ml | 4 h | The urine sample showed an intense green colour even before the test (++++) | | | | | +++ | SW, HP, HD, NAC, ST, Ab, MV | Leukocytosis, Oliguria, Hemoptysis, Hematuria, RD, LD, AKI | 4.6 | 1.8 | 2 | 4.6 | 1.8 | 4 days | Expired |
| 8 | 42y/M | 100 ml | > 8 h | Gastric juice +cf<br>Serum + (dark green) | | | | | | SW, HP, NAC, ST | Leukocytosis, Refractory Hypoxia, RD, LD, Cardiogenic shock | 2.7 | 2.2 | – | 2.7 | 2.2 | 1 day | Expired |
| 9 | 38y/F | < 10-20 ml | 3 h | – | – | – | – | – | – | SW, NAC, ST, Ab. | Leukocytosis | 0.6 | 0.6 | – | 0.6 | 0.5 | 7 days | Survived |
| 10 | 18y/M | 100 ml | 1 h 30 mins | ++ | + | – | – | – | – | SW, NAC. HP, ILT | No complications | 0.8 | 1.1 | 2 | 0.7 | 1.0 | 1 day | DAMA Survival |
| 11 | 18y/M | 50 ml | 3 h | ++ | + | – | – | – | – | SW, HP, NAC, ST | No complications | 1.0 | 0.8 | 2 | 0.6 | 0.6 | 8 days | Survived |
| 12 | 31y/F | 50 ml | 5 h | +++ | | + | ++ | ++ | – | SW, HP, NAC, ST | Hematuria, Developed Hypoxia, AKI, Liver dysfunction on 2nd day | 1.6 | 1.1 | 3 | 1.3 | 1.0 | 6 days | Expired |
| 13 | 58y/M | 100 ml | >4h | ++++ | +++ | ++ | + | Expired | | SW, HP, NAC, ST, Inotropes, CPR | Leukocytosis, Respiratory Failure type - II, Cardiogenic shock | 0.6 | 0.6 | 1 | 0.5 | 0.6 | 1 day | Expired |
| 14 | 21y/F | 100-200 ml | <4h | ++++ | +++ | ++ | + | + | – | SW, HP, NAC, ST | Leukocytosis | 0.6 | 0.5 | 7 | 0.6 | 0.2 | 7 days | Survived |
| 15 | 29y/M | 200 ml | <4h | | +++ | ++ | + | + | – | SW, HP, NAC, ST, Insulin | Leukocytosis, Gastritis, Hyperglycemia | 1.0 | 1.0 | 5 | 0.6 | 0.7 | 5 days | Survived |




### ECMO Bridge to Lung Transplantation Single Center Experience

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DOI: 10.5005/jaypee-journals-11011-0018.18

**Keywords:** ECMO, ARDS, Acute Exacerbation of ILD

**Purpose:** Extracorporeal membrane oxygenation (ECMO) is a life-saving technique that provides respiratory and/or circulatory support to patients with end- stage lung disease who are awaiting lung transplantation. However, the outcomes of ECMO as a bridge to lung transplantation are not well studied in India. This study aimed to evaluate the clinical characteristics and survival of patients who underwent ECMO as a bridge to lung transplantation in a single centre in India. **Method:** This was a retrospective analysis of 29 patients who required veno-venous ECMO as a bridge to lung transplantation from November 2021 to July 2023. Data on demographics, primary diagnosis, duration of ECMO per and post transplantation, length of hospital stay, and survival were collected and analyzed. **Results:** The mean age of the patients was 55.4 years (range 28-75), and 23 (79.3%) were male. The primary diagnosis was acute respiratory distress syndrome in 6 (20.7%) patients and acute exacerbation of interstitial lung disease in 23 (79.3%) patients. The median duration of ECMO was 17.3 days (range 2-60), and the median length of hospital stay post-transplantation was 57 days (range 24-132). Of the 29 patients, 11 (37.9%) died while waiting for an organ, and 18 (62.1%) received a lung transplant. Of the 18 transplant recipients, 4 (22.2%) patients required continuation of VV ECMO post transplantation for Primary Graft Dysfunction. 14 (77.8%) survived at day 30 and 13 (72.2%) at day 180. Survival was significantly lower in patients who had ECMO duration more than 10 days compared to those who had less than or equal to 10 days ($p<0.05$). **Conclusion:** Our study showed that VV ECMO can be used as a bridge to lung transplantation in selected patients with severe lung failure. However, the mortality rate is high among patients who require prolonged ECMO support before transplantation. Our study also highlight's an urgent need to increase the availability of donor organs, strategies to optimize donor and reduce waiting time are needed to improve the outcomes of this population.

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### False Prognostic Sign in A Patient Following ECPR – An Interesting Case Report

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DOI: 10.5005/jaypee-journals-11011-0018.19

**Keywords:** VA ECMO, e-CPR, Pressure natriuresis

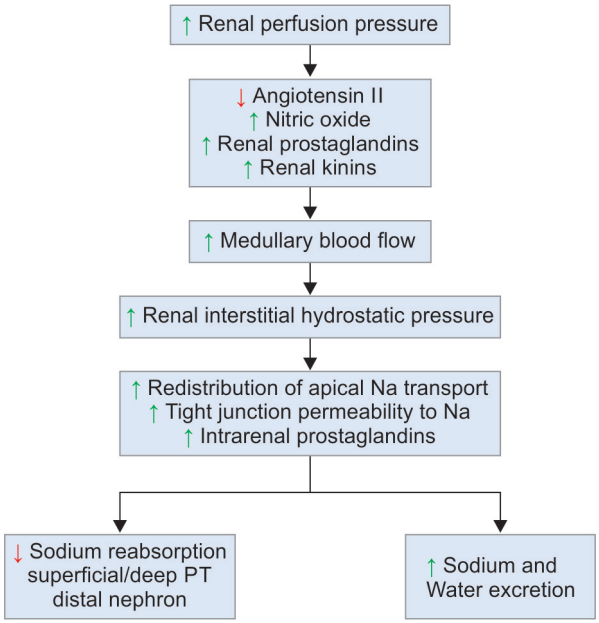


**Fig. 1:** Mechanism of pressure natriuresis (green arrow represents increase, red arrow represents decrease) adapted from reference 1.

**Background:** The ability of the kidney to alter urine flow and sodium excretion in response to acute changes in renal perfusion pressure – Pressure natriuresis. This is the central component that acts a feedback system for long term control of extra cellular fluid volume and blood pressure.[1] It is a non-adaptive mechanism where increased blood pressure leads to osmotically driven diuresis.[2] **Case Report:** We would like to report a unique and rare scenario that occurred in patient on VA ECMO which was initiated as e-CPR. The patient was a 51-year-old male, known diabetic, hypertensive, post PTCA status (2021), who presented to our ER in a state of cardiogenic shock (SCAI stage C i.e. extensive rales on NIV requiring vasopressors with Lactate > 2mmol/L), quickly progressing to SCAI stage D and E leading to cardiac arrest at the time of performing PCI.High quality CPR was immediately started and converted to eCPR with VA ECMO support being initiated within 30 minutes. About an hour into the initiation of ECMO, though the vital parameters started to stabilize, the patient started to pour out urine in the range of 1500-2000 ml per hour with the total volume of exceeding 20 liters within a span of 16-18 hours. Given the background of post CPR status, we were led to believe that it was probably cranial diabetes insipidus and almost painted a grave prognosis to the family. However, the neurological examination findings and investigative results were not much in favor of a central pathology. A thorough literature review enlightened us about the fact that the positioning of the arterial cannula in relation to the renal vasculature may lead to an increased GFR and thus an increased output.[3] Performing certain interventions lead to the resolution of the polyuria picture and motivated us to continue with ECMO support instead of withdrawing based on misleading signs. **Conclusion:** we would like to highlight this rare scenario and an interesting solution to counter any undue withdrawal of supports.

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## H1N1 Influenza Induced Acute Respiratory Distress Syndrome With Severe Right Ventricular Dysfunction Rescued by Veno-Venous Extracorporeal Membrane Oxygenation : A Case Report

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DOI: 10.5005/jaypee-journals-11011-0018.20

**Keywords:** ARDS, HINI Influenza, Right heart failure, VV ECMO

**Introduction:** Extracorporeal Membrane Oxygenator is an upcoming revolutionary technology for potentially reversible severe respiratory failure cases resistant to conventional therapy. The 2009 pandemic of swine flue revealed the lethal effects of H1N1 viral infection with a hospital mortality ranging between 29 and 32%. Severe ARDS is frequently complicated by right ventricular failure associated with high mortality and influencing the choice of ECMO modes. There is limited literature on management of RV failure during VV ECMO support. **Case presentation:** We report a case of 34 years old male patient, with respiratory pannel test positive for Influenza A virus, presenting with fever for one day, respiratory distress along with one episode of ventricular tachycardia which got controlled by cardioversion. Refractory hypoxia, inspite of full ventilation and proning-trial, necessitated the initiation of rescue femoral-femoral VV ECMO and was transferred to our institute on ECMO transport. He had echocardiography revealing severe right ventricular dysfunction and tricuspid regurgitation, acute kidney injury, deranged liver function and increased lipase with USG revealing hepatomegaly and bulky pancreas. He required several cycles of hemodialysis after which urine output got improved, was put on antiviral therapy along with broad spectrum antibiotics, underwent early tracheostomy and maintained hemodynamics with inotropic support, antiarrythmic medication along with lung protective ventilation and supportive management. Gradually his symptoms improved, was taken off ECMO and gradually inotropes were tapered off. However, he developed right sided hemiparesis with worsening sensorium and absent seizures, MRI brain showing left middle cerebral artery and left posterior cerebral artery territory infarct possibly resulting from embolic stroke — a complication of ECMO. He was put on neuroprotective medication, and after gradual weaning from ventilatory support and prolonged rehabilitation he was discharged in a stable condition with regular follow-up. **Conclusion:** VV ECMO is an effective salvage yet complicated and high-risk therapy when provided early in ARDS patients at specialised reference centre with adequate trained staff.

## Anesthesia Management for Complex Airway Cases with Intraoperative ECMO: A Panacea or Challenge? – A Comprehensive Case Series

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**Keywords:** Intraoperative ECMO, Bifemoral VV ECMO, Difficult airway
DOI: 10.5005/jaypee-journals-11011-0018.21

**Introduction:** Administering anesthesia for procedures involving complex airways is inherently challenging. The integration of intraoperative Extracorporeal Membrane Oxygenation (ECMO) is a rare and distinct challenge to the field of anesthesia. Effectively managing the complexities of advanced life support through ECMO requires a comprehensive understanding of both these intricate domains.[1] **Methods:** A retrospective analysis was conducted on patients undergoing intricate airway procedures between Jan 2023 and Dec 2023. The study focuses on the unique challenges encountered during surgery, outlining perioperative complications, and evaluating critical care outcomes associated with using ECMO and tailored anesthesia approaches, in three challenging airway scenarios: a) Tracheal stenosis requiring resection and anastomosis, b) pulmonary alveolar proteinosis necessitating bronchoalveolar lavage under one-lung ventilation, managed with VV ECMO under general anaesthesia and c) intratracheal tumor for resection and placement of self-expanding metal (SEMS) stent-under Awake VV- ECMO. **Results:** The mean duration of perioperative ECMO was 4 days. The study underscores the role of ECMO in maintaining hemodynamic stability, and gas exchange during intratracheal tumor resection and stenting done in awake patient and in bronchoalveolar lavage in pulmonary alveolar proteinosis both

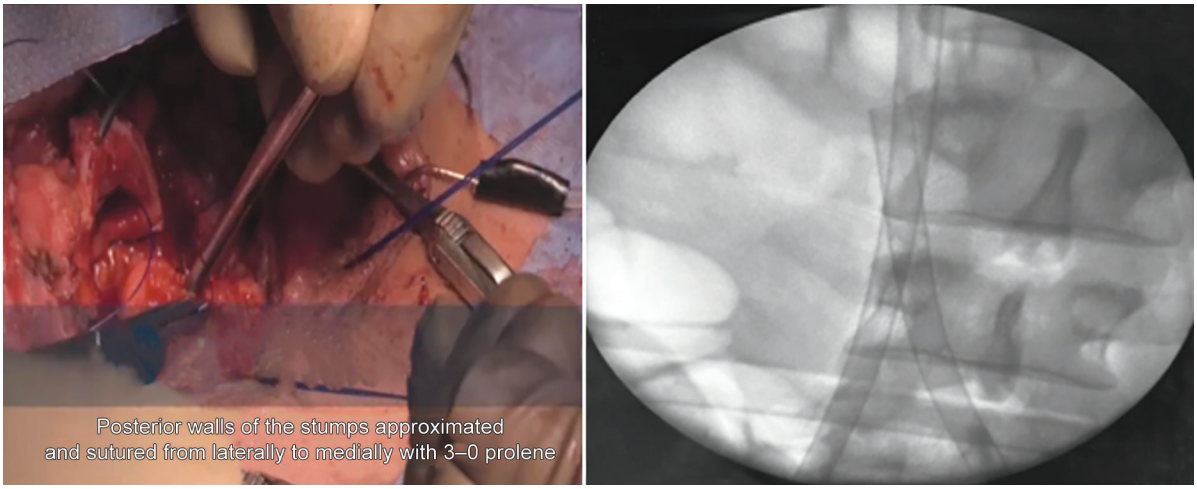


**Fig. 1:** Tracheal resection and anastomosis using Bifemoral VV ECMO

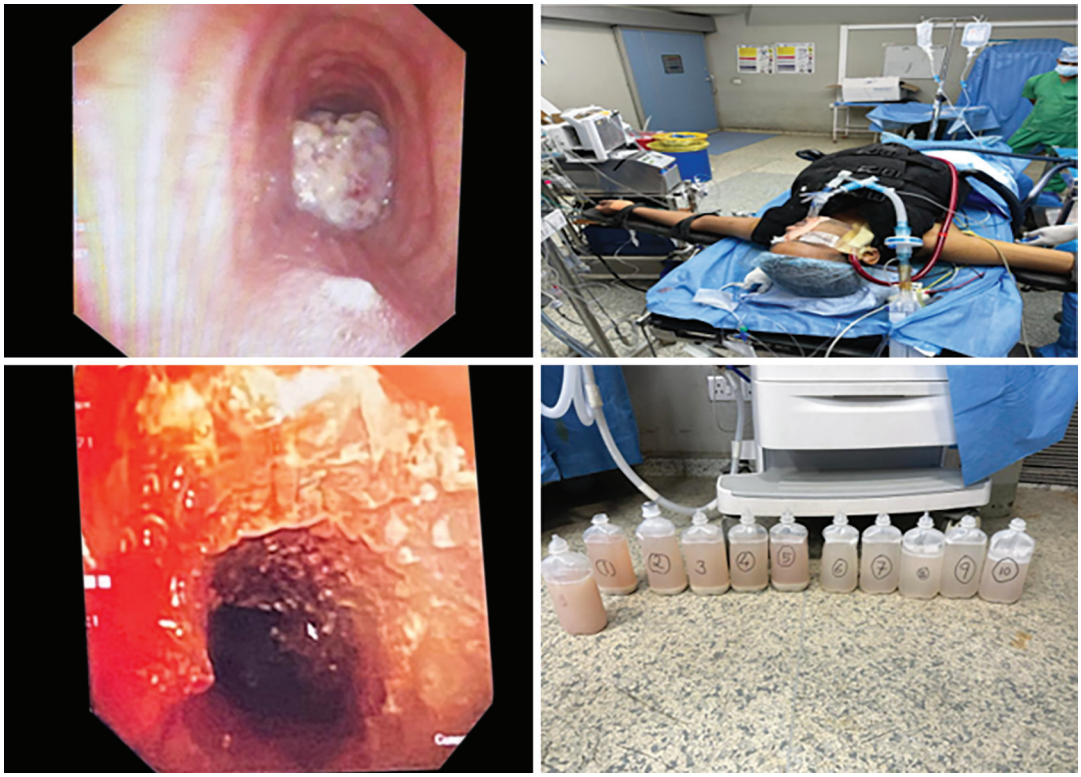

**Fig. 2:** A patient with Intratracheal Tumor underwent resection and stenting under awake VV ECMO and a patient with pulmonary alveolar proteinosis undergoing bronchoalveolar lavage under one lung anesthesia and VV ECMO

done in Jugular-femoral configuration and airway reconstruction in a case of tracheal stenosis for resection and anastomosis done in Bifemoral ECMO (**see Fig 1& 2**). There were no complications in all three cases and were discharged uneventfully. **Conclusion:** The study has limitations as these cases are rare; however, it offers valuable insights into the multifaceted challenges of intraoperative ECMO and anesthesia management in diverse airway pathologies.[2–3] By addressing the specific intricacies of using intraoperative ECMO in tracheal stenosis, pulmonary alveolar proteinosis, and intratracheal tumor with stenting, the study contributes to the evolving understanding of perioperative strategies, complications, and critical care outcomes. The findings provide practical insights to anesthesiologists in the perioperative period navigating complex airway interventions, guiding future approaches, and enhancing overall patient care in similar challenging scenarios.

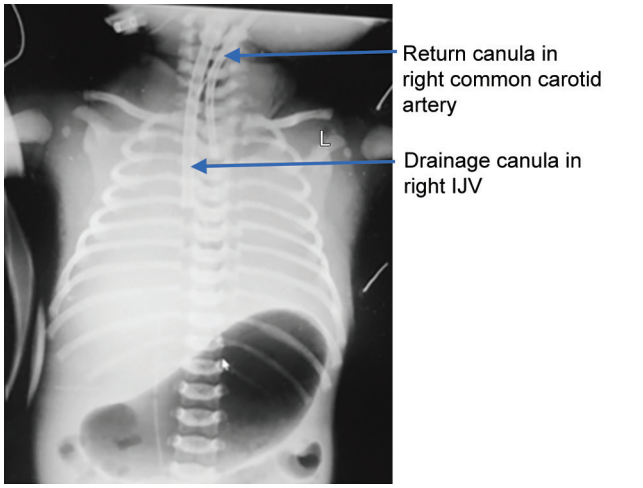


**Fig 1:** X ray showing drainage and return cannulas

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## Neonatal ECMO in India – Another Ray of Hope

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DOI: 10.5005/jaypee-journals-11011-0018.22

**Keywords:** ECMO, MAS, PPHN.

**Introduction:** ECMO (Extra Cardiovascular Membrane Oxygenation) is used to treat newborns with severe respiratory and/or cardiac failure with a probable reversible aetiology when conventional therapies have failed. Currently, neonatal cases account for < 10% of all ECMO runs. The majority of newborn ECMO cases (78%) are with a primary respiratory diagnosis. Common neonatal diagnoses include Congenital Diaphragmatic Hernia (CDH), Meconium aspiration syndrome (MAS) and Persistent pulmonary hypertension of newborn (PPHN), which account for approximately 75% of all newborn respiratory ECMO cases.[1] **Case presentation:** We describe a case of a newborn with severe MAS with PPHN that was successfully treated with Veno-arterial ECMO. It is one of the rare cases of neonatal ECMO transport in India. The baby was born to a primi mother with history of fever and amniotic fluid leakage for 2 days. An emergency LSCS was performed due to thick meconium-stained liquor. The baby had APGAR scores of 8 at 1'and 9 at 5'and developed respiratory distress soon after birth. Chest X-ray revealed bilateral white out lungs. She was intubated in 4 hours of life and initiated on mechanical ventilation. Empirical antibiotic therapy-Piperacillin-tazobactam, Amikacin was commenced. Echocardiography revealed pulmonary hypertension; hence Sildenafil, Milrinone and inhaled nitric oxide was started. She was initiated on high frequency oscillatory ventilation on post-natal day 3 to address refractory hypoxia. She also required noradrenaline, dobutamine and dopamine infusions for shock. Veno-arterial ECMO was initiated on post-natal day 4 for severe MAS/PPHN. Indications for VA-ECMO were refractory hypoxemia despite maximum respiratory support and 100 % FiO2 (oxygenation index > 40), pulmonary hypertension and catecholamine refractory shock. ECMO cannulation was done by our team in referral hospital. We used peripheral canulation strategy. By open technique right internal jugular vein as the drainage and right common carotid artery as return were cannulated with 12 Fr and 8 Fr canula respectively (Cannula position – Fig 1). After initiation of ECMO she was safely transported to our centre. In our centre she was initiated on full ECMO flows and kept on rest lung settings. Anticoagulation with heparin was initiated with an aPTT target of 40 - 60. i NO was continued; Levosimendan and milrinone cycling was used for pulmonary afterload reduction. She also had fluid overload while on ECMO for which CRRT-CVVHDF was initiated with drainage pre-oxygenator and return to pre-pump. CRRT was done for 4 days. She developed Stenotrophomonas bacteremia on day 5 of ECMO which was managed with Levofloxacin and Cotrimoxazole. She was decannulated on day 6 of ECMO after reaching 30 % ECMO flows and extubated to HFNC on day 11 of admission. She was discharged home on day 29 of life. She had celebrated her first birthday recently and is developmentally normal. **Conclusion:** Neonatal ECMO for MAS is associated with good outcome if initiated appropriately. Thus, neonates with MAS refractory to conventional modalities should be evaluated as a possible ECMO candidate. Timely referral, following appropriate patient selection and exclusion criteria will help in optimising outcomes.

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## Persistent Burkholderia Cenocepacia Bacteremia in VV ECMO – Clearing The Clutter

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DOI: 10.5005/jaypee-journals-11011-0018.23

**Keywords:** Burkholderia cenocepacia, persistent infection, ECMO

**Introduction:** ECMO has been used as a successful rescue modality for pediatric ARDS. Patients on ECMO are at risk for infectious complications. The most common organism causing sepsis in ECMO patients were coagulase-negative staphylococcus followed by *Candida and Pseudomonas* species. Early identification of sepsis, source control and optimal antibiotic therapy is the key to better patient outcome.[1] **Case description:** A 4-year-old girl with human metapneumovirus pneumonia/ severe ARDS was referred to our centre on day 7 of mechanical ventilation. Considering severe viral pneumonia with secondary infection, Ceftazidime-avibactam, Aztreonam, Vancomycin and Micafungin were commenced. She was initiated on VV-ECMO as refractory hypoxemia and hypercarbia persisted despite maximum ventilatory support. Peripheral canulation strategy with right femoral vein as drainage and right internal jugular vein as return was used (Fig 1). Blood cultures taken at admission were reported positive for Burkholderia cenocepacia. Thus, antibiotic therapy with IV Cotrimoxazole was initiated and Ceftazidime was continued. Blood cultures were repeated every 48 hours. Despite dual antibiotic therapy, blood cultures remained positive for Burkholderia. Thus, Cotrimoxazole dose was increased and changed to oral route considering circuit sequestration of IV antibiotics. Venous doppler and echocardiography seeking for thrombus and vegetations were negative. Considering ECMO circuit colonisation, pre- and post-membrane blood cultures were sent. Oxygenator colonisation was identified with pre-oxygenator cultures being sterile and post-oxygenator showing burkholderia. Hence, oxygenator was changed on ECMO day 10. Antibiotics were discontinued on day 18 of ECMO in view of clinical improvement and bacteraemia clearance. On day19 of ECMO, she had worsening lung infiltrates (Fig 2) and thrombocytopenia. Repeat Blood cultures revealed Burkholderia cenocepacia; hence combination therapy

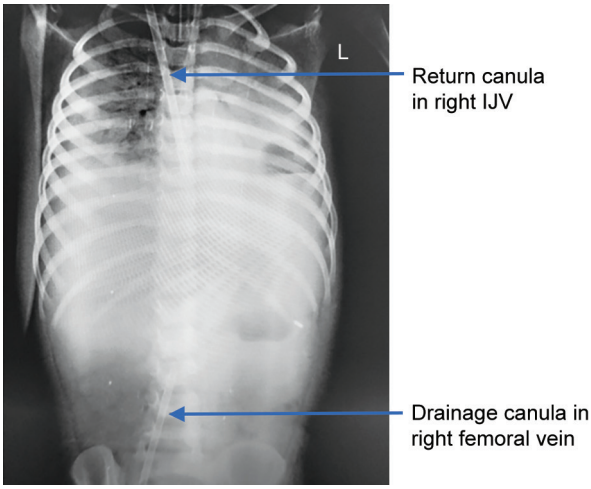


**Fig 1:** X ray showing drainage and return cannulas

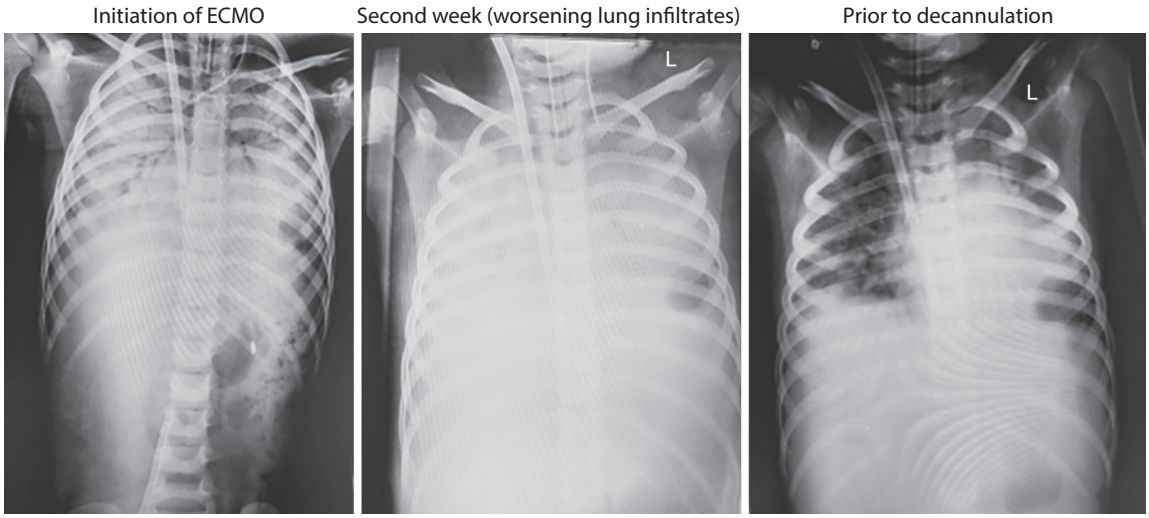


**Fig 2:** Chest X ray progression during ECMO

with oral Cotrimoxazole, IV Ceftazidime and IV Minocycline was commenced. As pulmonary status improved, she was weaned off ECMO and decannulated on day 26 of ECMO. Repeat Blood cultures on day 6 after decannulation showed no growth. Antibiotics were discontinued after 7 days of documented bacteraemia clearance. **Conclusion:** This case highlights the importance of early identification and initiation of appropriate antibiotic therapy in presumed sepsis. Antibiotic strategies in persistent bacteraemia include combination therapy, usage of higher dose and considering oral route and prolonged duration of therapy. These strategies may help in clearance of bacteraemia till definite source control is done

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### Exploring The Role of ECMO - A Single Center Experience


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DOI: 10.5005/jaypee-journals-11011-0018.24

**Keywords:** Cardiogenic shock, ARDS, DVT, Neuropraxia


**Introduction:** ECMO has become an essential tool in management of cardio respiratory failure where other interventions collapse. **Objective:** This study aims to present a single center experience with ECMO, focusing on the clinical outcomes, patient selection criteria, and the role of ECMO in various patient populations. **Methodology:** A retrospective, observational study of patients who received ECMO in one year at Citizens speciality hospital, Hyderabad from November 2022 to November 2023. In our study, we encountered a total of 14 cases of ECMO usage, with VA ECMO being performed in 10 cases of carcinogenic shock across various case scenarios, and VV ECMO being utilised in 4 cases. Indication of VV ECMO included severe acute respiratory distress syndrome refractory to conventional ventilator management and recruitment manoeuvres. Decision to initiate ECMO was based on several factors including the severity of cardiac dysfunction, refractory hypotension,and inadequate response to conventional therapies such as medication and IABP support. Additionally, one case of VV ECMO was used in the context of extracorporeal cardiopulmonary resuscitation (ECPR). **Results:** The mortality rate was measured as 50% (2 deaths in 4 cases) for VV ECMO and 50% (5 deaths in 10 cases) for VA ECMO. When comparing the outcomes of patients using various common scoring systems such as RESP, PRESERVE, and PRESET in VV ECMO, and SAVE and PREDICT in VA ECMO, none of these scores correlated with the outcome of our patients. The most frequently observed complications included deep vein thrombosis (DVT) at a rate of 28.57%, bleeding at a rate of 14.28%, and neuropraxia at a rate of 14.28%. Other significant issues that were addressed included brain death and withdrawal from extracorporeal membrane oxygenation (ECMO).

| *PREDICT VAECMO* | *SAVE* | *Outcomes* |
|---|---|---|
| 52% survival | 58% survival | Discharge |
| 64.1survival | 32% survival | Death |
| 36.5% survival | 42% survival | Discharge |
| 3.5% survival | 18% survival | Discharge |
| 3% survival | 30% survival | Death |
| 5.3% survival | 30 % survival | Death |
| 12.6% survival | 30% survival | Death |
| 1.1 %survival | 30% survival | Discharge |
| 4.5% survival | 27% survival | Death |
| 30% survival | 42% survival | Discharge |

| *PRESERVE* | *RESP* | *PRESET* | *OUTCOME* |
|---|---|---|---|
| 28% mortality | 33% survival | 68% mortality | Death |
| 11% mortality | 92% survival | 26% mortality | Death |
| 28% mortality | 57% survival | 93% mortality | Discharge |
| 0% mortality | 76% survival | 26% mortality | Discharge |

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### The Role of Dual Lumen Single Cannula (DLSC) in ECMO Patients - Our Experience–A Case Series


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DOI: 10.5005/jaypee-journals-11011-0018.25

**Keywords:** Dual lumen single cannula (DLSC), V-V ECMO, Early mobilization in ECMO patients


**Introduction:** The Dual Lumen Single Cannula (DLSC) ECMO aims to redefine and offer an efficient solution for enhanced cardiopulmonary support. This technology, with single cannula housing dual lumens, combines venous drainage and reinfusion pathways. **Objectives:** DLSC ECMO helps avoid groin cannulation and as such is expected to help with early mobilization and better patient compliance (1) typical for patients requiring venovenous extracorporeal membrane oxygenation (V-V ECMO. However, flow rates are comparably less than traditional dual cannula VV ECMO. We analyze our experience over 12 years to see its role in VV ECMO. **Methodology:** A single-center retrospective study was conducted

| *Variables* | *All (n =10)* |
|---|---|
| Extubated while on ECMO | 6 (60%) |
| Underwent Tracheostomy while on ECMO | 1 (10%) |
| Mobilized while on ECMO | 5 (50%) |
| In hospital survival rate | 6 (60%) |

on all patients supported with ECMO using a DLSC from June 2011 to December 2023. **Results:** Out of 208 ECMOs, 10 patients (4.81%) were treated using the DLSC ECMO method. Among these 10 patients, 1 patient underwent V-PA ECMO. The median age of the patients was 52 years, consisting of 40% females and 60% males. The primary cause of the DLSC - ECMO treatment was ARDS due to Covid pneumonia in 4 out of 10 patients (40%), followed by ARDS due to atypical pneumonia in 1 out of 10 patients (10%), ILD exacerbation in 2 out of 10 patients (10%), IPF exacerbation in 1 out of 10 patients (10%), hypercapnic respiratory failure (S/P LVAD, RVAD and Impella) in 1 out of 10 patients (10%) and Paraquat poisoning induced Lung fibrosis in 1 out of 10 patients (10%). 6 out of 10 patients (60%) were extubated during ECMO, 1 / 10 (10%) underwent tracheostomy. 5 out of the 10 patients (50%) were mobilized while on ECMO. The in-hospital survival rate was 60% (6 out of 10). **Conclusion:** Only a small fraction of patients were eligible for DLSC (2). In general patients considered as high risk or who required high flows of who had a background of sepsis did not benefit from DLSC. However, in patients in whose flow was adequate to maintain gas exchange, it was useful in early mobilization.

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## Surgical Cutdown and Semi-Seldinger Technique for Placing Distal Perfusion Cannula After Percutaneous Placement of Arterial Return Cannula In VA ECMO- Our Experience


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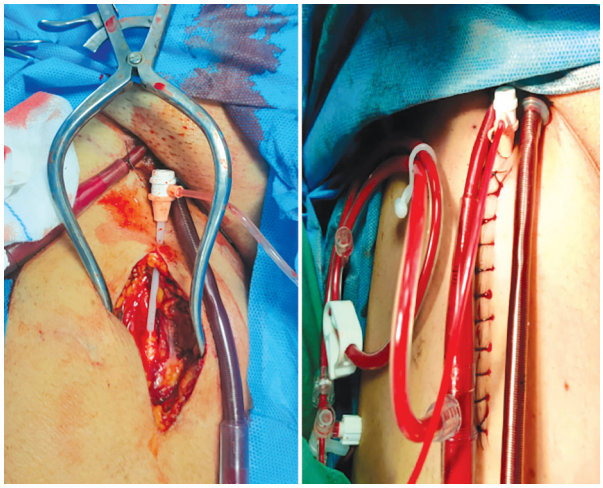
**Background:** Extracorporeal Membrane oxygenation has become a revolutionary technology for cardiopulmonary failure refractory to conventional management. Placement of femoral percutaneous arterial cannula is preferred as lesser invasive and faster technique but may lead to cannulation related limb complications in 10 to 70% of cases. To preserve distal limb perfusion, distal perfusion cannula (DPC) is usually being obtained before placing the main arterial cannula. But it can be challenging after main arterial cannulation especially when the patient is in shock. Our aim was to compare the technical benefits and time consumed for cannulating distal perfusing artery by surgical dissection and semi- Seldinger technique under direct vision in difficult cases while looking for the possible peri-procedural complications. **Method:** After unsuccessful attempts for anterograde placement of guide-wire via superficial femoral artery (SFA) under USG-guidance; ECMO physician would directly proceed with percutaneous placement of arterial return cannula at common femoral artery (CFA) and ECLS would be initiated. Vascular surgeon would be called to dissect SFA and cannulate using 6-8Fr distal perfusion sheath by semi-Seldinger technique under direct vision within 1-2 hours of arterial cannulation. Side arm of the sheath was connected to the side port of the arterial cannula after de-airing and maintained flow at 150-200ml/min. In the subsequent hours distal perfusion was checked by clinical examination of the limb viz. warmth, colour change, stiffness of the joints and Doppler assessment of the arterial system of lower limbs. **Results:** In 17 cases where ECMO physician failed to place distal perfusion cannula; arterial cannulation and ECMO initiation got delayed approximately by 15 minutes and 30 minutes respectively. Surgeon took less than 15 minutes to dissect out SFA and cannulated under direct vision within 5 minutes and achieved distal limb perfusion by 20 seconds without any surgical complications like bleeding, hematoma or infection. **Conclusion:** Thus in instances where patient is in circulatory shock and need an urgent ECLS with difficult vascular access, primary arterial cannulation and ECLS initiation followed by surgical exploration of SFA and semi-seldinger technique of cannulation for distal perfusion can be tried with minimal ischemic and vascular complications.



**Figs 1A and B:** (A) Superficial femoral artery dissected out and cannulated with 7Fr distal perfusion cannula by semi-seldinger technique under direct vision; (B) Distal perfusion cannula placed at superficial femoral artery and connected to percutaneously placed arterial return cannula

## CROSSWORD ANSWERS