CRITICAL CARE LIFE SUPPORT: WHEN THE BODY CALLS FOR BACKUP

Innovation and Improvement in Diagnosis, Treatment, and Monitoring at the Michigan Center for Integrative Research in Critical Care
Critical illnesses and injuries can result in moment-by-moment events causing a patient’s condition to change rapidly. Care providers must constantly ask themselves: Which patient is at the highest risk for suddenly dying? How might their condition change after one hour, one day, even one week? Is it better to act immediately or continue to monitor? What is the best way to monitor and support vital organ functions?

“Critical Care Life Support” refers to those diagnostic and therapeutic actions that are taken to support the life of a critically ill or injured patient hour by hour and day by day.

This support may take the form of invasive physiologic monitoring of patient vital signs and cardiovascular status like arterial and central venous blood pressures, supporting the lungs and blood oxygenation and carbon dioxide removal with mechanical ventilation, monitoring and preventing infections while in the hospital, monitoring complex blood processes like blood clotting, controlling pain, and many others.
We Power Innovations to Transform Critical Care

The Michigan Center for Integrative Research in Critical Care is the innovation hub for more than 200 critical care researchers across the University of Michigan from 7 schools/colleges and 43 departments.

As one of the first comprehensive enterprises devoted to transforming critical care medicine, we foster multidisciplinary collaborations between our members—unifying scientists, clinicians, engineers and industry partners—to accelerate science and deploy cutting-edge solutions that elevate the care, outcomes, and quality of life of the critically ill and injured.

In the last four years, MCIRCC multidisciplinary teams have licensed ten new products, started 5 new companies, and received more than $30 million in funding toward innovative projects in critical care.

We Are Wolverines With a Recipe for Success

MCIRCC is focused on leveraging our multidisciplinary model of research with our ability to integrate University of Michigan’s campus-wide talent and supporting resources to bring university-led critical care discoveries and innovations to patients. Our members span many disciplines across the university yet have the common goal of improving the lives of critical care patients and their families.
MONITORING, PREDICTING, INTERVENING
MCIRCC Innovations Improve Outcomes at Every Stage

MONITORING

Blood Vital Signs Platform
MCIRCC is developing the world's first microfluidic integrated blood vital signs platform that monitors the blood health by measuring viscosity, coagulation, red cell deformability, and redox potential (oxidative stress). The combination of these parameters are known to be affected by many disease processes and are also critical in the field of transfusion medicine. MCIRCC believes this platform will allow for new and transformative means to monitor patient health as well as open up new ways to develop life saving drugs that can favorably impact blood health.

Noninvasive Vascular Resistance Monitor
A patient's blood pressure is the result of many complex interactions which currently cannot be readily measured. MCIRCC researchers have developed a small device that can be placed on the finger which monitors changes in movement of small arteries in the fingers. These measures can be used to determine changes in vascular resistance, blood pressure, and cardiac function and are being used to predict when a patient's blood pressure can become dangerously low before the event happens. The technology is also being explored for its ability to help clinicians guide the use of medications that increase or decrease blood pressure.

Smart Pipette
The Smart Pipette is a point of care portable blood analysis system. It is uniquely combined with other patient data and advanced machine learning algorithms to allow for rapid bedside measurement of multiple blood biomarkers of inflammation such as cytokines. The data it gathers is analyzed and then correlated with a patient's condition to help in the diagnosis and treatment of sepsis, lung injury, trauma, and other conditions in order to improve outcomes.

Microvascular Tissue Oximetry
One of the most difficult tasks for any critical care specialist is rapidly determining if a patient's tissues are receiving enough oxygen. MCIRCC members have engineered a device that utilizes Resonance Raman Spectroscopy (RSS) to measure tissue oxygenation from the inside of the patient's cheek. RSS is a novel optical technique that uses a special wavelength of light to vibrate hemoglobin molecules. Values monitored via RSS are very similar to those of more invasive techniques such as central or mixed venous hemoglobin saturation which require placement of catheters into or near the heart.
Noninvasive Central Venous Pressure Monitor

Making sure critically ill patients have optimal amounts of intravenous fluid to support their circulation to avoid heart failure and shock can be difficult without the need to place catheters into or near the heart to measure pressures within the heart. These invasive procedures to measure central venous pressure are time consuming and can result in complications. MCIRCC members have developed a noninvasive means to measure central venous pressure using bioimpedance technology applied to the patient’s arms. Studies are demonstrating that the noninvasive measure can replace the invasive measure saving time and preventing complications.

THERAPEUTICS

Allosteric Modifiers of Hemoglobin

The ability of hemoglobin within the red blood cell to pick up oxygen from the lung and release it to tissues is critical. MCIRCC is developing drugs that can favorably change how hemoglobin carries oxygen as well as other important biologic gasses which can benefit tissues and patients who are experiencing sepsis, hemorrhage, and organ inflammation & failure.

Valproic Acid

Many conditions such as traumatic hemorrhage, sepsis, cardiac arrest and others can deprive vital organs of oxygen, severely impairing them. MCIRCC investigators are studying the use of valproic acid (a common seizure medication) to activate certain genes in the tissue which help cells survive the insult and injury from lack of oxygen. The drug is being demonstrated to improve survival and function of the brain, heart and other organs after injuries from severe hemorrhage, brain trauma, and cardiac arrest.

ICU Bed of the Future

Critically ill and injured patients can spend weeks to months in an ICU bed. As a result, they can develop severe complications such as skin ulcers, blood clots, muscle atrophy and weakness, and pneumonia. Some of these complications result in the Post Intensive Care Syndrome (PICS) requiring months to years of rehabilitation. MCIRCC is transforming the ICU bed into a diagnostic and therapeutic platform that incorporates technologies like specialized vibration that keeps patients from losing muscle strength. The bed will use special materials to prevent infection, control body temperature, and allow for news method of ventilation which do not require the use of traditional ventilators.

Prevention of Infections

Patients admitted to the ICU and who require mechanical ventilation and urinary and blood vessel catheterization can develop pneumonia, urinary, and blood stream infections. These secondary infections can become life threatening and prolong the need for ICU care. To combat this, MCIRCC is developing new powerful antibacterial agents which use naturally occurring compounds (found in nature) to coat catheters and other devices (oral mouth pieces), and even desk and keyboard surfaces to reduce chances of hospital acquired infections.
CASE STUDY

PICTURE This!
Real-Time Predictions of Patient Deterioration

According to a 2011 study in the Journal of Hospital Medicine, 14% to 28% of patients admitted to intensive care units (ICUs) are unplanned transfers.\(^1\)

An unplanned transfer is when a patient is moved to the intensive care unit from another unit in the hospital due to an unexpected change in the patient’s clinical status. A major cause of unplanned transfers is when a patient’s condition suddenly deteriorates.

Early detection of patient deterioration has been found to lead to reduced mortality risk, reduced length-of-stay, and decreased hospital costs; however, identifying patient deterioration can be a challenge for clinicians.

To address this need, MCIRCC developed PICTURE (Predicting Intensive Care Transfers and other Unforseen Events), a machine learning algorithm that uses electronic health record (EHR) data to passively and accurately predict ICU transfer or death as a proxy for patient deterioration. PICTURE has been demonstrated to predict these events hours to days before the events occur.

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Easy to Implement, Simple to Interpret, Robust to Change

The PICTURE platform was designed for seamless integration into any hospital and can run successfully using existing lab values for a majority of patients. This ensures that clinicians will not need to change their workflow or practices and that PICTURE will continue to make accurate predictions even if policy changes are put into place that alter which tests are routinely ordered.

In addition to supplying a patient deterioration score, PICTURE provides explanations for its predictions using SHAP (Shapley Additive exPlanations). In the clinical setting, this provides an invaluable layer of transparency that allows hospital teams to see why PICTURE is making its prediction. The teams can then quickly determine the legitimacy of an alarm which will aid in mitigating the effects of “alarm fatigue”—a sensory overload that occurs when clinicians are exposed to an excessive number of alarms, resulting in desensitization and an increased rate of missed alarms.

When PICTURE catches patient decline, the explanations also lend themselves to suggesting a course of treatment.

PICTURE is also tunable for other issues including the early prediction of sepsis in adult and pediatric patients. Recently, a special version of PICTURE was developed to predict deterioration and ICU admission of COVID-19 patients. It has even been used to assist in predicting readmissions of patients after discharge from a rehabilitation unit.

Efforts are now underway to uniquely supplement PICTURE with other data including special real-time automated analysis of ECG signals from monitors and chest X-rays that will bring even greater predictive accuracy to the health care team.

SAVE A LIFE; INFLUENCE SCIENCE AND DISCOVERY

With current scattered and insufficient funding sources, high-risk research to enhance long-term survival and quality of life for the critically ill and injured seems out of reach. In order to expedite the ability to better treat patients, we are embarking on a financial model that depends upon private support from donors, investors, and entrepreneurs. The investment is great, but the return on the investment holds the promise of being a game changer. These funds will enable MCIRCC to maintain research facilities, engage our members, and enable scientists, engineers, and physicians to be disruptive and transformative in their approach to invent the solutions necessary to save lives.