



US DEPARTMENT OF DEFENSE

# BLAST INJURY RESEARCH PROGRAM COORDINATING OFFICE

## Treatment Strategies

### Improving the Prognosis of Service Members with Acute Respiratory Distress Syndrome (ARDS) with Extracorporeal Gas Exchange (ECGE) Devices

Combat explosions rose significantly, from 18 to 69 percent, between 2003 and 2005, resulting in an increased number of combat-related burn injuries.<sup>1</sup> Acute Lung Injury (ALI), and its most severe form, ARDS, often result from smoke inhalation, which is especially detrimental to those who suffer burn injuries. Patients who acquire ALI and ARDS from combat-related burns are characterized by the sudden onset of edema in the lungs, leading to decreased exchange of oxygen and carbon dioxide. Approximately 33 percent of mechanically ventilated Service Members with burn injuries develop ARDS, and this often prevents them from returning to duty.<sup>1,2</sup> Recent studies also indicate mortality rates significantly increase for burn victims whom develop ARDS.<sup>1</sup> Additionally, mortality rates were found to increase with ARDS severity with mild, moderate, and severe ARDS diagnoses accounting for mortality rates of 11.1, 36.1 and 43.8 percent, respectively.<sup>3</sup> The mortality rate for burn victims who do not develop ARDS was 8.7 percent.<sup>3</sup> Current treatment options for ALI and ARDS are limited to supportive care such as use of a mechanical ventilator, which exacerbates ALI and leads to multi-organ failure. Researchers at the US Army Institute of Surgical Research (USAISR) study and develop both non-invasive and invasive techniques to treat ARDS due to smoke inhalation, burns, and combined models of trauma. The team is carrying out a comprehensive benchmarking study of three minimally invasive ECGE devices: the Hemolung (Alung Technologies, USA), the Mini Lung Petite System (Novalung, Xenios, Germany), and the Cardiohelp (Maquet Cardiopulmonary, USA). These miniaturized, self-operating, and portable ECGE devices are evaluated for therapeutic feasibility and improved outcomes in combat-burn patients. Using an animal model, the therapeutic efficacy of the ECGE devices is evaluated for their ability to lower injurious ventilator settings during transport and to reduce inflammatory responses, thereby preventing the onset of ARDS.

Preliminary data obtained in the first two years showed that all the devices enabled removal of nearly 50 percent of metabolically produced CO<sub>2</sub> and significant (from 25–50 percent) reduction in minute ventilation settings at blood flow rates ranging from only 500–800 milliliters per minute using 15-18 French scale catheters. This alone is an improvement over traditional methods of extracorporeal life support utilizing large catheters (27-32 French scale) that require blood flow rates of 2 to 5 liters per

- 1 Kauvar, D. S., Wolf, S. E., Wade, C. E., Cancio, L. C., Renz, E. M., & Holcomb, J. B. (2006). Burns sustained in combat explosions in Operations Iraqi and Enduring Freedom (OIF/OEF explosion burns). *Burns : Journal of the International Society for Burn Injuries*, 32(7), 853–857. <https://doi.org/10.1016/j.burns.2006.03.008>
- 2 DeMar, J., Sharrow, K., Hill, M., Berman, J., Oliver, T., & Long, J. (2016). Effects of Primary Blast Overpressure on Retina and Optic Tract in Rats. *Frontiers in Neurology*, 7, 59. <https://doi.org/10.3389/fneur.2016.00059>
- 3 Belenkiy, S. M., Buel, A. R., Cannon, J. W., Sine, C. R., Aden, J. K., Henderson, J. L., ... Chung, K. K. (2014). Acute respiratory distress syndrome in wartime military burns: application of the Berlin criteria. *The Journal of Trauma and Acute Care Surgery*, 76(3), 821–827. <https://doi.org/10.1097/TA.0b013e3182aa2d21>





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minute. Decreasing the high mechanical ventilator settings has a crucial effect on reducing ventilator-induced lung injury. Recently acquired benchmarking data suggests that the NovaLung Mini Lung Petite device is the most versatile and therapeutically efficient because it can be connected to oxygenators of various sizes (pediatric to large size) – all within the same system which can address ARDS of varying severity.

These studies are expected to lead to novel and improved clinical practice guidelines (CPGs) for use of ECGE devices which could reduce ventilator-induced lung injury, and more importantly could reduce inflammatory responses and thereby potentially prevent the onset of ARDS.

