

Yale students 3D-print a \$250 device for relieving the ventilator shortage

Ventilators are in astonishingly short supply. This \$250 device allows two patients to share the same ventilator.



Ventilators are in short supply all over the world, from the United States to [Africa](#). One concern is that this will lead desperate hospital workers to hook up multiple patients to one jury-rigged ventilator, which can be [dangerous](#), even if it may be better than no treatment at all.

Necessity breeds invention. A new startup born out of Yale has developed a device that allows one ventilator to treat two people, according to each patient's needs. It's the first device of its kind to receive emergency

authorization from the FDA. Called the Vent Multiplexor, the device is now being manufactured following just a few weeks of development and testing.



[Photo: Vent Multiplexor]

Developed by Brian Beitler and Tim Foldy-Porto, a pair of undergrad students at Yale, the 3D-printed device is being distributed by the new company Vent Multiplexor, LLC. It received the FDA's nod of approval after successfully co-ventilating two critically ill COVID-19 patients at the Yale New Haven Hospital. "It was a race against time," says Todd Higgins, president at Vent Multiplexor, of the rapid product development.

Ventilators have traditionally been designed for single patients, which makes some sense for a device that's calibrated to breathe air into one person's lungs. Ventilators are also expensive, costing [upward of \\$50,000](#). That's why

even major city hospitals tend to have just a few dozen ventilators. But in emergency settings, a few dozen ventilators won't cut it. So doctors and medical organizations have experimented with modifying a ventilator to treat two or more people. The nonprofit health organization Prisma Health received emergency FDA approval on a system called the VESper, which splits one ventilator to as many as four patients. The Presbyterian/Columbia University Irving Medical Center [began doubling up patients last month](#) and [shared a protocol to do so](#), following a YouTube video [posted by Dr. Charlene Babcock](#), a physician at Ascension St. John Hospital in Detroit, which outlined how simple tubing could retrofit a ventilator to work for multiple people at once. This work was based upon some [previous research](#) that proved it was possible.

But these modifications haven't been ideal. As Peter Kahn, Hospital Resident at Yale and Medical Director for Vent Multiplexor LLC explains, using a T- or Y-shaped adapter to share a ventilator as they do in the above scenarios is the same technology that lets you split the flow of a standard garden hose. That means both patients have to be on the exact same settings on the ventilator, which means they needed to be matched up by the severity of their symptoms. Of course, lung capacities and recovery times differ, and treatment needs to be tweaked from patient to patient over time. Another concern is that sharing a ventilator could cause two people to share breathed viruses and bacteria. Even if both patients already have COVID-19, there are all sorts of other infections that could be shared between two vulnerable patients.



[Photo: Vent Multiplexor]

The Vent Multiplexor is designed to fix these shortcomings. It's connected outside a ventilator. It contains four, one-way valves to control air flow in a circuit. These valves can be adjusted manually at any time to allow two patients to be on the same ventilator with different settings. And in case there is a failure in these valves, and the two patients end up breathing shared backflow air, high-efficiency filters trap many contaminants.

The price of the multiplexer is \$250—nearly inconsequential compared to the price of a ventilator itself. The system can be installed in minutes, according to the company, and it is being marketed as a disposable product. Once a pair of patients is done with the ventilator, the multiplexer is meant to be thrown out—even though the company agrees that, in theory, it could be sterilized between patients and used again. "When you combine it with the modest cost versus the alternative of acquiring more ventilators, this is a low-enough cost item that just using it as a one time and not having to worry

about putting it through sterilization process again [makes sense]," argues Higgins. "There was only so much we could speak to accomplish in the timeline."

The device is 3D-printed, in part because that allowed the company to rapidly prototype the multiplexor, and in part because it makes producing it quick and flexible—the company doesn't need to spend time with injection molding and other industrial tooling that takes time to ramp up.

But 3D printing raises another set of questions: Should the company consider licensing the design for others to manufacture, or even sharing the design freely to any hospital or agency that needs it during this pandemic? Does this startup have an ethical mandate given the circumstances to set the business plan aside and help people by sharing its patent-pending plans without the promise of compensation at all? "I don't think we've ruled it out," says Higgins. "It's the right question we all struggle with, which is why the price is . . . very modest. . . . There's not a significant profit." And at Yale, the company has supplied the multiplexors at cost.

Long term, the team believes that there's not as much money in these adapters, anyway, but in creating licensing partnerships with ventilator manufacturers to improve their products. "Ventilators should really be made with the emergency capacity to be split," says Higgins. "But that's almost for another day. The reason we did this [now] was to save lives."