

# *The New Yorker*

## **HEART SURGERY, UNPLUGGED**

*Making the coronary bypass safer, cheaper, and easier*

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In an operating room at Boston's Beth Israel Deaconess Medical Center, a heart is being repaired. For the most part, the surgical team is following the standard steps of a coronary-bypass operation: the patient's breastbone is sawed through in a straight, vertical line, a steel retractor is inserted and ratcheted back to expose the chest cavity, and the bleeding edges of the incision are stanching with an electric cautery. With each dab of the cautery, there is a tiny wisp of smoke, which dissipates, and the smell of burning flesh, which does not. Then the pericardium, a fibrous sac that encases the heart, is slit open with a scalpel, and the heart itself, pulsating and slick, is exposed to view.

Billy Cohn, the attending surgeon, peers into the chest cavity. He runs his right index finger over the surface of the pulsating ventricle until he feels a gritty atherosclerotic deposit; though he has already consulted the coronary angiograms, surgery remains a tactile endeavor. "This is where we do the bypass," he says, in a deep Texas accent. He threads a couple of white elastic strands deep into the contracting muscle, to either side of a blocked vessel. These stitches will brace the diseased artery as the bypass graft is made. Cohn is preparing to do something that until recently would have been inconceivable—operate on a beating heart.

In a conventional bypass operation, the heart must be stopped for the duration, with the blood shunted into a heart-lung machine. As the name suggests, this machine has a dual function, and that's because the heart and the lungs work as a unit. The right chamber of the heart pumps blood to the lungs, where it receives oxygen and releases carbon dioxide; the blood returns from the lungs to the left side of the heart and is then pumped out through the aorta to the tissues. So when the heart is stopped in order for it to be operated on the lungs must be stopped, too. First, the heart-lung machine is filled with an electrolyte solution, to prime the pump; once the blood starts flowing into the machine, oxygen is percolated into it through sheets of porous plastic that work as surrogate lungs. As a further safeguard, the machine cools the blood to about eighty-two degrees Fahrenheit, so that, when the machine's forceful pump returns the cooled blood to the body, it lowers the body temperature and slows the metabolism of the tissues, lessening their need for oxygen. The heart itself is stopped by being flooded with ice-cold fluids that are rich in potassium, an ion that arrests muscle contraction. Only then does the bypass surgery proper—circumventing clogged vessels with a healthy graft—proceed. It's a complicated and laborious sequence—and one that Billy Cohn has managed to dispense with entirely.

Assisting at the operation is Ronald Weintraub, a senior surgeon and the former chief of cardiac surgery at the hospital. As Weintraub explained to me, there have been three generations of cardiac surgeons. First came the patriarchs—surgeons such as John Gibbon, at the Massachusetts General Hospital; John Kirklin, at the Mayo Clinic; Michael DeBakey, at Baylor; and C. Walton Lillehei, at the University of Minnesota. Their development of the heart-lung machine made modern open-heart surgery possible. Unlike the other vital organs, the heart is in constant, vigorous motion. Because performing delicate surgery on a pumping heart was considered to be impossible—like cutting a gemstone while you were on horseback—the major problem had been figuring out a safe way to arrest the heart during surgery. The second generation of heart surgeons (among whom Weintraub counts himself) refined the surgical techniques, improved the heart-lung machine, and created the modern intensive-care unit to coordinate the complex medical support that the procedure required. The surgeons of Billy Cohn’s generation—“the Nintendo generation,” in Weintraub’s phrase—are mostly in their thirties and forties, and they have made it their mission to come up with the techniques and the contraptions that will change heart surgery from a complex and expensive procedure to a simple matter of sawing, slicing, and sewing. They want to take the bypass operation out of intensive care.

Billy Cohn, a thirty-eight-year-old Texan with sandy-brown hair, took an unusual route to becoming a cardiac surgeon, as he explained to me over coffee in the cavernous glass-and-chrome atrium of the hospital’s outpatient center a few days before the operation. Growing up in Houston, he had been a poor student in elementary and secondary school, easily distracted and easily bored. “I was like a kid with A.D.D.,” he recounted with gesticulating hands and in rapid-fire speech. “But it’s like with every Jewish boy—your mother wants you to be a doctor.” In despair at his academic performance, his mother would leave newspaper clippings on the breakfast table about two famous home-town heart surgeons, Michael DeBakey and Denton Cooley. But Billy Cohn rarely read beyond the headlines. He wanted to be a rock star, and as an undergraduate at Oberlin he spent most of his time in a punk band playing bass guitar. “I had a wild two-tone hairdo—black with a white stripe down the middle,” he told me. “I looked like a skunk.” In his junior year of college, he realized he wasn’t going to make it as a rock star, and decided “to do something more” with his life. He got into Baylor Medical School, in Houston, which specializes in cardiac surgery, a field with a certain glamour of its own. In 1994, when Cohn was recruited by the Boston hospital, he set out to make his mark by figuring out a better way of doing the most common type of heart surgery, the coronary-artery bypass.

The coronary arteries—there are three principal ones—carry blood from the aorta over the surface of the heart. Their branches penetrate the heart and provide oxygen-rich blood to feed the pumping muscle. Blockage of the coronary arteries tends to occur in middle age as deposits of cholesterol, calcium, and cellular debris build up—a process called atherosclerosis. If the blockage is severe, not enough blood flows to the heart muscle, and it dies—resulting in a heart attack, or, in the medical jargon, an MI, for “myocardial infarct.” Surgery to restore coronary blood flow was first performed successfully in the sixties, and it has advanced considerably in the succeeding decades. Usually, a vessel called the saphenous vein is removed from the leg and grafted onto the coronary artery to

provide a detour around the atherosclerotic block. By now, heart surgeons have mastered the techniques of grafting and suturing, and for those patients who qualify for the operation success rates are excellent—greater than ninety-five per cent.

There remain, however, serious side effects and occasional deaths, most of which result not from surgery itself but from the heart-lung machine. The problems begin as the cooled blood flows over the machine's porous membranes: when oxygen bubbles into the blood, it "roughs up" the blood cells. The white cells, which serve to protect against infection, become less effective, and the rate of postoperative infection is relatively high. The roughed-up cells also release inflammatory substances, which irritate the lungs. The blood platelets are damaged by the artificial oxygenation, too, and the patient becomes prone to bleeding. More damage is caused by small clots—composed of blood fats, proteins, platelets, and clumped red blood cells—that form around the oxygen bubbles. When these clots are infused back into the patient, they may block capillaries in sensitive tissues, like those of the brain, the retina, and the lung. Patients on the heart-lung machine have a two-to-four-per-cent risk of stroke and a twenty-five-per-cent risk of transitory retinal damage. And from thirty to fifty per cent of patients will experience a syndrome Cohn calls "pump head," in which they suffer significant cognitive deficits: memory loss, inability to concentrate, difficulties in recognizing patterns, and an inability to perform basic calculations. Although the cognitive deficits usually subside over a period of weeks or months, they may delay recovery, and some physicians suspect that they contribute to the clinical depression that often afflicts patients after heart surgery. In addition, patients retain about twenty pounds of fluid as a result of the dilution of their blood in the machine and the trauma of surgery, and this excess fluid puts a further strain on the heart and the lungs. In fact, the very sick or the elderly have been considered ineligible for bypass surgery simply because they are too fragile to withstand the rigors of the heart-lung machine. The machine also involves considerable expense. An expert technician, called a perfusionist, has to be present in the O.R. to supervise the equipment. Fluids used to preserve the stopped heart, so that the muscle is not damaged, are costly. And patients may require a respirator to help them breathe for several days after the operation, and must be monitored in an intensive-care unit for as long as a week. The new generation of heart surgeons has set out to make the operation safer, cheaper, and available to just about everyone who might benefit from it.

Attempts to bypass the bypass machine started in earnest about ten years ago, when Steven Gundry, at the Loma Linda University School of Medicine, in California, devised a procedure of threading elastic bands through the heart muscle just under the diseased coronary artery to raise the vessel and allow a surgeon to cut into it even while the heart continued to pump. Though the results were promising, the artery would sometimes wiggle under the surgeon's knife, making the technique too difficult and unreliable for widespread adoption. Then, three years ago, a small group of surgeons—including Valavanur Subramanian, of the Lenox Hill Hospital, in New York, and James Fonger, then of Johns Hopkins, in Baltimore—tried again to operate on a beating heart, using a different technique. Cohn decided to look into it, and visited Johns Hopkins in March, 1996.

Instead of performing full open-heart surgery, Fonger made a small incision between the ribs, which meant that his technique could only be used for a single coronary artery on the front surface of the heart. Through the incision he passed a device that looked like a two-pronged salad fork. The forklike stabilizer would, as Cohn describes it, “ride with the heart muscle, like a cowboy on a bronco.” The surgeon had to follow its undulation as he made a stabbing cut 1.5 millimetres in diameter into the single coronary artery and then sewed a series of about a dozen stitches to make the graft.

“I saw that artery filled with baklava,” Billy Cohn told me, referring to the atherosclerotic sludge, “and when Dr. Fonger was able to get around it using the two-pronged tines, I said to myself, ‘Hot damn, this is great!’”

Cohn began doing single-artery bypasses using the two-pronged device inserted through a small incision in the chest. The results were promising, but he found the method technically demanding. Even with the device, it was hard to stitch and insure a tight graft. Furthermore, the approach could be used only for cases of a single diseased artery, on the front of the heart. In late April of 1996, while driving home after a trying day in the operating room, Cohn was seized by the notion that there must be a better instrument than the salad fork.

“I went straight to Stop & Shop,” he told me, “and bought myself a whole bunch of soup ladles.” Cohn is an amateur car mechanic and appliance repairman. In his basement, he maintains a cluttered metal shop, with vises, awls, a lathe, and a drill press. When he returned from the supermarket, he worked in his metal shop through the night, turning the soup end of the ladles into flat surfaces at different angles to the handle, and cutting a square hole into them. By holding the long handle, he figured, he might be able to press the flattened end against the diseased coronary artery and operate through a cutout window.

“After a few hours, I had something I thought might work,” Cohn recalled. He arrived early at the hospital the next morning and immediately went to the large animal lab. His prototypes were tried on dogs, pigs, and sheep. But he was not satisfied; there was still movement from the heart muscle. He returned to Stop & Shop for soup spoons and different kinds of ladles. After several attempts, he had something that worked well enough on animals to be tried on a human being.

As we sat together at the outpatient center, Cohn arrayed a series of long metal ladles on the table next to my coffee cup. Each handle ended not in the concave belly of a spoon but in a metal rectangle with a central window in it the size of a small postage stamp. Despite Ron Weintraub’s talk of a Nintendo generation, Cohn’s innovation was largely a matter of old-fashioned industrial arts.

In December of 1996, a patient gave Cohn his “informed consent” to be operated upon with a homemade instrument that had previously been tried only on animals. “There I was, in the operating room, trying it on the first human,” Cohn told me. “And it was gorgeous.”

Cohn began to use his modified ladles for all the off-pump cases, which had previously depended on the two-tined stabilizer—bypasses involving a single artery on the front of the heart. Catheterization studies were conducted after each surgery: dye was injected into the repaired arteries to make sure that the grafted detours were open and functioning. And at the end of every week Cohn returned to his basement metal shop to modify yet another ladle. “After eight months, I was happy with my last spoon,” he said. Soon he was confident enough to operate on patients with several blocked coronary arteries—classical “open-heart surgery,” where the breastbone is split to expose all the surfaces of the beating heart.

In mid-1997, a Cambridge-based company, Genzyme Surgical Products, became interested in the device. Billy Cohn had done a 3-D computer rendering of how it worked, and he gave his computer disk to executives of the company. He also invited them to observe how the stabilizer performed in the animal lab and in the O.R. The company decided to create a mold for a commercial model. The prototype used a long metal rod in place of the spoon’s handle. A firm plastic polymer was used to create the rectangular platform, and it was given a textured surface to help it grip the surface of the heart. The prototype was sent for testing to hospitals throughout the country, and surgeons who tried it responded enthusiastically. Sixty medical centers in the United States have now adopted the device.

The creation of the Cohn Cardiac Stabilizer (surgeons traditionally name their devices after themselves) was only part of the growing effort to change the character of open-heart surgery. Among the Cohn stabilizer’s competitors is an advanced version of the two-tined fork called an “octopus,” which uses tentacles fitted with a series of suckers that grip the heart muscle with a vacuum seal. Not surprisingly, there is intense rivalry among cardiac surgeons about the superiority of their own approaches. Nonsurgical efforts to deal with atherosclerosis are also being explored, such as injecting growth-promoting proteins into the sick coronaries to try to trigger the development of collateral vessels. Unfortunately, it can take months for collateral vessels to grow, and there’s still no way to insure that new vessel growth will deliver blood where it’s needed. So most serious heart problems remain in the hands of surgeons.

Look at this heart beating happily,” Billy Cohn says to his team in the operating room. Ron Weintraub mounts a long metal rod on a steel retractor that clamps on either side of the gaping chest cavity, and he lowers it to just millimetres above the beating heart, then fixes it in place by tightening a knob on the retractor. Now Cohn takes a plastic stabilizer and connects it to the bottom of the rod, deftly adjusting its rectangular aperture so that it sits over the atherosclerotic artery. He checks that the two bracing sutures he had earlier passed through the heart muscle are tight under the diseased artery. Then he ties them around the plastic rectangle, fastening it firmly onto the surface of the heart. The rod is now anchored rigidly to the retractor, and helps keep the plastic stabilizer immobile. Even as the rest of the heart thrashes away in the exposed cavity, the Cohn stabilizer has grabbed on to one small area and is holding it steady.

Cohn stops to glance at the cardiac monitor. “Look at how well he’s doing,” he says. The monitor indicates a blood pressure of 138/75, a heart rate of 50, and a robust cardiac

output of 5.5 litres. But the cardiogram is flat. “We lose the EKG when the heart is lifted and manipulated outside the chest,” Cohn goes on. “But we’re not really flying blind, because of the vital signs—blood pressure, heart rate, cardiac output. They’re rock stable, just as that ol’ heart keeps beating away.”

The nurse shows Cohn a segment of the saphenous vein that was dissected from the man’s left leg. “Man, that is one beautiful vein—a blue-plate special,” Cohn observes. He slowly moves his right hand, guiding a sharp knife he calls “the stabber” to the spot that he identified earlier with his index finger, and punctures the diseased coronary artery. There’s a burst of bright-red arterial blood and Cohn tightens the sutures so that the stabilizer presses down as a tourniquet and stops the flow; he will be finished before the impeded flow can cause any damage to the heart muscle.

“We can readily sew to that,” he says, pointing to the artery that protrudes from the window of the plastic stabilizer. The saphenous vein—marked with blue stripes to make sure that it isn’t twisted—dangles like a painted earthworm as Weintraub lowers it onto the stabilizer. The nurse adjusts seven beams of light overhead so that they converge on the operative field. Working through magnifying loupes like those used by a jeweller, Cohn begins to suture one end of the saphenous vein to the hole he has just made in the coronary artery. The needle and the thread, as thin as a single hair, are hardly visible.

“See how stable it is?” Cohn asks. “I get to pick my stitches and see if I like them.”

The thick, striated fibres of the rest of the heart pulsate, its glistening surface moving within an inch of Cohn’s sewing hand, but he takes no notice of it. After about fifteen minutes, the vein is fully sewn, “heel to toe.”

“That’s it,” Weintraub announces. He removes the two sutures that anchor the plastic stabilizer to the heart, and the grafted vein is visibly pulsing and filled with arterial blood. “Billy’s a third of the way there,” Weintraub adds. That is, two more vessels are blocked and will need to be bypassed. I was invited to observe this operation because it’s a particularly difficult one: the patient, a sixty-two-year-old retired gardener from the suburbs, has *situs inversus*, a congenital condition in which the organs are arranged in mirror image, so that his heart sits in the right side of his chest rather than the left.

“I didn’t have to switch my hands or use mirrors to do this case, now, did I?” Cohn asks, looking pleased. “I only needed to flip my brain right to left.” For a moment, he stands back and views his work with unabashed satisfaction. I move behind a sterile barrier and observe the patient’s face. It is peaceful and ruddy, as if he were napping. The lead surgeon chooses the music in the operating room. Ron Weintraub always plays classical, but Billy Cohn has a rock station on. Even the fevered wail of the singer doesn’t diminish the controlled calm in the room.

Cohn runs his gloved index finger along the second coronary, verifying where its obstruction lies and where another segment of the saphenous vein will have to be grafted around it. The rod and stabilizer are swivelled over the site. Cohn makes the stabbing cut and then works with steady strokes, but after completing half of the connection he decides that the last stitch wasn’t quite what he wanted. “When in doubt, take it out,” he

announces, in his distinctive drawl. Every few minutes, he glances at the cardiac monitor to check that the blood pressure, the heart rate, and the cardiac output are stable. By noon, the operation is over. Three diseased coronary arteries, including one on the underside of the heart, have been bypassed.

Billy Cohn has achieved outstanding results using his stabilizer, but such results are not restricted to the inventor or to his own device. At a conference on “minimally invasive cardiac surgery” held in New Orleans in January just a year ago, Valavanur Subramanian reported on over a thousand patients who had had off-pump bypass surgery performed with a variety of instruments. More than ninety-five per cent of the grafts functioned, and there were significantly fewer complications than there were with traditional heart-lung bypasses. These patients had a smaller incidence of respiratory dysfunction, stroke, retinal bleeding, cognitive problems, and wound infection. The savings in expense were striking, too. The University of Pittsburgh reported that the average postsurgical length of stay was 2.5 days among two hundred patients done off-pump compared with a six-day length of stay for pump patients. The average cost of an off-pump operation was less than thirteen thousand dollars; the comparable bypass was more than twenty-one thousand dollars. (In addition to obviating the need for the heart-lung machine and the perfusionist, off-pump operations required less I.C.U. time and fewer blood tests, as well as the shorter hospital stay all told.) Robert Marquis, a senior perfusionist who operates the heart-lung machine at the Beth Israel Deaconess Medical Center, told me, “Billy Cohn may put me out of business for coronary surgery. But it’s O.K. when you see the difference for the patient.”

Several hours after the operation, I visited the gardener, and found him propped up in bed, talking with his family. I began to review the course that brought him to surgery. “It was in 1987 that you had the first symptoms,” I said. He politely corrected me: the first symptoms actually occurred in the late summer of 1986. He then recounted in great detail the two heart attacks that had forced him to give up heavy outdoor labor around his town. It turned out that I had lived in the same working-class suburb some four years earlier. We talked about the local geography, and he confirmed my memory of intersecting streets and told me which shops had survived the invasion of large national chains.

“Incredible, isn’t it?” Philip Devine, the surgical-I.C.U. fellow, observed later. “He has no pump head at all. These guys come up after beating-heart surgery as clear as a bell. No fluid overload, and platelets O.K., white cells happy.” Devine said he expected that the gardener would be up and walking some twelve hours after surgery and sent home within three days.

The next day, Billy Cohn, with hand-tooled black-leather cowboy boots and a broad gait, strutted through the hospital’s outpatient center to meet me and talk about the case. He had done two more off-pump cases since the gardener’s. I remarked on how smoothly that one went.

“You can get a precision stitch, same as when the heart is stopped,” he said, and then he cautioned that there is “a learning curve” for all heart surgeons. “We are like craftsmen in a medieval guild. Everyone begins as an apprentice, learning for years from a master

each detail of the art—down to the exact style of his stitch.” As Cohn acknowledges, most older coronary-artery surgeons are unlikely to give up the heart-lung machine. It’s hard for them to master a whole new technique. Besides, the results of most standard bypass operations are excellent. Nor has there been any long-term follow-up on the beneficiaries of off-pump surgery. But each month about a dozen younger cardiac surgeons from around the country come to Boston to learn from Billy Cohn. Using pigs, he instructs them in the manipulation of the customized metal retractor, the adjustable rod, and the plastic stabilizer. About a hundred heart surgeons have been trained so far.

Unlike the heart-lung machine, the stabilizer Cohn devised is no technological marvel; it’s just an unprepossessing piece of plastic. A number of the young surgeons are undoubtedly wondering whether they can’t design a better one. And Cohn freely admits that “the jury is still out” on which instruments will ultimately prevail, and that although he is “happy” with his stabilizer, he thinks there is room for improvement. “Generation Two is being tooled in my basement, Generation Three is on the computer, and Generation Four is in the back of my head,” he says. But he’s certain that a change in the default method of heart surgery is just a matter of time. “To stop the heart in order to sew on its outside—and that is where the coronary arteries are, right smack on the surface—is simply barbaric,” he says. “You’ll see. Over the next decade, nearly all coronary surgery will be done on a beating heart. I want to make it so anybody who can throw a stitch can do it.”