THE Edge OF MEDICINE

Ryder Trauma Center in Miami exploits the latest in training and technology to treat patients on the brink of death.

BY **KATHLEEN McAULIFFE**
PHOTOGRAPHY BY **COLBY KATZ**

Ten p.m. at Ryder Trauma Center in Miami: A gunshot victim in his late twenties has just been cut open from sternum to groin, exposing glistening organs that quiver and pulse. The attending physician, Fahim Habib, and two surgeons in training—a fellow and a resident—are using powerful retractors to pry apart the giant incision. Then four, five, even six hands at a time reach in and begin probing for the source of the bleeding. Soon the man's gut is piled on top of his body like a mound of spaghetti. Working side by side, the fellow and the resident begin gently unraveling the intestine, inspecting it for damage a foot at a time. "Clear!" they call out again and again. Thirty-one feet later, they get to the large intestine, and finally, the bladder. A small incision is made in the organ. Instantly it begins disgorging blood. Habib plunges a fin-

A drill on the helipad at Ryder Trauma Center.

His arm crushed in a car crash, Leonard Sanchez is prepared for follow-up surgery after an on-site amputation by David Shatz, a surgeon at the Ryder center.

ger deep inside it and feels around. The gushing, he determines, is coming from the neck of the bladder. A plan is hatched to stanch the bleeding, and three hours later, the operation ends successfully. Habib's work, however, has just begun. Before the night is over, he will go on to treat another gunshot victim as well as four people battered in car crashes.

Founded in 1992, Ryder is one of the country's oldest and busiest critical care facilities; about 4,000 people come through its doors each year. But Ryder physicians do far more than local emergency trauma care. They train all Army forward surgical teams for deployment in Iraq and Afghanistan. They are developing better methods of triage and making improvements in surgical techniques. The center has even been a prime mover—through its extensive exposure to auto injuries—in enhancing automobile safety and expediting treatment of crash victims. It is also a pioneer in the development of trauma telemedicine, the pairing of robots and advanced telecommunications technology to extend the expertise of its specialists around the globe. Small wonder the institution is viewed as a trendsetter and a paragon of care in the field.

Located at the University of Miami/Jackson Memorial Medical Center, Ryder is one of only three freestanding facilities in the United States designed from the ground up as a trauma center, making it a model of streamlined efficiency. Housed within the structure is everything needed to do the job: resuscitation bays, operating rooms, CT scanners, an intensive care unit, a burn unit, and a rehabilitation department. On the building's roof is a helipad (40 percent of its patients come by air). Ryder owes much of its success to the fact that Florida was among the first states to have a coordinated 911 system and was at the forefront of setting up regionalized networks for transporting patients quickly to hospitals with the equipment and expertise to treat their injuries. Florida invested heavily in both Ryder and in a community-based system of care—and it paid rich dividends. Trauma is the leading killer of people aged 1 to 44, and Florida's system has reduced preventable deaths from serious injury by half. Many other states have not made the same commitment (see page 65). In large swaths of the country, trauma care is quite literally in need of emergency resuscitation.

A man with an arrow in his head, a baby with a crushed skull, a teen with a knife plunged so deep in his belly only the handle is visible. A relentless onslaught of catastrophic injuries comes through Ryder, making it an ideal training ground for doctors preparing for both civilian medicine and the battlefield. In addition to having one of the largest fellowship programs in the country, Ryder is responsible for instructing military surgical teams made up of doctors, nurse-anesthetists, nurses, and technicians—20 people in each unit—before deployment overseas. Many team members have seen little in the way of severe injury beforehand, and it is the job of Lieutenant Colonel Donald Robinson to bring them up to speed in just two weeks. To that end, he relies heavily on a $200,000 mannequin that looks and behaves remarkably like a real patient. It breathes, urinates, oozes blood, and even cries out in pain. A microphone is

The beauty of these methods is that you don't have to draw blood or penetrate the body in any way.

embedded in its head, and Robinson himself provides some of the sound effects. "I groan, swear, and scream out things like 'Get away from me!'" he says. During training, the teams practice resuscitating the high-tech dummy, which can be programmed to mimic any number of dire casualties—for example, it may go into cardiac arrest or need a limb amputated. Thanks to these mock trials, Robinson says, the teams can rapidly progress to the core part of their training: assisting in the treatment of real patients.

Just as important as its teaching mission, Ryder invests huge resources in finding better methods of caring for trauma patients. A big concern, for example, is triage. As many as 40 percent of injured people flown in or rushed by ambulance to Ryder are discharged the same day they arrive. That's a clear indicator they never needed to be there in the first place. Conversely, others appear unscathed after an accident—and may even decline treatment, only to deteriorate rapidly 20 minutes later from an unsuspected internal injury.

To distinguish critical injuries from less serious ones, Ryder is harnessing a noninvasive method called near-infrared spectroscopy. In this technique, Kenneth Proctor, a professor of surgery and anesthesiology, employs a fiber-optic probe. When placed on the head or torso, the probe emits infrared light, which penetrates skin, muscle, and bone to about three-quarters of an inch. Because the underlying tissue reflects light differently depending on how well it is oxygenated, Proctor says, the probe can detect if oxygen levels are declining near the surface of the body. If someone is in shock from internal bleeding, the body shunts blood to the most critical organs—the heart and brain—while constricting blood flow to peripheral tissues. "The probe can tell us whether a patient is just shaken up or truly in physiological shock," Proctor says.

He and his colleagues are also refining a technique that measures variability in heart rate to get yet another read on just how hurt someone is. The strategy, which involves analyzing a patient's EKG signal, rests on an intriguing observation: Healthy people have more variable heart rates than sick individuals. The brain-dead fall at the extreme end of the spectrum; their hearts beat steady as a metronome. Thus the degree of heart-rate variability, or rather, invariability, provides a means of assessing a patient's level of shock.

Ryder is currently testing both near-infrared spectroscopy and heart-rate variability analysis. If either tool lives up to advance billing, Proctor says, they could eventually transform how EMS crews or battlefield medics do triage. "The beauty of these methods is that you don't have to draw blood or penetrate the body in any way," Proctor says. "This is *Star Trek* stuff—a person with minimal training could just press the device against the skin and, a few minutes later, get a readout that indicates this guy is very likely OK but this one needs urgent intervention."

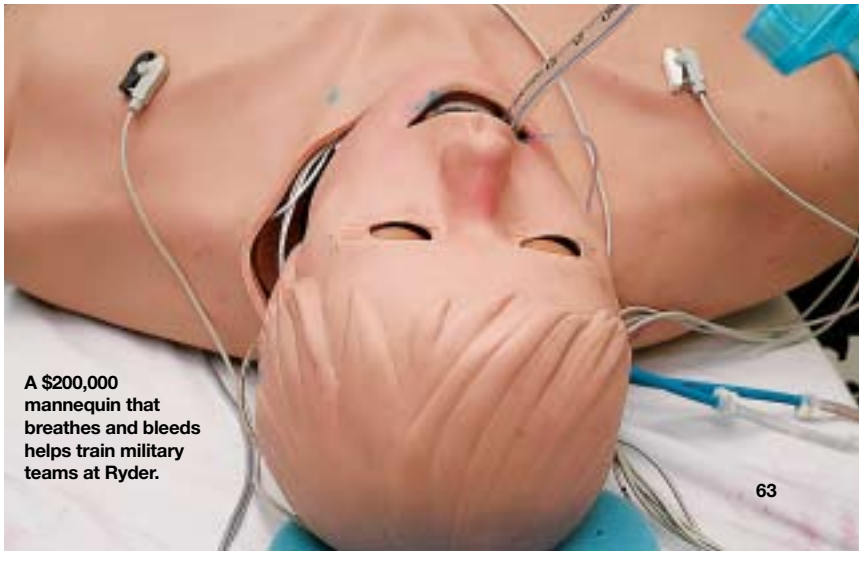
After triage comes therapy—and in this arena as well, doctors at Ryder are calling upon many new techniques. Borrowing a tool used in organ transplant operations, Ryder surgeons have pioneered a more aggressive approach to treating liver injuries, which rank among the most lethal problems they encounter. The transplant tool, called a Rochard retractor, hooks under the rib cage to lift it up like the hood of a car, providing surgeons unprecedented access to the organ.

Another medical advance in use at Ryder is factor VII, a new genetically engineered product that mimics a clotting agent normally found in blood. Given intravenously, factor VII is typically employed in the middle of surgery, when a trauma patient is at risk from profuse bleeding from many small capillaries. In no time, the floor may become drenched in the patient's blood.

That's when trauma surgeons reach for factor VII. It costs $15,000 per treatment, but 19-year-old Andrea Arevalo, who was injured in a 2004 car crash, is proof that it can save lives. Arevalo was on the verge of bleeding to death from a devastating liver laceration when she became one of the first patients at the center to receive factor VII. "They told me it was a miracle I survived," Arevalo says. Within minutes of treatment, her bleeding subsided.

Perhaps the biggest news of all in trauma medicine, however, does not relate to heroics in the operating theater. It is the surgery that Ryder is *not* doing that most excites its doctors. As recently as 10 years ago, a standard diagnostic procedure at the center was to insert a syringe into the belly; if blood came out with the fluid withdrawn, the patient would be rushed into the operating room and cut open. By then, however, the bleeding may have stopped on its own. Today, because ultrasound and CT images have improved so dramatically in detail and clarity, doctors often take a wait-and-see attitude with less serious injuries. "That's great for patients, who used to end up with incisions all over their body just to find out if they were injured," says Patricia Marie Byers, a Ryder surgeon and chairwoman of the American College of Surgeons committee on trauma care for Florida.

Radiotherapy—another stunning advance—combines diagnosis and treatment in one, further reducing the number of major surgeries to which patients must be subjected. "Say you were bleeding from your liver due to a gunshot wound," Byers says. "Not so long ago, I would have opened you up, split your liver in half, made it bleed more to find the artery that was damaged, and then sewn you



A $200,000 mannequin that breathes and bleeds helps train military teams at Ryder.

Ryder surgeon David Shatz works on a skin graft to cover the stump of the arm of Leonard Sanchez, who lost his limb in a car accident.

up." Now, she says, a radiologist will inject contrast dye, pinpoint the problem on an X-ray, and then snake a catheter through an artery to the site and seal it off by injecting a little gel foam. In this way, it is often possible to avoid major operations on critically ill patients—with all the complications and high risk of mortality that such procedures entail.

Ryder is also working on understanding the conditions that set the stage for traumatic injury in the first place. Because almost 70 percent of its patients are the victims of motor vehicle crashes, automobile safety is a major focus of study at the center. Under the guidance of Jeffrey Augenstein, a professor of surgery and director of the center, Ryder has been assembling a huge database that correlates injuries with the type of crash and the design of a vehicle. As a result, the center was the first to document that front air bags, which deploy at over 100 miles per hour, can kill small children in low-speed, otherwise survivable crashes. The same database has also revealed that drivers who wear a shoulder strap but neglect to wear a lap belt are at much higher risk of suffering a fatal liver injury.

Now, after years of collecting such data, Augenstein is working with the auto industry to create a new generation of cars equipped with "black boxes," much like those in airplanes, that will automatically convey information about the location and severity of a crash to an emergency dispatcher. His vision may sound far-fetched but it's already been partially realized in some recent car models that offer Advanced Automatic Crash Notification (AACN): When an air bag goes off, the car transmits key information, including the GPS coordinates of the crash, to a telematic provider, who calls 911. Examples of these systems include BMW's Assist, which Augenstein himself helped develop, and GM's OnStar.

For a preview of what the most advanced AACN systems on the market can do now, the recent experience of Mike Monticello, a 38-year-old writer for *Road & Track* magazine, is telling. Last May, he was a passenger during a test-drive of a new BMW luxury sedan when the driver misjudged a curve on a country road just outside Modesto, California. The car flew into a drainage ditch and flipped over several times before finally coming to rest upside down. Miraculously, Monticello had only bruises and minor abrasions, but the driver was unconscious and bleeding badly from the head. As Monticello struggled to help him, the voice of a woman came through the passenger door: "I understand you've been in an accident. Are you OK?" Far from being shocked by the disembodied voice, Monticello felt—in his own words—"immensely comforted." The telematic provider went on to assure him that an ambulance, a fire truck, and the highway patrol were already on the way. The upshot: The driver, who had a concussion and three vertebral fractures, got swift treatment and has made a good recovery. "We could have been in big trouble," Monticello says. "We were in a rural area where neither of our cell phones worked."

Given the concentration of talent under Ryder's roof, the institution is understandably trying to extend the reach of its experts around the globe. Toward that goal, the center is positioning itself at the vanguard of telemedicine—a field that merges telecommunications and robotic technology. According to Antonio Marttos, a young Brazilian surgeon who heads the initiative, the centerpiece in this plan is a $200,000 robot on wheels. It resembles a high-tech upright Hoover mounted with a monitor, video camera, and microphone for two-way communication. From anywhere in the world, the robot can be remotely operated by a doctor seated next to a laptop with a joystick plugged into one of its USB ports. The image on the laptop's screen portrays what the robot "sees" and the joystick controls the motion of its wheels and the angle of its camera. Funded by the military, Ryder is one of four trauma centers in the country involved in the project.

In the next few months, the Army intends to install these robots in a hospital in Landstuhl, Germany, where severely injured troops are transported for care before being ferried back to the United States. "A specialist could be seated in an office here, and using a laptop and joystick, do ICU rounds in Landstuhl," Marttos says. The Ryder-based doctor could even roll the robot down the hall to Landstuhl's operating room, he says, and give advice in real time about how to do a complicated surgery. Or here in the United States, telemedicine could offer rural hospitals far from any trauma center the same expertise. "Essentially," Marttos says, "it allows us to bring the eyes and ears of our specialists to any place that has the robot."

As telemedicine illustrates, the most essential ingredient of care is the people who provide it. Ryder is brimming with talented and devoted doctors, but one individual stands out. David Shatz belongs to a rare breed of trauma surgeon whose focus is EMS, or prehospital care. Shatz is a tall, easygoing man with an athletic build and the long, slender fingers of a piano player. He's also a thrill seeker who loves flying planes and helicopters. And he may be the only trauma surgeon in the country who has done amputations outside the sterile, optimal conditions of a hospital. Just weeks before my visit to Ryder, Shatz was called upon to do a roadside amputation right in Miami itself.

A cement truck had flipped over on one of the city's busiest high-

Shatz knew that every precious inch of the limb he could save would have a huge impact on the young man's recovery.

ways, pinning the right arm of 17-year-old Leonard Sanchez underneath it. "I know my arm is gone," Sanchez told the fire and rescue squads that arrived on the scene. "Just cut it off and get me out of here." After exhausting every option for extricating him, the squads came around to Sanchez's view, and 20 minutes later, Shatz was flown to the scene. Because it was impossible to get a clear view of the injury in the tight space of the wreckage, the surgeon faced the ultimate handicap: He'd have to do the amputation guided only by touch. "I'm reaching back there," he says, "and I'm thinking this feels like muscle, this feels like skin, this is a cord that might be a nerve or a blood vessel."

Just lopping off the arm at the shoulder would have been the easiest thing to do save the trapped teenager. But Shatz knew that every precious inch of the limb he could save would have a huge impact on the young man's ability to benefit later from a prosthesis. So as he crouched down on the ground to do the operation, he took care to cut as far down the arm as possible. Once the teenager was safely ferried back to Ryder, Shatz kept constant vigil over him, operating on Sanchez six days in a row to keep the stump as clean as possible. "An infection at that stage could have been deadly," Shatz explains.

The unstinting attention paid off. Not only did Sanchez live, but as this article goes to press, he is meeting with a prosthetic team to be fitted with a state-of-the-art artificial arm that responds to the nerves that activate muscles. "I've got high hopes for him," Shatz says. "Our prosthetic team just showed me a video of a high-arm amputee outfitted with a similar prosthesis and he was tying his shoes the next day." ■

Members of the U.S. Army trauma training program practice in a simulation of a patient injured in a motorcycle accident.

NOT ENOUGH CARE TO GO AROUND

While cutting tile last year, Jake Bleed sawed through the bone of his ring finger. The 31-year-old resident of North Little Rock, Arkansas, waited for about six hours at nearby Baptist Health Medical Center while the medical staff there called all over town—and ultimately as far away as Dallas and Memphis—to find a hand surgeon to reattach his finger. Finally, a willing surgeon was located in Louisville, Kentucky. But even though Bleed had insurance, he would have to hire a private plane to get himself there, at a cost of $4,300. In the end, he charged the cost to two credit cards, and his finger was saved. His insurer eventually reimbursed him for the cost of the plane, but his plight highlights the fact that trauma care in the United States is not only geographically arbitrary, but in many places, nonexistent.

Only eight states—New York, New Jersey, Maryland, Illinois, New Mexico, California, Oregon, and Washington—have fully functional, regionally coordinated trauma systems. The remaining states have partial systems, and 12—including Arkansas—have no trauma system at all.

Although President Bush has signed a bill authorizing $12 million to states for the purpose of bolstering trauma care systems, many on Capitol Hill are reluctant to set aside federal funds for a service they think should be paid for by states, says Wayne Meredith, medical director for trauma programs at the American College of Surgeons. Meanwhile, numerous state legislatures have also failed to find the dollars to support trauma systems. To aggravate matters, emergency care services are heavily utilized by the uninsured, placing a huge financial burden on the medical centers that serve them.

For the same reason, doctors, too, often go unpaid and are opting out of performing emergency care, worsening critical shortages of neurosurgeons, orthopedists, and hand surgeons—the very types of specialists Bleed needed at short notice.

Funding a trauma system doesn't take much. A half-penny sales tax in Miami-Dade County underwrites its outstanding system. In Arkansas alone, says J. Michael Gruenwald, a surgeon on the Arkansas governor's advisory council on trauma, it is estimated that a well-funded trauma system would prevent 200 to 600 deaths each year. If deficiencies were plugged across the nation, experts say, many thousands of lives each year could be saved. "You don't get much better return on your investment than that," Meredith says.