



Extracorporeal membrane oxygenation—a moving target

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Extracorporeal membrane oxygenation (ECMO) is an incremental technology, built on the pioneering work of Gibbon et al. in the 1940s and 1950s in the development of cardiopulmonary bypass (CPB), who in turn rode on the successes of Kolff and Berk in demonstrating oxygenation of blood as it passed through the cellophane membrane of the artificial kidney [1]. When the concept initially originated, it was used as a salvage technique for no-option patients and was therefore also labelled extracorporeal life support (ECLS). Building serially on the successes of Rashkind et al. (1965), Dorson et al. (1969), Baffes et al. (1970), and many more, Bartlett et al. reported the first successful use of ECMO in neonates in extremis with respiratory distress [2]. He is therefore rightfully endowed with the sobriquet of ‘Father of ECMO’ and we are indeed privileged to have the legend put pen to the paper for an ‘Invited Editorial’ for this issue. However, the programme crawled lackadaisically, especially after the negative randomized controlled trial (RCT) of ECMO use in adult respiratory distress syndrome (ARDS) by Morris et al. [3], but was given a fresh lease of life by the CESAR Trial [4], and thereafter, it has not looked back.

ECMO is indeed an iteration of CPB which can restore and maintain optimum tissue perfusion and oxygenation, giving time for the heart and the lungs to recover. New hardware in terms of centrifugal pumps, more efficient and long-lasting hollow fibre oxygenators, heparin-bonded circuits and miniaturization of circuits, etc. have revolutionized the use of ECMO. With the increasing experience, pari-passu with improved techniques and technologies, ECMO is now beginning to find its rightful place as a life-saving technique, either allowing for heart and lungs to recover under the ‘bridge to recovery’ theme or acting as a ‘bridge to definitive therapy’, in a form of organ transplantation or long-term ventricular assist device (VAD) implantation. Thus, a concept developed by

Prof. Robert Bartlett at the Boston Children’s Hospital in the 1960s, and later carried on at the University of Michigan, to support babies dying of acute lung failure has now blossomed into a myriad of applications, both cardiac and pulmonary. Extracorporeal support for cardiopulmonary resuscitation and trauma is emerging as a novel area for ECMO application. ECMO helps address not only the primary issue with trauma in terms of fluid/blood resuscitation etc. but also secondary issues associated with infection, acute coronary syndromes, ARDS, and other thrombo-embolic issues, all of which lend supremely to ECMO support. It has been used in trauma also for maintaining vital organ and peripheral perfusion, besides quick rewarming and for fluid resuscitation. Inter-hospital transport of critically ill patients is another ‘historically less-travelled road’, where ECMO may find traction going forwards [5].

In fact, in a short period of time, ECMO has evolved to be used even as a defunct prophylactic strategy for short-term use for complex and high-risk interventions in the cardiac catheterisation laboratory, such as for deployment of percutaneous valves, structural cardiac interventions, and for complex ablative procedures for malignant cardiac arrhythmias. Obviously, collateral neo-indications—e.g. recent applications in the Corona 2019 pandemic [6] and ‘bridge to surgery’ [7], will continue to emerge.

Not only the understanding of the type of ECMO to be used is basic to the success of ECMO but also its timing, selection of optimum cannulation strategies, anticoagulation protocols, etc., besides selecting the right patient. One must realize that ECMO is essentially an organ supportive therapy and does not modify the disease, and therefore, its use for the right patient at the right time is of paramount importance. The development of an ethos of teamwork amongst the technocrats, supported and egged on by the hospital administrators, cannot be emphasized enough for the development of a successful ECMO programme.

It is a no-brainer that with the use of such disruptive technologies, complications are bound to arise, and in ECMO, they come in a panoply of forms, prima-donna being renal failure, neurologic complications, infections, bleeding, and

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Fig. 1 Patient care during ECMO, 3 eras [8]

ECMO I, 1980-2008	ECMO II, 2009-2017	ECMO III, 2018-20??
Sedation, paralysis	Awake, spontaneous breathing	Awake, ambulatory
Intubated	Tracheostomy, extubate	Extubated
Rest vent settings	CPAP	Off vent
Specialist 24-7	ICU Nurse ECMO team support	Conventional care, weeks Home, months
Lung recruitment	Watch and wait	Spontaneous breathing
Bleeding: major	Bleeding: minor	No anticoagulation

thrombo-embolic events. A better understanding of the biologic (human) to machine (ECMO circuit) interactions, due to intra-corporeal blood coming in contact with extracorporeal artificial surfaces, will help, if not eradicate, at least address these issues appropriately and diligently.

Obviously, ECMO is a moving target and a work in progress (Fig. 1) [8]. The final destination is the development of a true artificial lung, which could be available off the shelf for transplantation. Abrams et al. posit an important question, ‘When the momentum has gone: what will be the role of extra corporeal lung support in the future?’ They attempt to provide an answer, ‘... its true value will not be known until more information is gleaned from prospective randomised controlled trials. Novel applications of extracorporeal lung support include optimization of donor organ quality through ex-vivo perfusion and extracorporeal cross-circulation, allowing for multimodal therapeutic interventions’ [9].

Financial and ethical dogmas continue to reign supreme in any discussion on ECMO. No doubt this technology is resource-intensive, and as a corollary fiscally draining—to the patients, the hospitals, and the state alike. ‘Naysayers’ may sceptically challenge the need for developing such programmes in developing countries like India. On the flip side, the ‘progressives’ take these as baby steps towards the ultimate goal of preserving life and therefore consider them every bit worthwhile. But not all new centres are emerging with this laudable philosophy, at least some are cropping-up for the deplorable one-upmanship. Moreover, the flipside of this burgeoning trend is that practices in these centres are based on individual and institutional experiences from anecdotal cases (level ‘C’ recommendations), rather than by evidence-based guidelines. This trend needs to be reined in by proper regulation. These programmes should run only in centres with an active and vibrant heart failure programme; in all its manifestations—VADs and transplant, with a supportive infra-structure, dedicated and initiated man-power and adequate fiscal resources; and other cardiothoracic centres yielding to it in a ‘hub and spoke’ model. Worku and Gaudino, in a ‘Commentary: To ECMO or not to ECMO: That is the

question’, give the central message, ‘Given the significant costs of extracorporeal membrane oxygenation and the highly variable outcomes associated with this heroic therapy, standardization of indications and management is mandatory’ [10]. Considering the even more acuteness of the limited human and financial resources in the developing nations, indications for use of ECMO in these countries must vary from the developed ones, and especially those launching into new programmes may like to confine themselves initially to only the low hanging sweet fruits.

No doubt, ECMO is coming of age, with the blossoming of the ‘ugly duckling’ into a ‘swanky swan’. It is becoming a mainstream therapy for a lot of ailments. In congruence with the contemporary ‘zeitgeist’, we conceived this compendium to provide a concise and one-stop repository of most that a practitioner of ECMO would like to, and in fact should, know. Pearls are there for the picking, dime a dozen, should one care to dig in...so, wishing you an intellectually stimulating read.

Declarations

Informed consent Not required.

Conflict of interest The author declares no competing interests.

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