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Researchers pioneer an advanced sepsis detection and management system

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When Jason Martin gives a talk about his research, he begins with the dramatic story of Mariana Bridi da Costa: The young Brazilian supermodel died from severe sepsis in January after amputation of both her hands and feet failed to stop its spread.

Martin, who is a fellow in allergy, pulmonary and critical care medicine, is part of an interdisciplinary team at Vanderbilt University that has come up with a high-tech approach to combat this deadly illness, which is one of the top 10 causes of death in the United States and kills more than half a million people worldwide every year.

The team is made up of clinicians and informatics experts from the Vanderbilt University Medical Center and computer scientists from Vanderbilt's Institute for Software Integrated Systems (ISIS). They have developed and begun testing what they believe is the first real-time system for sepsis detection. In May, the system was deployed in the hospital's intensive care unit to test its effectiveness. This summer, they will add an automated decision support system designed to guide attending physicians through the complex process of sepsis treatment.

"This is an effort to use the power of informatics to move from reactive to proactive medical treatment by creating tools to support the use of evidence-based clinical guidelines," said Peter Miller, director of the Vanderbilt HealthTech Laboratory, who oversees the project.

Sepsis, or systemic inflammatory response syndrome (SIRS), causes the

body to attack itself. It is triggered when bacteria invade the body from outside through wounds or IV lines. The bacterial infection overstimulates the body's immune system, setting off a cascade of inflammatory and abnormal clotting responses that can lead to organ failure and death. Infections that cause sepsis can be acquired outside the hospital, but those acquired in the hospital are more difficult to manage because many patients are already weak and the invading bacteria are more likely to be drug-resistant strains.

According to a study conducted by the Emory University School of Medicine and the Centers for Disease Control in 2003, the incidence of sepsis increased by an average of 8.7 percent a year over the prior 22 years. Today, sepsis treatment accounts for 40 percent of all ICU costs - more than $17 billion annually, according to a 2001 study.

In 2006, Miller came to Vanderbilt from the Department of Homeland Security with the mission of fostering "the revolutionary transformation of healthcare" by the application of informatics technologies. "For a while, we were a solution looking for a problem," Miller recalled. In consultation with Gordon Bernard, the associate vice chancellor for research at VUMC, and with Associate Professor Arthur Wheeler and Assistant Professor Todd Rice in allergy, pulmonary and critical care medicine, Miller decided to focus on the problem of sepsis because it is common, deadly, expensive and treatable.

At the same time, ISIS computer scientists were investigating the issue of security and privacy of electronic patient records under the aegis of the National Science Foundation's TRUST (Team for Research in Ubiquitous Secure Technology) Science and Technology Center. When Miller and ISIS Director Janos Sztipanovits compared notes, they realized that ISIS had developed computer-modeling tools that could be used in the new project and that the project was compatible with TRUST's mandate.

Two years ago, Miller assembled his team. The clinical members were Martin; Liza Weavind, associate professor of anesthesiology; and David Maron, associate professor of medicine and emergency medicine. The informatics experts included Ed Shultz, director of information technology integration, and health system engineer Daniel Albert. Joining them from ISIS were Sztipanovits, senior research scientist Akos Ledeczi and graduate student Janos Mathe.

The first step in the $360,000-plus project was creating a common vocabulary and knowledge base among the team members. The ISIS researchers spent two weeks at the hospital to familiarize themselves with the clinical environment. "I had to learn their language and they had to learn mine," Martin said. "They see the world totally differently, so we think of different problems. That makes it a lot of fun."

"Working with the docs is a pleasure," Mathe added. "They are very busy, but they are so smart it is scary. They pick up new ideas very quickly."

The first part of the project was the development of an automated early detection system that can alert doctors that a patient may be developing sepsis. The doctors came up with a formula involving patient temperature, heart rate, respiration rate and white blood count that they felt was indicative of the onset of SIRS. Currently, the alerts appear on "patient dashboards" displayed on ICU workstations. (In the future, they hope to add the capability of displaying the alert on doctors' cell phones.) When a doctor gets an alert, she checks out the patient. If she decides it was a false alarm, the system goes to sleep for 48 hours before resuming operation. If she decides the system was right and begins treatment, the alert system turns off for a week.

"For the last 15 years, we have been storing more and more of our information electronically," Shultz said. "But even a few years ago we

couldn't have done a project like this because it makes decisions based on information stored on different systems that could not communicate effectively in real time." Patient temperature and respiratory data are handled by one system, for instance, while another handles laboratory test results. So a major technical challenge was building pipelines between the different systems and getting them to "play nicely" with each other.

Creating the decision management system presented a different kind of problem. The doctors wanted to base it on a set of guidelines developed by the Surviving Sepsis Campaign, a worldwide consortium of critical care professional societies, based on peer-reviewed studies, an approach broadly referred to as evidence-based medicine.

"I tried to organize the protocol into a flow chart, but it was a mess," said Martin. "It's not easy to convert medical protocols into ones and zeros because there is a lot of nuance and judgment involved."

After a period of "beating our heads against the wall trying to make this work," the ISIS team suggested a new approach, something they called a "state-based decision engine." Essentially, this involved breaking down the guidelines into a series of independent processes that can take place sequentially or simultaneously. "This really captures the way doctors work. If we see low blood pressure, then we think of one set of treatments. If we see low blood sugar, then we think of another set. If we see the two together, then we
consider a third set of possible measures we can take," Martin said. "The more we kicked it around, the more we liked it."

Using this approach, Mathe and his colleagues developed a special modeling language specifically for clinical decision-making. "Although the language is specific to sepsis management, we made the underlying technical infrastructure so general that it can model virtually any medical

protocol," Mathe said. The team has already begun applying it to a second problem, treatment of chronic heart failure.

According to the researchers, it will take six to 12 months of operation before they can begin to judge the system's effectiveness. They began running the detection system in the background in March. During this time they averaged three to four alerts per day in the 25-bed ICU. When the system was deployed, the very first alert led an attending physician to begin antibiotic therapy. They will run the detection system for several months before implementing the decision management system. This sequential implementation will allow them to independently assess the effectiveness of the alert and management parts of the system.

"A key message of this project is that collaboration is very important in addressing these kinds of problems," Miller said. "When people from different disciplines come together they produce positive outcomes."

Source: Vanderbilt University (news : web)