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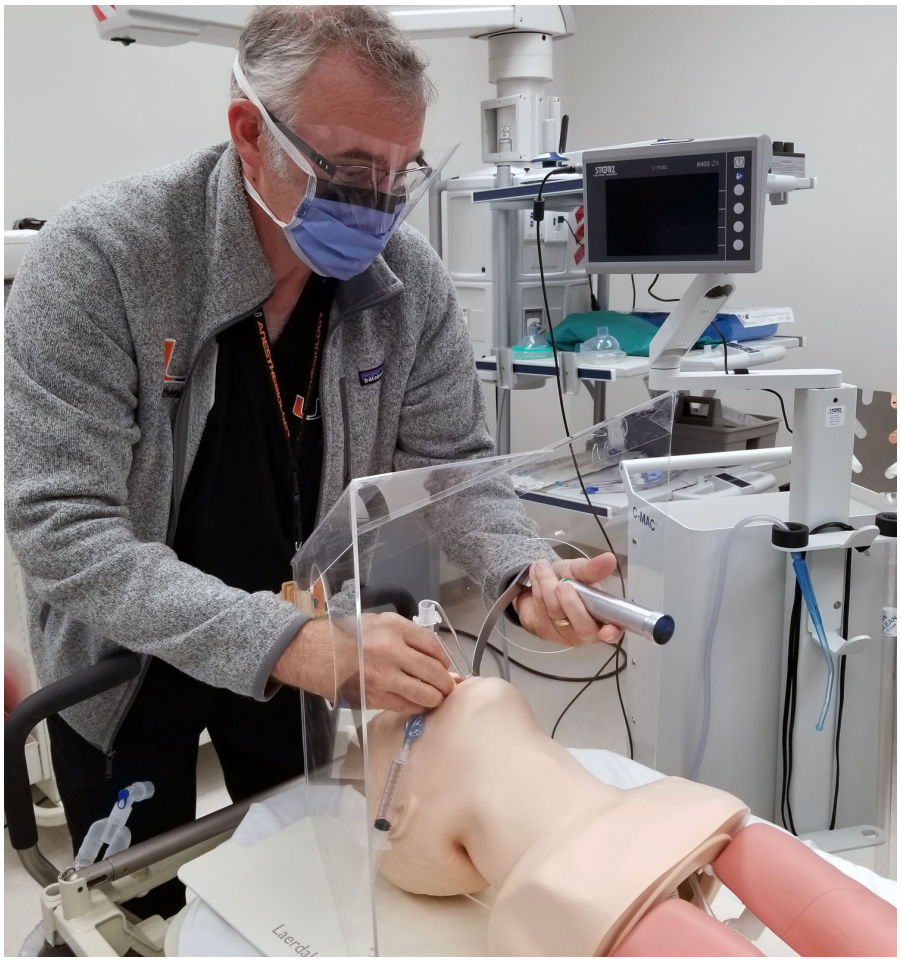
UM Multidisciplinary Team Fabricates Suctioning Tool and Intubation Boxes to Protect Health Care Workers from COVID-19

Smoke billowed from the patient simulator's mouth and nose, filling a pyramid-shaped acrylic chamber that encased the mannequin's head.



Standing nearby was anesthesiologist Richard McNeer, M.D., Ph.D., associate professor of clinical anesthesiology at the University of Miami Miller School of Medicine.

The chamber, he observed, was working flawlessly, preventing the smoke – in this case, theatrical fog used to mimic COVID-19 respiratory particles – from reaching him and the team of other health care experts who had gathered to test the device as part of a mock intubation procedure.

But then, Dr. McNeer had one of those "aha'' moments. He discovered that a Yankauer, a special suctioning tool used in many medical procedures, could evacuate most of the aerosol particles if it were positioned – prior to intubation – strategically near the opening of the mannequin's vocal cords.

"It was a serendipitous discovery," Dr. McNeer recalled. "Suction has been used to remove everything from stomach contents to blood. But this is perhaps the first time it has been considered for use in suctioning out aerosols. This is something that can be done upstream of just about any of the other strategies and safety measures to prevent exposure to the virus during intubation."

A formidable one-two punch, the chamber, or intubation box, and suction tubing are part of a broad University of Miami initiative to 3D print and fabricate devices and personal protective equipment (PPE) for medical personnel on the front lines of the war against COVID-19.

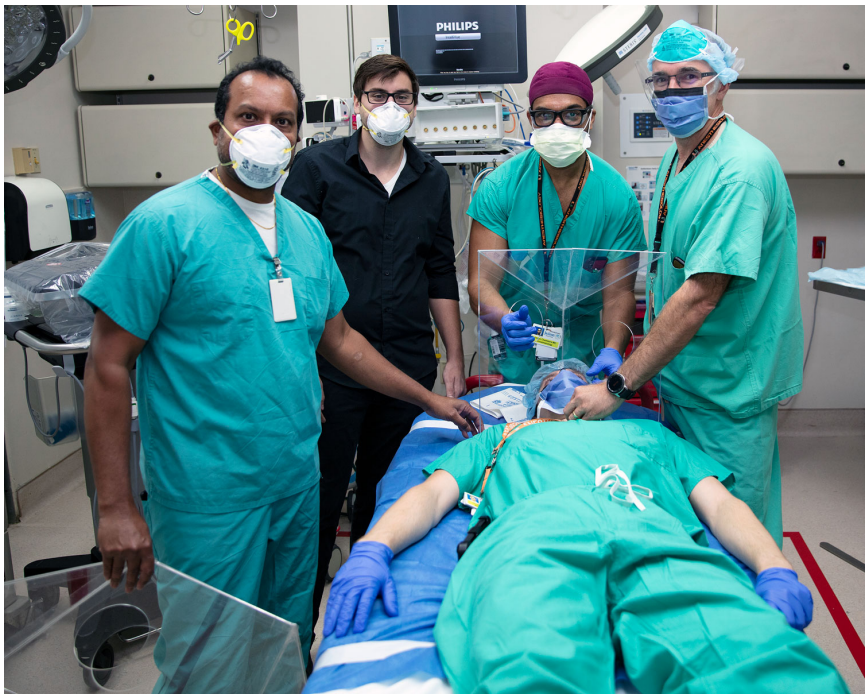
From low-cost ventilators and powered air-purifying respirators to surgical helmets, filter caps for N95 masks, and even nasal swabs used to test for the coronavirus, a multitude of products are either in the design and testing phase or, as is the case with the intubation box, in actual use.

Departments and divisions from across the University are involved in the endeavor, helping to ramp up stockpiles of medical supplies and ensure that demand doesn't outpace supply.

"We're responding to the needs of all those in the health care field who are caring for COVID-19 patients. That's our guiding principle," said Jean-Pierre Bardet, Ph.D., M.S., vice provost of strategic projects, who is spearheading the University's COVID-19 Preparedness Committee.

"Doctors and nurses still need better PPEs. And when the crisis subsides, the public will need more effective personal protection and more testing," Dr. Bardet said. "How will we address those challenges? How will we deal with the second COVID-19 wave? Ventilators are no longer in short supply in the U.S., but what about other parts of the world like South America? Our goal is to produce badly needed supplies and equipment that will be used, not squandered."

Global pandemics, said Jeffrey Duerk, Ph.D., UM's executive vice president for academic affairs and provost, "require local responses and quick action by the entire community. It has been impressive to see the mobilization of faculty, student talent, and institutional leadership in responding to emerging and evolving needs."



Standing, from left, Suresh Atapattu, Maxwell Jarosz, anesthesia resident Ethan Chambers, M.D., and Richard McNeer, M.D., Ph.D. On bed, anesthesia resident James Burnett, M.D.

Of all the fabrication projects now underway, the intubation boxes are at the most advanced stage, with physicians and nurses at Ryder Trauma Center, Jackson Memorial Hospital, and Nicklaus Children's Hospital already using them as protective shields during certain medical procedures.

Made from acrylic, the reusable, clear enclosure covers a patient's head and has two circular ports through which an anesthesiologist inserts his gloved hands and arms to perform an airway procedure.

"We knew that anesthesiologists were at risk of being exposed to splatter and respiratory droplets when performing

intubations, so we were trying to find a way to protect them," said Suresh Atapattu, a biomedical engineer at the Miller School's International Medicine Institute. "We're not anesthesiologists, but we wanted to come up with something to help those physicians at the tip of the spear in this fight."

As Atapattu and Eduardo de Marchena, M.D., professor of medicine and surgery, associate dean for international medicine, program director of the Eberhard Grube International Structural Heart Training Program, and director of interventional cardiology, searched for a solution, they found inspiration from half a world a way. A physician in Taiwan, they learned, had constructed and used a clear barrier device to protect health care workers when intubating COVID-19 patients.

So Atapattu quickly sprung into action, designing a version of the box and then driving to a local Lowe's home improvement store to buy the acrylic to build it. He constructed the first prototype in the garage of his Plantation, Florida, home, using Crystal Clear Gorilla Tape to attach the sheets of acrylic, and a Dremel tool to create the ports.

"It was a learning process from the very beginning," Atapattu recalled of building the first box. "The design had to be clean, which meant we couldn't use screws to attach the sheets because there couldn't be any places inside where the virus could hide."

He initially built two boxes, giving one to Nicklaus Children's Hospital, where pediatricians praised the functionality of the design, and another to Dr. McNeer, who tested the device on a patient simulator at the University of

Miami School of Nursing and Health Studies Simulation Hospital for Advancing Research and Education (SHARE).

In the latter case, the box turned out to be a bit cumbersome. So, Dr. McNeer and two nursing school clinical faculty members, who participated in the testing phase, reimagined the design. They suggested to Atapattu that the boxes be pyramid-shaped and collapsible, so they could be easily stored when not in use.

With the design now finalized, Atapattu turned to the University of Miami School of Architecture, where Maxwell Jarosz, architect and manager of the fabrication lab and model shop, employed a precision laser cutter to build more intubation boxes.

“The lines are now cleaner, and the design is more prism-shaped,” Atapattu said. “But the key elements are still there – acrylic and Gorilla Tape.”

Twenty of the boxes were recently delivered to Ryder Trauma Center, where Dr. McNeer works as an anesthesiologist, performing airway procedures on patients who are brought in with serious and often life-threatening injuries.

“Sometimes, we have to intubate them because of the injuries they’ve sustained, not knowing if they’re COVID-19 positive or not,” he explained. “We’ve intubated patients who have subsequently been shown to have the virus. We’re trying to protect ourselves as much as possible. But it’s different than what a lot of the frontline caregivers are experiencing, where they know that a patient is COVID positive. In our situation, we have to prioritize. If a patient is febrile, we treat them

like they're COVID-19 positive."

A total of 50 intubation boxes will be fabricated, with the College of Engineering's Johnson & Johnson 3D Printing Center of Excellence Collaborative Laboratory donating additional acrylic to complete the construction phase.

"A lot of architects have skill sets that are valuable, knowing about 3D printing for one," Jarosz said. "Doctors can do a very good job describing what they need, but because of their clinical obligations, they aren't always able to make it. So, we've been able to contribute in that regard. It's been a very interesting collaboration—one I thought I'd never be in but am happy to be a part of."

As for the suction tube to be used in tandem with the intubation box, Jarosz worked with Dr. McNeer on a design that was more ergonomically friendly. Once the design is finalized, the tubes will be 3D printed in mass quantities at the School of Architecture.

"We're exploring some modifications so that we're able to perform the suctioning while staying out of the way of the person who is inserting the endotracheal tube," Dr. McNeer said. "And we want to make sure that we're better able to place it in the proper position before the intubation is attempted. The aerosol is generated once you start to look for the vocal cords. So, the actual suctioning has to be started before then."

The prototype suction tubes were incorporated into a series of experiments at the simulation hospital under controlled conditions, and the impact of the suction device in reducing

the aerosol exposure was carefully recorded. The work done by the multidisciplinary UM team will be presented for peer review in a scientific publication in the near future upon completion of the experiments.

The intubation box and use of periglottic suctioning, as it is formally called, are applicable not only to anesthesiologists, but to anyone in the medical field performing intubations, said Jeffrey Groom, Ph.D., professor of clinical and associate dean for Simulation Programs at SHARE, who participated in the simulations.

“From paramedics in the pre-hospital setting to emergency department personnel to physicians and nurses, as well as the anesthesia and ICU folks, it has implications across the health care setting,” said Dr. Groom, a former City of Miami paramedic for 12 years. “Beyond the current COVID-19 pandemic, the routine use of barrier boxes and periglottic suctioning should be considered for use with all endotracheal intubation procedures where there may be an exposure or infection risk.”

Nichole Crenshaw, D.N.P., A.P.R.N., assistant professor of clinical and director of the Acute Care Nurse Practitioner Program, who performed the mock intubation procedure at the nursing school, recognizes the critical need for health care workers to protect themselves as the pandemic continues to rage.

“Being a part of this project has been a way to make sure we’re all staying safe,” Crenshaw said. “There’s been a heightened sense of taking care of each other during this crisis. And, that’s what has stood out to me more than anything.”