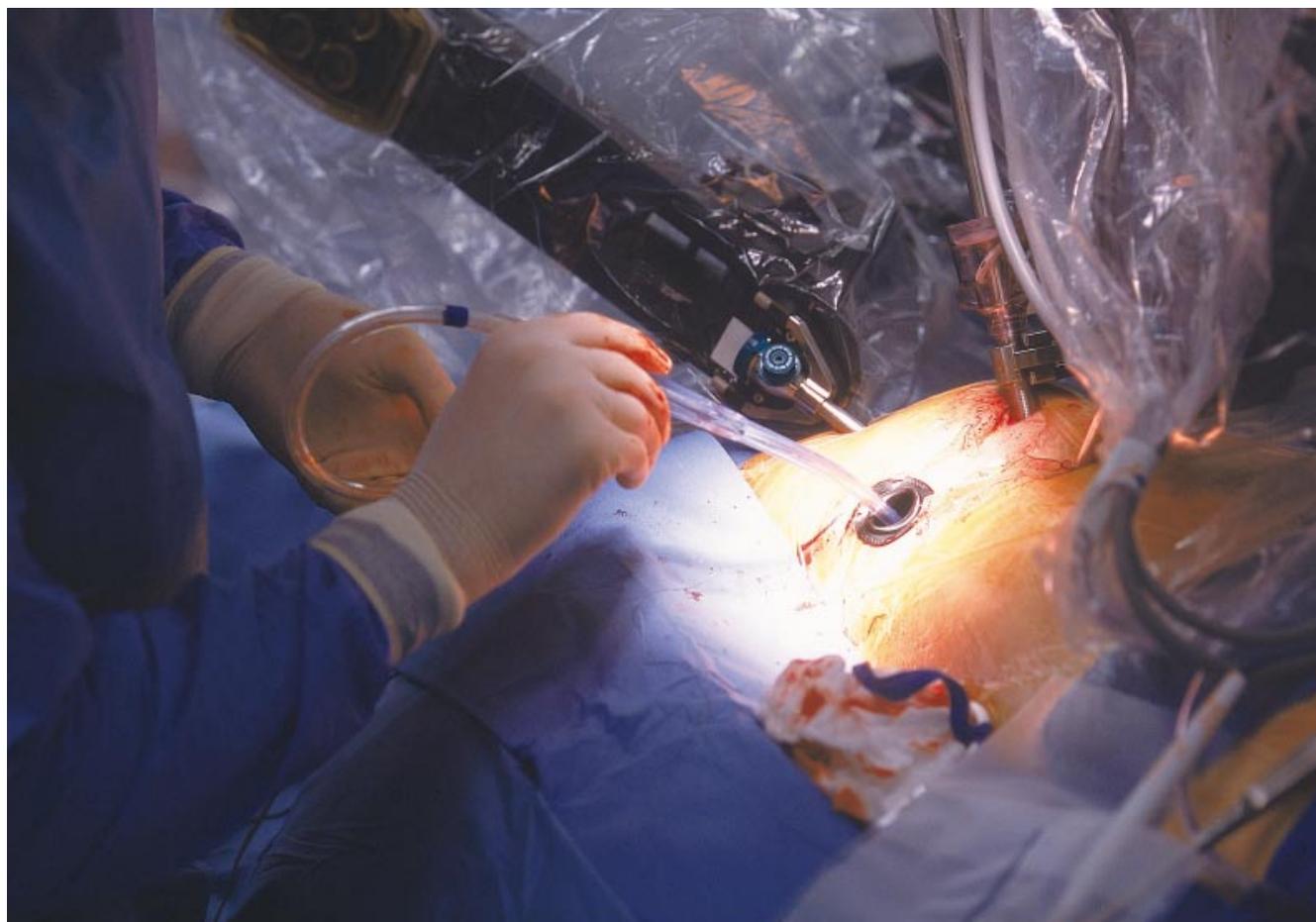


Tiny holes, big surgery

Minimal surgery hurts less and scars less—but is it right for you?



HEART REPAIR. The opening for this robotically assisted operation is only 1/2 inch wide. Rods equipped with tools like the forceps below are manipulated through even smaller holes a few inches away by surgeon Michael Argenziano from a separate console.

BY AVERY COMAROW

NEWS
YOU
CAN
USE

Plugging “minimally invasive” into an online search engine like Google is like swinging wide the doors of an overcrowded theater. Pages pour forth from hospitals, clinics, and doctors proclaiming their prowess at performing operations through small openings—so small they need only a stitch or two to close, maybe even just a bit of tape. Why languish in a drab hospital room, groggy with pain medication, a rolling IV stand your constant companion? Instead, you’ll check out in a day or two, even after complicated surgery, and zip back to your reg-

ular routine in no time.

Barely a dozen years ago, no one was talking about minimally invasive surgery—also called minimal-access or keyhole surgery. Now these procedures, done through small openings rather than long incisions—usually with the help of a tiny video camera, or laparoscope, inserted into the body—are elbowing ordinary “open” operations aside. Rare is the medical center without a department, or at least a director, of minimally invasive surgery. Some surgeons want to do away with open operations entirely. A survey done for *U.S. News* by



Medtech Insight of Tustin, Calif., of 17 kinds of surgery performed in 2001 found that an estimated 1.7 million procedures—more than one third—were done using minimally invasive methods.

The door opened in 1989 with laparoscopic cholecystectomy—truncated to “lap choly” in surgeonspeak—or removing the gallbladder with small tools on long rods. Within a couple of years the procedure became wildly popular. As patients heard about it, they began to insist that they, too, wanted their gallbladders removed with this wonderful new alternative to having their bellies sliced open,

a long and uncomfortable recuperation, and an unaesthetic scar. Hospital marketers and consultants pricked up their ears, surgical-device manufacturers geared up to develop expensive new instruments, and the race was on. Should you say yes if given a minimally invasive alternative to conventional surgery? Often—but not always. The surgeon's and

hospital's experience with the procedure might be limited. It still might have quirks to work out. It might pose dangers. And the old way might be better. A pointed discussion with the doctor is very much in order.

SURGEONS LOVE TO CUT; IT IS BECAUSE they can fix problems with their hands

ROD LITTLE—US&WR

Keyhole surgery

Even major operations are being done through small incisions. The totals represent 2001 estimates for both open and minimally invasive methods.

ADRENAL GLAND

Remove all or part
Total: **8,000**
Minimally done: **60%**

KIDNEY

Remove from living donor for transplant
Total: **5,300**
Minimally done: **95%**

KIDNEY

Remove kidney stone
Total: **377,000**
Minimally done: **90%**

APPENDIX

Appendectomy
Total: **367,000**
Minimally done: **20%**

HERNIA

Repair inguinal hernia
Total: **987,000**
Minimally done: **12%**

Source: Medtech Insight, Tustin, Calif.

CHEST

Repair child's sunken chest
Total: **2,500**
Minimally done: **50%**

HEART

Coronary artery bypass graft
Total: **310,000**
Minimally done: **25%**

STOMACH

Bypass for weight loss
Total: **54,000**
Minimally done: **70%**

GALLBLADDER

Completely remove
Total: **1.1 million**
Minimally done: **85%**

UTERUS

Remove uterus
Total: **643,000**
Minimally done: **10%**

LEG

Extract saphenous vein from leg for heart bypass
Total: **279,000**
Minimally done: **5%**

that they gravitated to the operating room. But some operations are so messy, so crude, that some surgeons recoil. That's how Donald Nuss felt about the Ravitch procedure. "I hated it," says Nuss, who as surgeon in chief at Children's Hospital of the King's Daughters in Norfolk, Va., had performed many of them. "It was so *brutal*." But like other pediatric surgeons, he had no real alternative. Four decades after Johns Hopkins physician Mark Ravitch published a description of his procedure in 1949, it remained the standard method for correcting the deformity called *pectus excavatum*, or funnel chest. Several thousand U.S. children, mostly boys, are born each year with the condition, which makes the chest appear punched in, as if slammed by a cannonball. In extreme cases, the sternum, or breastbone, nearly meets the spine. Out of embarrassment, a boy may not want to go topless at the beach or shirtless in skins-and-shirts games. Many children self-consciously hunch forward as they grow older, a posture that has become a badge of *pectus*. Half or more need surgery because their lungs are compressed and their heart squeezed out of position. They may have little endurance and are often short of breath. Heart murmurs are common.

Lifetime scar. It is a dramatic deformity; the equally dramatic Ravitch procedure restored the child to normal. But when the surgeon was done, the stainless-steel basins contained heaps of misshapen bone and cartilage taken from the child's rib cage, the sternum had been methodically bent back and forth until it broke, and the large chest muscles had been sliced, peeled back, and reattached. Boys carried a long scar down the middle of the chest, girls a scar across the bottom, for life. And many of the children developed breathing problems years later because of extensive internal scarring caused by the surgery, which made the chest wall stiff.

Mired in the midst of a Ravitch in 1987, Nuss was struggling with a rib he'd bent nearly into a **U** that refused to break. Suddenly, he recalls, it came to him "like a bolt of lightning": If the chest was that flexible, why hack out bone and cartilage? A long, curved metal bar, shaped to the patient and inserted beneath the ribs and sternum, should pop the chest into the right position and hold it there until the bones remolded themselves into the new configuration. Then the bar could be removed. Lengthy incisions would be avoided, because the bar could be pushed into the side of the chest through a small opening between the ribs, and out

through another on the other side. The procedure would be as minimal as the Ravitch was maximal.

Nuss tried out the idea on his next *pectus* patient, a 5-year-old boy. To get the bar from one side to the other, it had to be inserted with the curve facing down. Using ordinary Vice Grips pliers, Nuss then grabbed one end, an assistant across the table grabbed the other, and on the count of three they flipped the bar 180 degrees into position. When the boy's chest immediately popped out, Nuss was elated. "I was surprised at how well it worked," he says.

Few innovations are hitch free, however. Under constant pressure from the muscles and ribs, the titanium bar that was supposed to hold the youngster's chest in place for two years slowly buckled within six months and had to be removed. Even doubling the bar wasn't always enough. Switching to surgical steel in 1994 provided the solution. And for the first 10 years the bar was maneuvered blindly through the patient's body, with the volume on the operating room's heart-beat monitor turned up to alert the team if the bar touched the heart. Then Nuss had a patient "whose heart rate went crazy." So in 1998 he added a thoraco-

scope—a tiny video camera inserted through an opening in the chest after carbon dioxide was pumped in to push the lungs aside. Now Nuss could observe in full color as the bar was eased across.

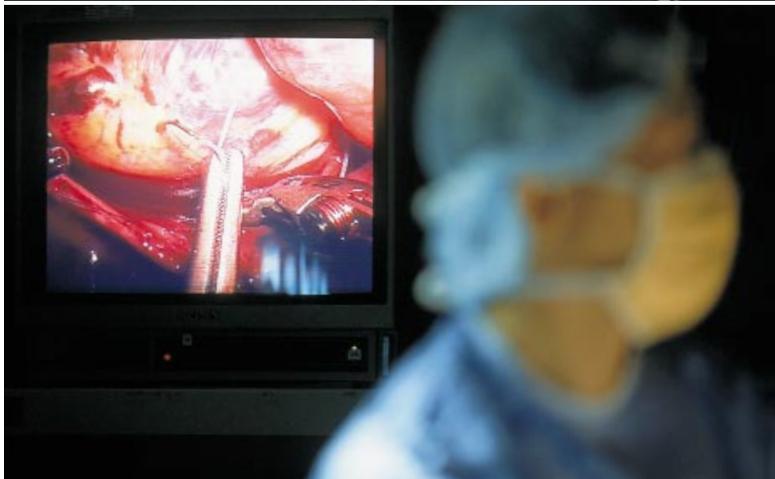
In 1997, Nuss and his team at the Norfolk hospital presented results from their first 42 patients at a meeting of children's surgeons. In the conservative world of pediatric surgery, the effect was as electric as the introduction of the lap choly had been. At least half of all *pectus* corrections today are done using Nuss's method. Johns Hopkins Hospital in Baltimore, where Ravitch devised his procedure and where Nuss learned it, switched about four years ago after surgeons there watched Nuss demonstrate. Hopkins pediatric surgeon in chief Paul Colombani has extended it to adults as

old as 48 who didn't have the surgery as children and couldn't have the Ravitch later because their stiffer bones made it overly risky.

Quicker, easier. Nearly 500 patients have had the procedure at Children's Hospital of the King's Daughters. Although the operating room is reserved for two hours in case of complications, rarely does a case take longer than 45 minutes, compared with several hours for a Ravitch. Last month Nuss needed a little over an hour with Gabe Patgorski, a cheerful and uncommonly calm 15-year-old from nearby Chesapeake, Va., because the bar repeatedly hung up on a small ridge of cartilage, but soon the bar slipped through. Nuss and his assistant slid "bar flippers" (specially made to replace the Vice Grips), onto the ends of the bar,

Nuss counted, "One, two . . ." and in unison they cranked the bar into position. Gabe's chest obediently elevated. He went home the fourth day after surgery. Following several weeks of healing, deep-breathing exercises, and stretching, he'll be unleashed for everything except contact sports until the bar is removed. Gabe's legacy from the \$27,228 operation will consist of two faint lines from the bar, a smaller mark where the thoracoscope was inserted—and a perfectly ordinary chest outside and in. Most health insurers cover the expense of minimally invasive operations without too much resistance, since they would have done so for the open version.

Given the long list of procedures now done minimally, it is sobering that Nuss's innovative surgery is on a much shorter



ROBOSURGEON. Named da Vinci, the robot looms over the patient like a praying mantis. When a tool has to be changed, the arm can be ordered to remember its last position. A monitor (left) shows the heart being sutured. Twin lenses give Argenziano a 3-D view.

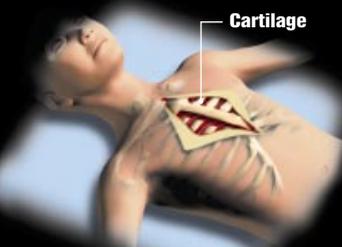
Two ways to fix a deformed chest

Children born with pectus excavatum, or funnel chest, look as if they've been punched in the breastbone. A major operation to correct it, called the Ravitch procedure, is being replaced by Donald Nuss's minimal approach.

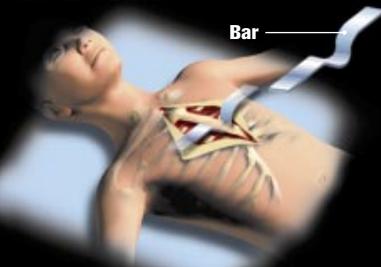
OLD APPROACH



1 A long incision is made down the middle of the chest.



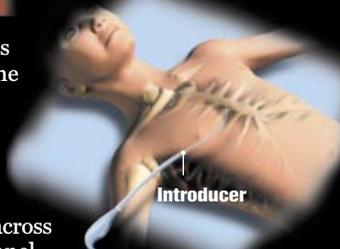
2 Skin and muscles are peeled back. From four to 10 sections of cartilage are cut or pried out and discarded.



3 The breastbone is cut and fractured. A short bar is wired to the ribs to hold the chest in its new position.

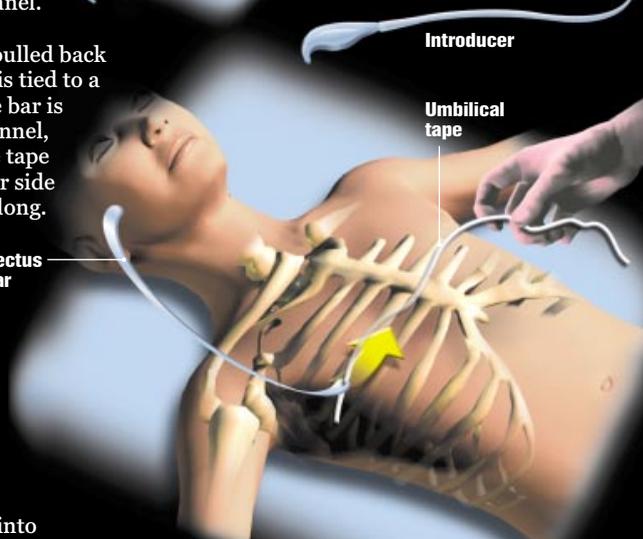
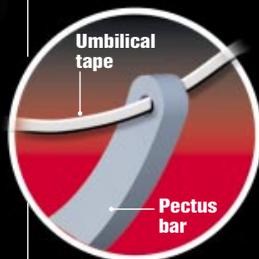
NEW APPROACH

1 A 1-inch incision is made on each side of the chest and a small one toward the front; a video camera is inserted through the small incision. An "introducer" is worked across the chest to make a tunnel.



Introducer
Created for the Nuss procedure, the long curved rod is blunt to avoid injury. After it is pushed through to the other side of the chest, cotton umbilical tape is tied to an eyelet at the end.

2 The introducer is pulled back through, and the tape is tied to a curved pectus bar. The bar is pushed through the tunnel, curved side down. The tape is pulled from the other side to help move the bar along.

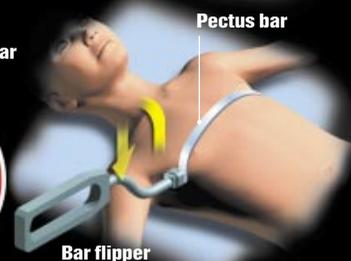


3 The bar is turned into position with a pair of bar flippers. The chest pops out.



Bar flipper

Also created for this surgery, this cranklike tool fits onto the end of the bar. Nuss used to employ pliers.



Sources: *Annals of Surgery*; Donald Nuss, Children's Hospital of the King's Daughters

list that can claim technical superiority and happier patients. Another is laparoscopic kidney donation. Aside from the cosmetic advantages of a minimally invasive procedure, a surgeon wants to do the least possible damage to a healthy person who is there to save someone else's life. In the open approach, an incision of 8 inches or more is made along the side of the body. Because of the size of the cut, patients often develop nagging problems such as a tendency of the wound to reopen, and returning to work

may take six to eight weeks. Its use has limited the number of kidney transplants, less because of donor reluctance than because of concerns about subjecting the donor to the operation. Laparoscopic techniques permit a kidney to be removed through an incision of 2 to 2½ inches around the navel or, in a woman, below the bikini line, plus small punctures for the video camera and instruments. The openings heal without leaving noticeable marks, donors typically go back to work in a couple of weeks, and an

estimated half of the people who need a kidney come up with a donor.

Suppose you're a woman of childbearing age and have large uterine fibroids—benign growths in the organ's muscle wall. You're having heavy bleeding and painful periods. In all likelihood, you'll be told your uterus has to be surgically removed, putting an end to any childbearing plans; about one third of the 600,000 hysterectomies done every year in the United States are because of fibroids. A minimally invasive procedure,



A chest-popping bar

Last year a physician gave Gabe Patgorski a sports physical and recognized the signs of funnel chest. Last month Gabe, 15, had minimally invasive surgery to correct it.

1. FINAL EXAM. The day before surgery at Children's Hospital of the King's Daughters in Norfolk, Va., Gabe inspects his chest as his mother, Linda, looks on.

2. THE BAR. With Gabe asleep, surgeon Donald Nuss checks the shape of the steel bar that will push the boy's chest into position. Disinfectant is deliberately pooled to emphasize the depression's depth and contours.



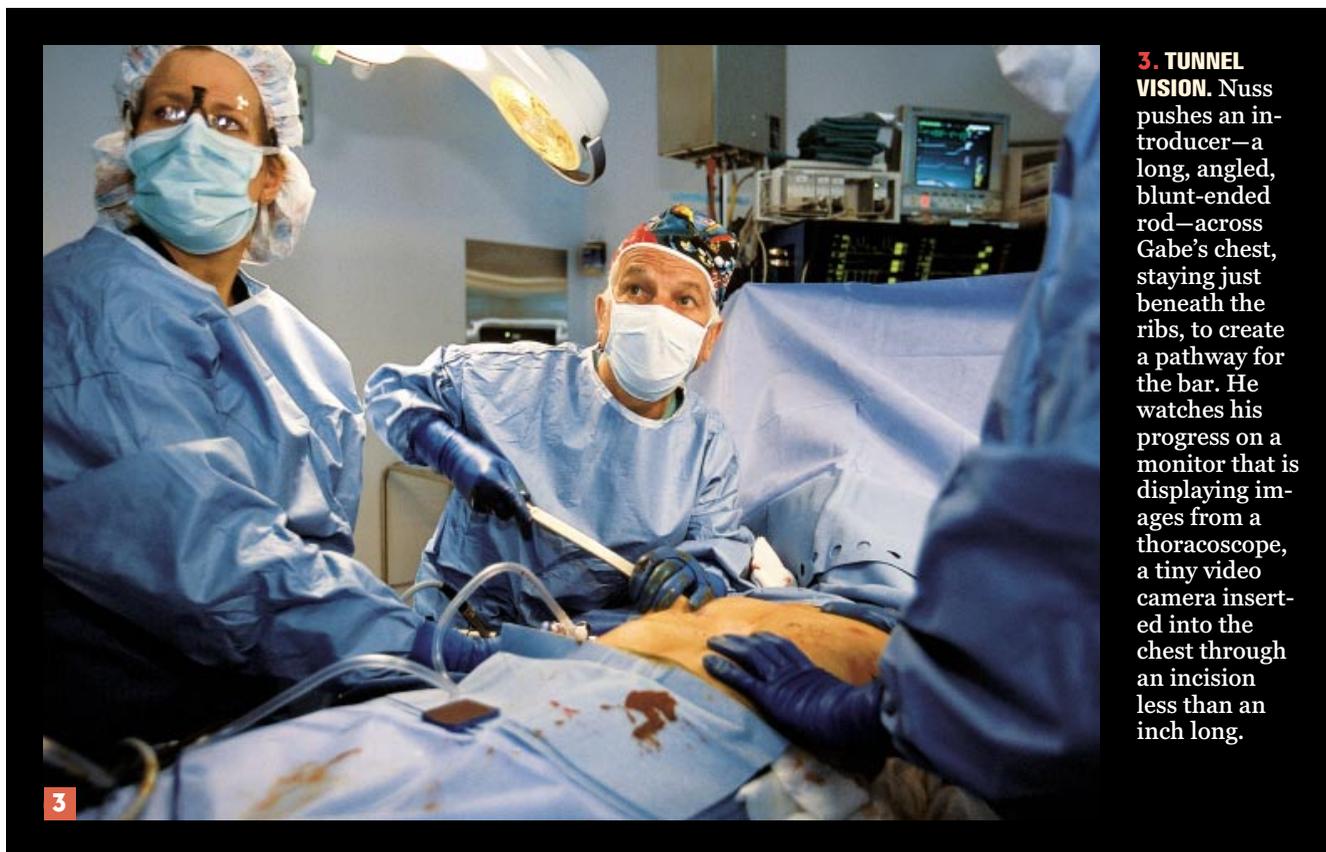
uterine fibroid embolization, can save the uterus and shrink the growths by cutting off their blood supply. The surgeon inserts a catheter into a tiny opening in the groin. Guided by X-ray images, the catheter is placed into the artery supplying the growth with blood, and sand-size particles are injected to block the flow. The technique requires considerable skill. But it works about 90 percent of the time, leaving uterus, skin, and child-bearing ability intact.

While minimal procedures can save considerable time and trouble, that doesn't make them a cure-all. It's one

thing to get back on your feet quickly, but how good was the operation compared with the conventional approach? Because an operation is performed minimally doesn't mean it is safer. "There are surgeon-based outcomes," explains Jonathan Meakins, chairman of the American College of Surgeons committee on emerging surgical technology and head of surgical services at McGill University Health Centre in Montreal. "Surgeons want to know the repair worked: The hernia is fixed; the bleeding stopped; the patient is cured. Patient-centered outcomes are different—recovery to a normal level of activity, nor-

mal eating habits." Most people don't know enough, says Meakins, to ask whether a procedure has surgical advantages—and dangers. Minimal procedures can be risky because even the simplest ones are harder to do than their open equivalents. That means the procedure is harder to learn and possibly more hazardous if a surgeon hasn't done a fair number and isn't doing it regularly.

Miniature everything. The basics of a lap choly can help show why. It is as straightforward as laparoscopic surgery gets. Nothing is being fixed, only taken out, so there aren't many steps. The organ must



3. TUNNEL VISION. Nuss pushes an introducer—a long, angled, blunt-ended rod—across Gabe's chest, staying just beneath the ribs, to create a pathway for the bar. He watches his progress on a monitor that is displaying images from a thoracoscope, a tiny video camera inserted into the chest through an incision less than an inch long.

be snipped from its stalk—the cystic duct—and a blood vessel cut and sealed. The surgeon makes four punctures, or ports, in the abdomen, two slightly under $\frac{1}{2}$ inch across and two just under $\frac{1}{4}$ inch, with a sharp-bladed instrument called a trocar. A video camera and light source are passed into one opening. The others are for instruments and to allow the gallbladder to be removed. The abdomen is inflated, as Nuss did with Gabe, to push the organs out of the way for better vision and access.

The surgeon goes to work. Miniature clamps, cutters, and other tools are mounted at one end of hollow rigid rods about a foot long. A linkage in the rod connects with a handle that the surgeon manipulates. After a rod is inserted, the opening in the abdomen serves both as a fulcrum and a steady point. Changing a position is like being on the end of a seesaw: To go up, the rod must go down. Left is right. Moving in circles is done in the usual direction, but the instrument is halfway around the circle from where the brain says it is. The surgeon works in three dimensions but loses depth perception because the video camera's image is displayed on a two-dimensional screen.

No wonder a lap choly, even when done by an experienced surgeon, takes

far longer than an open one. This easiest of laparoscopic operations is in fact technically demanding. "Patients should not be shy about inquiring into the number of laparoscopies the surgeon has performed," counsels a report from the Harvard Medical School on gallstones. "It should not be fewer than 30." That's not bad advice for most procedures. In 1995, with concern building about the absence of safety data, a study in the *American Journal of Surgery* of nearly 9,000 lap cholys performed by 55 surgeons found an undeniable learning curve. Ninety percent of the injuries to patients, the authors concluded, are likely to happen in a surgeon's first 30 cases. Their findings suggested that a surgeon's first patient runs a 1.7 percent chance of harm; the 30th patient, about .25 percent.

Experience counts. Regardless of the kind of minimally invasive operation being considered, says Jonathan Meakins, "patients have to ask questions: How many have you done? What complications have you had?" If a procedure is relatively new, little information may be available. Besides asking about volume, patients should ask surgeons when they have done it recently. "It's the last three or four years that count," says Lawrence Way, professor of surgery and

director of videoscopic training at the University of California, San Francisco Medical Center.

Some procedures appear to carry a hazard that even reassuring answers won't dispel. In lap cholys, for example, the bile duct is cut several times more often—though still very rarely—than it is in the open version. It's not inadvertent; the surgeon inspects the bile duct, thinks it's the cystic duct, and snips it. Serious liver damage, or death, can follow. It has to do with the loss of touch. "The problem is that you can't get your hand in there," says Way. "Using your fingers, you can feel how the base of the gallbladder funnels down to the cystic duct." Strangely, he says, it doesn't stem from lack of experience or skill. "It seems almost to be a random event."

The lap choly shares two other tiny but real risks with other laparoscopic procedures in which part of the body is inflated. In rare circumstances, bubbles of the gas can enter the bloodstream through a nick in a blood vessel and then travel to the heart or brain and cause unconsciousness or death. Using CO₂ also requires general rather than less risky local anesthesia, because being inflated while awake would be impossibly uncomfortable.

Although the risks are remote, for some



4. TURNING POINT. Nuss sees from the monitor that the bar, just visible under his finger, is in position. Next, he and his assistant will give it half a turn with “bar flippers” to make the curve face out.

5. WIRED IN. A short vertical stabilizer bar is lashed with surgical wire to one end of the long bar. It will be sutured to the chest muscles to keep the bar from slipping out of position.



6. GOOD NEWS. With clear relief, Gabe's mother and father, John, see from a Polaroid taken a few minutes before that the operation was completely successful.

7. WHAT SURGERY? The morning after, Gabe cheerfully displays his chest to his mother and older sister, Sara. The depression in his chest is gone, the operation has left few marks, and he doesn't even hurt that much.

top surgeons they are real enough, added to the inherent difficulty of laparoscopic procedures, to flash a yellow caution light. Repair of inguinal hernia—a condition affecting at least 1 in every 50 men, in which a loop of intestine bulges into the muscles of the groin—is one of the most heavily marketed minimal operations. The headlong rush to the lap choly, with training of hugely varying quality, was on the minds of leading surgeons. So in the early 1990s, the American College of Surgeons launched a large study to compare the efficacy and safety of open with minimally invasive repair. “The ACS didn't want the same thing to happen with lap hernias,” says Robert Fitzgibbons, professor of surgery at Creighton University School of Medicine in Omaha and lead author of *Hernia*, a standard text.

It was hopeless. The results of the study are just now being analyzed, and lap hernias are hot. The pitch is the standard “less pain, quick recovery.” But how many men are told that a recurrence may be several times more likely for lap hernias than it is for open hernias? And that there may be alarming consequences?

No free ride. “No matter how experienced you are,” says Fitzgibbons, “there will be some number of major complications—.5 percent to 1 percent—from

the laparoscopy. The risk of major complications from conventional surgery is essentially nil.” Moreover, he says, changes to the open procedure in the past decade have improved the effectiveness so dramatically that “there's no real advantage to lap repair.” Only about 10 percent of Fitzgibbons's hernia repairs are done laparoscopically, and only on a few kinds of patients: those whose conventional surgery failed, those with an inguinal hernia on both sides, and someone having another laparoscopic abdominal procedure anyway.

A laparoscopic operation to remove cancerous tissue raises the chilling prospect of seeding cancer cells elsewhere. Anecdotal reports in the early 1990s cited patients who had had cancerous portions of their colon removed laparoscopically and had cancer reoccur where the instruments penetrated the body. Surgeons also worry about seeding tumor cells deep within the body. Until long-term studies offer guidance, the *Journal of the American Medical Association* advised last March, laparoscopic operations on the large intestine should be done only in clinical trials. Ironically, a study in last month's *Lancet* dropped tantalizing hints of increased longevity for patients who had a portion of can-

cerous colon removed that way. The study compared 106 patients who had laparoscopic surgery with 102 others who had open surgery. After three to six years, 17 percent of the laparoscopic patients had recurrences, compared with 27 percent for the open group. The authors speculate that reduced surgical trauma leaves the immune system in better shape to fight off cancer.

Finally, there's the pain claim. “I really hate the marketing” of minimally invasive procedures, says Irving Kron, chairman of surgery at the University of Virginia Health Sciences Center in Charlottesville. “It makes people think they're going to have this painless little operation when in fact it could hurt more.”

The Midcab, for minimally invasive direct coronary artery bypass, is a good example. It was devised because the old approach to heart bypass surgery involves sawing through the sternum, spreading the rib cage to give the surgeon a wide-open view, and putting the patient on a heart-lung machine so that suturing the tiny bypass vessels can be done on a motionless heart. It's not as invasive as the Ravitch, but it's impressive enough.

The Midcab appeared in the mid-'90s, mostly to eliminate the heart-lung machine because of the neurological and



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VETERANS. Nicholas Wood, 18 (left), from Trinity, N.C., had his bar removed last August. His brother, Jordan, 13, has a year or so to go.

other complications it can introduce. The Midcab's other benefit is that the chest doesn't have to be split. Instead, the surgeon makes a horizontal incision near the heart, pries a couple of ribs far enough apart to gain access to the heart wall, and uses a device that stabilizes the surface of the heart where he needs to work.

No heart-lung machine, no split chest. The problem is that "people who have Midcabs probably hurt more than people who have sternotomies," says Kron. "A lot of people with sternotomies wake up and ask, 'When am I going to have surgery?'" Thump the middle of your chest for the explanation. A Midcab is done through the fleshiest part of the chest; the sternum has almost nothing covering it. Complaints about pain after conventional bypass surgery come from people who had a saphenous vein carved out of a leg to use as bypass fodder.

Robotic help. The gee-whiz trend in minimally invasive surgery is to give the surgeon a hand—several, in fact—from a robot. The surgeon sits at a console away from the table, equipped with a viewing screen, hand and finger controls, and foot

pedals. His movements command an assembly of mechanical arms positioned over the patient. The arms are equipped with interchangeable tools that enter the patient through the usual small openings. A robotic assistant permits the surgeon to do procedures that are far more intricate—heart valve repair, for instance—than can be performed using long, rigid laparoscopic rods. The arms and tools are manipulated without the up-down, left-right problem, and they become an extension of the surgeon's hands. Last month at New York Presbyterian Hospital, Michael Argenziano, codirector of robotic surgery, enlisted da Vinci, a robot from Intuitive Surgical, to help him repair an atrial septal defect—a small hole in schoolteacher Ralph Gallo's heart.

After Gallo was asleep, with the heart-lung machine pumping away and the heart stopped, Argenziano removed his shoes ("to get a better feel for the pedals") and took a seat about 10 feet away at da Vinci. He peered into a pair of screens, one for each eye, giving him a 3-D view of the inside of Gallo's chest. Over the next two hours, he entered the heart, closed

the $\frac{1}{8}$ -inch hole in the wall between the right and left atrial chambers that caused Gallo's small stroke last December and brought him to New York Presbyterian, and fixed a weak spot on the wall.

Argenziano is participating in three clinical trials of robotic heart surgery and is a cheerleader for the technology. But he freely concedes there's a price to pay for using a robot beyond da Vinci's \$1 million-plus cost. He gets frustrated. He can't feel his patient's tissues and organs, can't guide his assistant with a touch or a shake of the head. "Minimally invasive surgery transfers the pain from the patient to the surgeon," says Argenziano with a sardonic grin. "It's more difficult to learn and more difficult to do—so that's not entirely a joke." No kidding. Some surgeons are modifying minimal procedures to let them put a hand inside or see better—requiring more than minimal incisions.

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