



Modern medicine has saved war veterans with horrific genital injuries from dying. Now it's finally giving them hope of a normal life as well. ay almost missed it, the message that would change his life. On a Saturday in March 2018, just as he was about to take his dog for an afternoon walk, he pulled his phone from his pocket and discovered a string of voicemails. Eight years had passed since the bomb had blown up underneath him while he was on patrol in Afghanistan, five since he'd first met his doctor. He'd been on the waiting list a year. He was getting impatient.

He dialed back. This is it, he thought. It has to be.

A nurse picked up. Ray needed to come to the hospital immediately, she said. They had a donor. He was getting a new penis.

Ray had carried his unseen injury for years—always furtive, always anxious, always wondering how anyone who found out might react. Having lost both legs in the blast didn't bother him that much; Ray often left the house in the summertime wearing shorts, his prosthetics shining in the sun. But his other injury? Aside from his parents, hardly anyone knew—not even the guys he went to war with.

For men like Ray who lose their genitals, the usual treatment—if there was any—was phalloplasty: a rolled tube of tissue, blood vessels, and nerves taken from the forearm or thigh and transplanted to the groin, an ersatz penis that needs an external pump to get erect. When he first met with plastic surgeon Richard Redett, an expert in genital reconstruction at Johns Hopkins Hospital in Baltimore, phalloplasty was what he was offered. But soon after, Redett decided Ray could be a candidate for one of the world's first full penis transplants. Not a crude substitute; the real thing.

"This was actually something that could fix me," says Ray. "I could go back to being normal again."

PENIS TRANSPLANTATION IS a radical frontier of modern medicine: extremely rare, expensive, and difficult to perform. Replacing a major organ like a damaged liver is one thing: it contains just one type of tissue. But grafting a penis from a deceased donor onto a living recipient is a chaotic amalgamation that entails stitching millimeters-wide blood vessels and nerves with minuscule sutures.

In 2013, when Ray first went to Johns Hopkins, there was no precedent for such a transplant. Since then, only four patients have had one.

South African urologist Andre Van der Merwe completed the first-ever successful transplant in 2014, sewing a donor penis onto a 21-year-old whose own had turned gangrenous after a grisly circumcision. In 2016, doctors at Massachusetts General Hospital transplanted a donor organ onto 64-year-old Thomas Manning, who had lost his penis to cancer. A year later, Van der Merwe and his team at Tygerberg Academic Hospital in Cape Town repeated their procedure on a 41-year-old victim of another circumcision gone wrong. Ray became patient number four.

After getting off the phone with the nurse that Saturday afternoon, he went into action. With military precision, Ray called his parents, packed the items he would need, boarded his dog, and made his way to the hospital. He checked in, as requested, at 1:30 on Sunday morning. At 2 a.m. Monday, he lay anesthetized on an operating table. And 14 hours after that, Redett and his team had completed the procedure. It was the most extensive penis transplant ever performed, and the first for a military veteran anywhere in the world.

RAY HAD BEEN a US Navy corpsman trudging through Afghanistan when Taliban fighters ambushed his squad in 2010. As he rushed to give first aid to a downed soldier, he stepped on a roadside bomb.

"I remember everything froze and I was upside down," he says. "I remember thinking a quick thought: 'This isn't good.' And then I was on my back."

The butcher's bill was steep: both of his legs up to and including the thigh were blasted off, along with his penis, his scrotum, and an upside-down-U-shaped chunk of his abdominal wall. Only a handful of people know the full extent of his injuries.

Two years later, while he was learning to walk on prosthetic legs, his urologist at Walter Reed National Military Medical Center referred him to the reconstructive surgery group at Johns Hopkins.

At the time, Hopkins was a leader in vascularized composite allotransplantation, more commonly called VCA surgery. It's used in face, hand, arm—and penis—transplants, taking multiple types of tissue from a donor and hooking up blood vessels and nerves so they work for the recipient. In December 2012, Hopkins surgeons completed their first bilateral arm transplant, on an infantryman who had lost both his arms and legs to a road-side bomb. If anyone could help Ray, it was these surgeons.

At their first meeting, Redett talked about phalloplasty, which didn't excite Ray much. He resolved to go through with it, thinking it was the only choice. Yet Redett soon changed course, deciding that Ray

Johns Hopkins surgeon Richard Redett first suggested phalloplasty before realizing Ray made a good transplant candidate.

was a better candidate for a transplant.

In fact, it was probably the only surgical fix given the extent of the damage. Van der Merwe calls Ray's procedure "the most complex to date," largely because of the scope of his injury. To repair it, Hopkins doctors didn't just transplant the penis itself. They also transplanted the donor's scrotum and extensive amounts of tissue from the thigh and lower abdomen.



"When I heard they wanted to do it, I felt this huge sigh of relief," says Ray.

"For him, it was almost either you do this transplant, or you live the rest of your life with your defect," Redett says.

RAY, WHO IS now in his mid-30s, is a thin man of average height, with touches of gray in his beard and a wobbly gait, a result of the prosthetics he now calls his legs. He hasn't discussed his surgery since April 2018, when he gave a short interview to the New York Times. But this March, one year after his surgery, he agreed to talk to me so long as MIT Technology Review protected his identity. (His name has been changed in this article.) He did so, he says, because he wants other veterans to know about their options.

And many others are affected. A total of 1,367 American infantrymen sustained significant genital injuries in Iraq and Afghanistan between 2001 and 2013. Such hidden wounds of war represent a relatively new problem. Bombs from below used to be a death sentence, but better body armor and modern casualty care ensure that more wounded soldiers survive—and more of them with devastating genital-urinary trauma. In a report last year, military urologists wrote that groin injuries have increased "to a level never before reported in the history of war."

The US Department of Defense recognized the problem as long ago as 2008, when it set up an institute to research various reconstructive transplants. Eventually, the TOUGH Project—Trauma Outcomes and Urogenital Health—placed a figure on it: among infantrymen with genital-urinary injuries from Iraq and Afghanistan, 502 were injured so severely that a penis transplant might be their only recourse.

Quantifying the number of such injuries is easy. Outlining the psychological toll they take on guys in their 20s and 30s is much harder.

Even those closest to the trauma, like Timothy Tausch, have to use anecdotes to explain. He's an Army lieutenant colonel and director of trauma and male reconstructive urology at Walter Reed. "As soon as they wake up, they're not asking about where their legs are," he says. "They're asking where the testicles and the penis are. You can't put a number on how significantly this affects one of these wounded warriors' lives."

Yet some experts wonder if the procedure is really necessary. Kidney and heart transplants save lives, but someone who lost a penis isn't going to die without a new one. Getting one may even be inviting a different set of psychological issues. (It bears mentioning that a poorly documented transplant attempt happened in 2006 in China, but the 44-year-old recipient apparently demanded reversal after his wife panicked, shocked at the idea he had someone else's penis.) In the months following Ray's surgery, Hiten Patel, a chief resident at the Johns Hopkins Brady Urological Institute, wrote that a penis transplant "lacks both life-saving and life-enhancing properties when compared to a readily available alternative in phalloplasty."

Others argue that for young men devastated by their wounds a transplant is, in fact, both life-saving and life-enhancing. Suicide risk among US veterans is already high: one study found that those deployed between 2001 and 2007 were 41% more likely to take their lives than civilians. Ray himself entertained thoughts of suicide after his injury. The idea gradually faded once he realized he could have gone to war and died; instead he was alive, on the first step of a long climb back.

"Even though we do a pretty good job with phalloplasty reconstruction, it's still a quantum leap to put on a real penis," says Curtis Cetrulo, one of the surgeons who operated on Thomas Manning in 2016. Phalloplasty recipients, for example, may regain some erotic sensation, but they must use a pump to achieve an erection or have intercourse.

Ray wouldn't say the transplant saved his life, exactly, but it has improved it.

"This surgery was a way for me to overcome that little subconscious voice or whatever it was that would always keep me feeling different from everyone else," he says. "It was one of those injuries that really stresses you out and you think, 'Why would I keep going?' I guess I always just kept this real hope that there's an answer out there."

SEVERAL HOURS BEFORE the hospital contacted Ray, Richard Redett had received a phone call of his own. He had gotten it enough times before to know the words by heart: *We may have a donor.*

Usually such calls were dead ends: the potential transplant almost never met Redett's strict criteria. For Ray's surgery to stand a chance, the donor had to be a young, healthy guy; the organ had to be a good color match and average in size; and, crucially, it had to be no more than two hours away, so that once it had been removed from the donor's brain-dead but still living body, it could be brought to Johns Hopkins before it started decaying.

"If you do an arm transplant, we know exactly how long that will hold up on ice. But nobody really knows that for a penis," he says.

This particular call on that Saturday in March was more promising. There was a brain-dead patient nearby who was donating his organs, including his penis. Over a rapid string of conversations, Redett evaluated the patient's medical history and determined when his team could get there. By the afternoon, Redett knew he had his donor.

Still, no doctor had ever worked with a graft as large as the one Ray required. To transplant a penis, you need the two dorsal arteries and the two dorsal veins from the donor. Fortunately, Ray's two penis nerves were intact. But to transplant the abdominal wall and scrotum, even more veins are necessary. Fail to take those, and the new scrotum and abdominal tissue will die, along with much of the skin of the penis.

Over five years, Redett and his team had deciphered the topography of penis transplantation with cadavers and food coloring. It was basically a grand perfusion experiment: inject dye into the blood vessels of a dead man, and watch for blush on the skin to know which vessels are required as part of the transplant. "We were injecting

every blood vessel we could find down in the region with blue and red food color," he says. "We just needed to know which vessels, and we needed to get very quick, very efficient, and very safe. We knew this had the potential to be a very long operation."

On the Sunday afternoon, his team boarded a chartered jet to meet their donor (the donor's identity and the state he's from can't be disclosed). At 6 p.m., they entered the procurement room. Other doctors and medical staff, 25 in all, were there grabbing solid organs: lungs, heart, kidneys, liver. It's a bloody choreography, finding your place in an organ procurement. Redett and his team sliced into and isolated the lower abdominal wall, thigh tissue, scrotum, and penis, dissected out the requisite arteries and veins, and let the other doctors take what organs they needed before finishing.

Once they had removed and packed Ray's graft, nothing else mattered except speed. Bodily tissue begins to break down the instant it's deprived of blood. If enough toxins are released, the tissue can swell so much it asphyxiates. It's why you throw transplants on ice, as Redett's crew did for their Learjet flight back to Baltimore—it delays the breakdown process.

It's also why surgeons train, practice, and visualize their maneuvers. Redett's team had already run dry rehearsals of their procedure. In the operating room, they had set up the table where Ray would lie, figured out where the ice machine went, placed the optical microscope Redett would use, and even tested every power outlet to make sure they wouldn't short a circuit.

As the team ate snacks from their go-bags on the plane back to Hopkins, other surgeons wheeled Ray into the operating theater. By this time it was 11 p.m. on Sunday, almost 24 hours after he had arrived at the hospital. They prepared him by removing all the diseased tissue and exposing the blood vessels, nerves, urethra, and penile stump. At 2 a.m. Monday, Redett and his fellow surgeons took their places—some standing above Ray, the rest tending to the graft at another table—and steeled themselves. The gravity of his mission consumed Redett's thoughts.

"I remember

everything froze

"We felt very confident we could do it, but we had never done it," he says. "If you're not anxious for something like that, you're not thinking hard enough."

In the Johns Hopkins operating room, a surgical microscope with a craned neck like a brachiosaurus magnified the view by up to 20 times, enabling Redett to see the very tip of the needle-point instruments that hold the sutures for stitching together vessels barely two millimeters thick.

"The threads are smaller than a human hair," he says. "Unless you're under a 'scope, you can't really even see it."

They began by sewing Ray's urethra onto the donor's. Then came the arteries and veins that bring blood to the skin of the abdominal wall, scrotum, and penis shaft. Next they sutured Ray's penile nerves, which were buried deep underneath his pelvic bone, to the nerves of the donor penis. Finally, Redett's team stitched together the skin.

"You know how to do it, but until that last blood vessel is hooked up and you release the clamps and blood flows through it—I mean, that's a huge sigh of relief," says Redett.

A kidney transplant usually takes three hours. The first penis transplant surgery in 2014 took nine. Redett's team needed an additional five hours to complete Ray's transplant. In a surgery that long, doctors are allowed to take bathroom breaks, and even slug some coffee. Redett did neither.

RAY'S FIRST MEMORY after he came out of the anesthesia was the heat. His room was warm to help keep his transplant at body temperature. It wasn't until two days later that Ray looked down and saw his new penis for the first time.

"It was swollen and still had a lot of healing to do," he says. "In the back of your mind, you know this is a transplant, and you wonder if it's going to be too much for you to handle. Once I went through with the surgery, all of those concerns just went away."

The surgery wasn't just technically complex; it also required weighing various ethical questions. For example: if they were giving Ray a scrotum, should they give him testicles too? The answer was no: transferring sperm-generating tissue might have made it possible for Ray to have the donor's genetic kids. (In the end, the donor had not given consent to use his sperm.)

Another matter was the prospect of lifelong immunosuppression. In penis transplant surgeries, it's critical: Van der Merwe had to cut off half of the penis he transplanted in 2014 because the patient stopped taking his medication and rejection set in.

The team came up with a novel answer to this problem. In a procedure spearheaded by Gerald Brandacher, scientific director of the reconstructive transplantation program at the Johns Hopkins School of Medicine, bone marrow and stem cells from the donor's vertebral bones were isolated in the lab. Two weeks after his transplant, Ray was injected with a large amount of the donor's bone marrow cells.

In organ transplants of any type, recipients are typically given a cocktail of immunosuppressant drugs every day. Ray, on the other hand, requires just one pill.

"It's kind of like reeducating the immune system," says Brandacher. "It allows us to minimize the need for immunosuppression but not completely stop it."

Minimizing the drugs needed after a transplant, in fact, may be what really got the US military interested in surgery like Ray's. Immunosuppressants ensure that the body doesn't attack a new organ, but they also weaken the immune system and can lead to toxic complications like kidney failure. For a heart or lung, the trade-off is obvious: immune problems versus death. For a penis, the question is more muddled.

"If we can get to a point where we have therapy that doesn't require that level of toxicity, the calculus changes completely," says Lloyd Rose, a former program manager for rehabilitative medicine research in the US Army. "Then a transplant can become a surgery for anybody who's missing a hand or a foot or a face or a penis—or anything."

If vets with transplants have to take fewer pills, it means fewer complications as they get older, and an easier life. It also saves the government money in the long term. The issue is so important to the military

that the \$12 million Congress appropriates each year for the Armed Forces Institute of Regenerative Medicine is now spent primarily on immunosuppressive research—not on paying for things like penis transplants.

ON A HOT afternoon last April, a year after his surgery, I met Ray for the first time. He balanced his modest frame on his partmetal, part-polymer prosthetic legs, and in his left hand he carried a cane. Even with the support, he picked his way gingerly along the sidewalks until we made our way over to a public bench near a coffee shop.

"When I got hurt, one thing I did realize is that the world is not designed for a guy like me, being blown up," he told me matter-of-factly. "I knew then I would have to change myself to fit the world."

While he doesn't hide his prosthetics—when we met, he wore gym shorts—his unseen injury still causes him some consternation. It's not that he hasn't accepted his new penis. On the contrary, Ray doesn't seem to think about it as a donor organ at all. It's just that so few people know what happened to him, and he's not quite ready, and may never be ready, to identify himself.

"It may not necessarily be that people are going to say bad things about it," he says. "But it's just one of those things. It's a private thing."

Still, those around him recognized a change. A close friend of Ray's, one of the few who know, says she noticed "a little boost" following the procedure. "It was such a profound wound, there was a no-light-at-the-end-of-the-tunnel kind of feeling," she says. "Now he's much more confident ... It's this feeling of being whole again."

In some ways, Ray is still figuring out how his transplanted organ will shape the contours of his life. He's not dating at the moment, and knowing that he can't be a biological father, he wonders if that will deter women who may want to start a family.

In other ways, the surgery has made a huge difference to his daily emotional state. He's more outgoing, less afraid to meet new people, and more fit, mentally and physically, piecing back together a life interrupted. Important questions—such

as whether he's able to pee standing up (he can), whether he gets erections (he does)—already have answers.

"He told me, which was the best news I could hear, that it feels normal," says Redett.

It took six months before the nerves of his transplanted penis started firing. Stitching nerves together isn't like splicing

"The world is not designed for a guy like me," says Ray.

a wire; a nerve cell's axons, the long threads along which impulses are sent from one cell to another, have to grow all the way out to the organ they're supplying. Now, more than a year removed from surgery, those nerve signals have grown only stronger. "I'm still getting sensation back. It's pretty close," Ray says. "This is not going to be a quick fix, but I've seen improvement over time."

Where penis transplant surgery for wounded veterans goes is still up in the air. South Africa's Van der Merwe, the originator of the transplant, says the VCA procedure itself is now proven; its future depends on other matters. There's the problem of who pays, and of finding appropriate donors. And then there's the immunosuppression issue that the military is trying to solve.

"The risks of immunosuppression in many people's minds also outweigh the benefit of doing an arm, or a face, or a genital transplant," Redett says. "We disagree, but that will slow down progress."

Ray barely blinked when I asked him some of these questions at our second meeting, in July. Dealing with immunosuppression, he says, is easy: he takes a pill and washes his hands frequently. Guys who need it and can handle it, he says, should get a transplant. He feels no ambivalence about that phone call, when doctors told him they were ready to sew on the donor penis for which he had waited five years.

"I don't regret it," Ray says. "It was one of the best decisions I ever made."

Andrew Zaleski, a writer based near Washington, DC, covers science, technology, and business. "I don't regret it. It was one of the best decisions I ever made."