Dr. Daniel Brodie: we anticipate a widespread application of ECMO as a carbon dioxide removal device

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The Annals of Translational Medicine (ATM) was honored to have the chance to meet Dr. Daniel Brodie (Figure 1) at the 2014 Chinese Heart Congress, Director of the Medical ICUs and the Medical Critical Care Service at the Columbia College of Physicians and Surgeons and New York-Presbyterian Hospital. He is a leader and innovator in the field of adult ECMO and runs one of the largest ECMO programs in the world for adult respiratory failure. After the meeting, Dr. Brodie and his colleagues, Dr. Cara Agerstrand and Dr. Darryl Abrams, Assistant Professors from Columbia University Medical Center, shared with us their profound ideas about ECMO.

Figure 1 Dr. Daniel Brodie at the 2014 Chinese Heart Congress.

ATM: How is the application of ECMO in the USA? What is the beneficial rate? How have this technology developed over these years?

Dr. Brodie: ECMO is the general term referring to an extracorporeal circuit that directly oxygenates and removes carbon dioxide from the blood via an oxygenator. Venous blood is withdrawn from a central vein through a drainage cannula via an external pump, passes through the oxygenator, and is returned to the patient through a reinfusion cannula. When the circuit reinfuses oxygenated blood into a central vein, it is referred to as venovenous ECMO. Venovenous ECMO only provides gas exchange support. When the circuit reinfuses oxygenated blood into an artery, it is referred to as venoarterial ECMO. Venoarterial ECMO provides both respiratory and circulatory support.

The most common indication for venovenous ECMO in the USA is as rescue therapy for severe forms of the acute respiratory distress syndrome (ARDS), when conventional therapies are insufficient to maintain adequate oxygenation or ventilation. Alternatively ECMO may be applied in circumstances where gas exchange is adequate, but only at the expense of excessively high airway pressures. Data supporting the use of ECMO for the above indications is limited and outcomes vary greatly depending on underlying etiology and ECMO center experience. That being said, many centers have reported significantly higher survival rates than would traditionally be expected for this patient population. A multicenter randomized controlled trial is currently underway to determine the efficacy of ECMO over conventional therapies for these patients.

Venovenous ECMO use has also been expanding as a bridging therapy to lung transplantation in patients with end-stage lung disease. Although ECMO has traditionally been associated with poor post-transplant outcomes, more recent studies have reported high rates of success, particularly at centers with more extensive ECMO experience. In a subset of patients who would traditionally require invasive mechanical ventilation for gas exchange support, ECMO may be able to replace the ventilator entirely, eliminating the risk of ventilator-associated complications.

The high efficiency with which venovenous ECMO removes carbon dioxide makes it particularly well suited for patients with acute hypercapnic respiratory failure, although this indication needs further study before it can be recommended for widespread use.

Venoarterial ECMO has a wide variety of applications, including myocardial infarction-associated cardiogenic shock, severe nonischemic cardiomyopathy, rescue therapy during

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cardiac arrest (extracorporeal cardiopulmonary resuscitation or ECPR), and, more recently, decompensated pulmonary hypertension. Outcomes vary greatly by indication and center experience, with the majority of data for these indications limited to case series and retrospective analyses.

Much of the improvement in ECMO survival rates over the last several years can be attributed to advances in extracorporeal technology. Centrifugal pumps help minimize blood trauma and risk of tubing rupture compared to traditional roller pumps. Improved biocompatibility of circuit components permits the use of lower levels of anticoagulation, which helps to minimize bleeding risk without significantly increasing thrombosis rates. Newer oxygenator membrane materials, such as polymethylpentene, have improved gas exchange efficiency and oxygenator durability. Likewise, advances in cannula design, particularly the advent of the bicaval dual-lumen cannula, have allowed for single-site venous access, minimizing the need for femoral cannulation and improving mobility during ECMO support.

ATM: How can ECMO benefit our patients?

Dr. Brodie: Venovenous ECMO has the potential to correct severe, refractory hypoxemia for patients in whom conventional strategies have failed. In some circumstances, respiratory system compliance is so severely compromised that the application of lung protective ventilation is limited by unacceptable levels of acidemia and hypercapnia. In these cases, ECMO can facilitate low tidal volume ventilation by directly removing carbon dioxide. Additionally, the gas exchange support of ECMO may allow for the application of even lower tidal volumes and airway pressures than the currently accepted standard of care in ARDS, potentially reducing ventilator-associated lung injury even further.

In cases of severe, refractory cardiogenic shock, venoarterial ECMO may supply sufficient circulatory support until the heart failure improves, including the application of cardiac catheterization with percutaneous coronary interventions in the appropriate clinical context. In cases of irreversible cardiogenic shock, venoarterial ECMO may be considered as a bridging therapy to ventricular assist device implantation or heart transplantation when available. In patients with decompensated pulmonary hypertension, venoarterial ECMO may act as bridging therapy to recovery when there is an opportunity to treat an acute process, or as bridging therapy to transplantation for irreversible disease.

ATM: Dr. Brodie, you mentioned the application of ECMO as artificial lung in your speech, could you kindly share your experience on it? What challenges are we still facing?

Dr. Brodie: A major limitation in venovenous ECMO is the lack of destination device therapy. ECMO in its current form requires ongoing management in an intensive care unit due to its complexity and the need for frequent monitoring. Future developments, including more compact circuits and more efficient membranes, will likely move the field toward more portable, long-term devices. There are ongoing efforts to create such devices.

ATM: There is still a wide gap between China and your country on the technology of ECMO. What is your suggestion on the training of the use of ECMO for Chinese doctors?

Dr. Brodie: Centers that have successfully implemented ECMO programs are often large, tertiary care centers with the resources to develop an experienced, multidisciplinary ECMO team.

ATM: As the performance of ECMO entails team work, would you like to share with us your experience in this regard?

Dr. Brodie: We employ a multidisciplinary team for the management of patients receiving ECMO support, consisting of cardiothoracic surgeons, medical intensivists, perfusionists, acute care nurse practitioners, critical care registered nurses, pharmacists, respiratory therapists, and physical and occupational therapists. In cases where cannulation is performed at a referring hospital prior to transport to our facility, we will dispatch a mobile ECMO transport team consisting of cardiothoracic surgeons, perfusionists, and critical care paramedics.

ATM: What is your expectation on the future development of ECMO?

Dr. Brodie: With the development of smaller cannulae and more efficient circuits, we anticipate a more widespread application of ECMO as a carbon dioxide removal device. Patients requiring invasive mechanical ventilation for acute exacerbations of chronic obstructive pulmonary disease

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(COPD) have high rates of complications that can be attributed directly to the ventilator itself, including but not limited to ventilator-associated lung injury, ventilator-associated pneumonia, immobility, and impaired delivery of aerosolized medications. ECMO, by correcting the respiratory acidosis associated with these exacerbations, may facilitate extubation, thereby minimizing these complications and facilitating mobilization. With further developments in oxygenators and pumps, we anticipate the development of ECMO circuits that can serve as destination devices for patients with chronic respiratory failure, much in the way ventricular assist devices serve as destination support for patients with heart failure.

ATM: Impressive! Thank you very much for you informative share!

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