Remote Surgery

Operating on patients from afar

By TINA ADLER

Imagine a doctor using a tiny robot to hunt down a polyp in your colon. Now imagine she is doing this remotely, from another city. Or country. Or planet. And medical students are watching — in three dimensions, on a huge monitor, in living color — as the little robot cuts the polyp out. Your viewers can even smell the scents and hear the sounds of the operating room.

Welcome to some really modern medicine. Welcome to telesurgery.

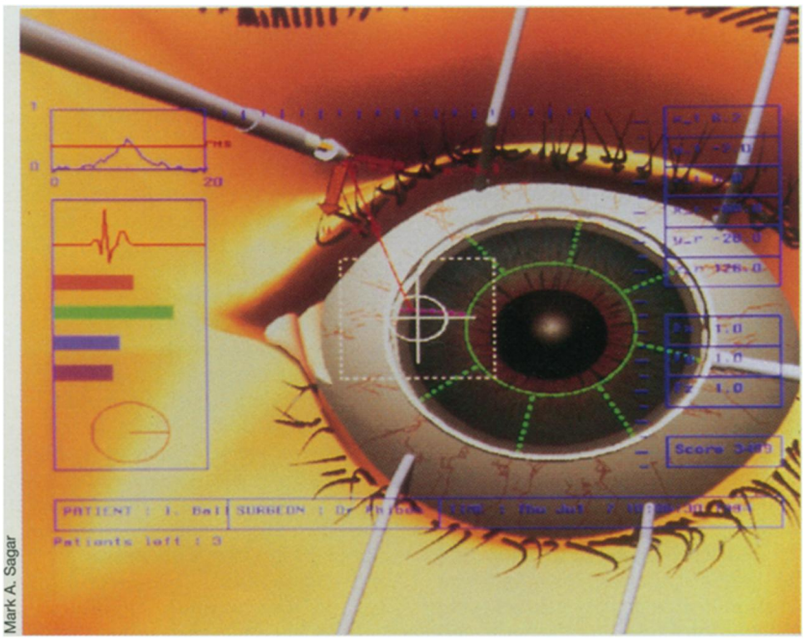
In this new field, a group of technowizards is developing devices for long-distance surgery. They want to make it possible for surgeons to operate from a nice, clean hospital room in a major city on a patient in a high-tech ambulance in a war zone or in a small town that has no surgeon.

These visionaries are employing mechanical arms, virtual reality, and more. Eventually, the new technology will save lives — and money — its inventors say. And doctors won't have to risk exposure to dangerous environments or microbes, they point out.

No one has yet undergone a long-distance operation, and no one is likely to for some years. But the technology will become safe enough to use on people within the next 2 to 3 years, contends one of telesurgery's biggest advocates, Richard M. Satava of the Department of Defense's Advanced Research Projects Agency (ARPA) in Arlington, Va. Getting approval from the federal government to test the technology on humans will take longer than that, he acknowledges.

Other experts in the field consider Satava overly optimistic. Someday, a doctor in the United States may perform simple surgery on a wounded soldier in a distant land, says surgeon David W. Rattner of Massachusetts General Hospital in Boston. But certainly not in the next 5 years, he adds. Rattner is helping to build an operating room there that will incorporate telesurgery.

At least 10 research groups in the United States and Europe are developing telesurgical systems, says Satava. ARPA funds some of this work through its Advanced Biomedical Technologies program, which Satava heads. The program seeks to "save lives on the battlefield," he asserts. If soldiers need surgery, the medic would put them in a special van that comes loaded with the remote manipulators and other tools necessary for doctors to do long-distance repairs. Civilian hospitals will use the technology also, Satava says.



Mark A. Sagar

Doctors performing telesurgery on an eye using the MSR-1 being developed at MIT would have this three-dimensional computer representation to guide them. Surgeons could wield the scalpel (the long white tool at left) via their computer from anywhere in the world. The white ring surrounding the eye keeps it stationary, and the four thin white rods hold the lids away from it. The white crosshairs on the eye show the surgeons where to cut. They could determine how much pressure the tool is exerting on the eye from the information in the blue box on the right. The purple line at the top of the left box reveals the amount of tremor in the surgeons' hands. The colored bars and lines below provide data about the patient's vital signs, including heart rate and blood pressure.

Philip S. Green of SRI International in Menlo Park, Calif., has invented one telesurgical device called the Green Telepresence Surgery System. Surgeons sit at a console, wear three-dimensional glasses, and view the operating room and an enhanced image of the patient. Eventually, physicians may use voice commands to control the movements of the cameras filming the surgery. An audio component conveys all the sounds of the operation — from voices to the scraping of a scalpel on bone. Green originally designed the device to improve on laparoscopic surgery, which uses fiberoptic instruments to perform abdominal or pelvic procedures.

Using the Green system, surgeons "operate" on the image of the patient with instruments that feel real but actually direct the mechanical arms doing the work. These arms feed back to the doctors, through the tools that they're holding, all the sensations of surgery, Satava and Green say.

Green and his colleagues have used the device to practice suturing and other procedures on animal organs. They have demonstrated its precision by, for example, directing the mechanical arms to thread a rod through a tiny washer without touching the sides and to carve a grape into 1-millimeter slices.

Physicians can enhance the images they see by incorporating scans, such as those from a magnetic resonance imaging machine, that provide an inside view of the patient. Green and his colleagues intend to build into the device a surgical simulator that will create a virtual-reality image of human tissue and organs for surgeons to use for experiments or practice.

Virtual reality already is used to train pilots, among other applications. But many such systems have shortcomings, a new National Research Council report asserts (SN: 10/1/94, p.221). For example, they may become uncomfortable to wear after long periods and can cause motion sickness.

an W. Hunter and his colleagues, now at the Massachusetts Institute of Technology, have developed a robot that resembles the Green device but specializes in microsurgery, such as eye operations, they report in PRESENCE (vol.2, no.4). They began developing the microsurgical robot (MSR-1) in 1989 while at McGill University in Montreal.

The device has a unique feature: It scales down the surgeon's movements, so the robot's snips and cuts are as little as one-hundredth the size of the physician's. What's more, the computer filters out hand tremors and performs safety checks.

"It detects when [surgeons] are about to do something silly and avoids it," Hunter says. For example, if users move too quickly and therefore may make a bad cut, the computer sounds an alarm.

The physician gets all of the physical sensations of doing surgery — plus some. The computer can magnify the forces the robotic arm encounters, so the surgeon feels more than he or she would during a normal operation.

The team designed MSR-1 for nonremote procedures as well as telesurgery. At present, however, the high-speed communication technology required for telesurgery costs too much to use, Hunter says, and less expensive approaches take too long to relay signals.

Hunter and his colleagues don't have commercial backers yet, nor have they sought out federal approval to test MSR-1 on humans. Developing the system was expensive, but mass-producing and operating it should not prove very costly, he claims.

The researchers plan to develop a miniature robot that would help physicians perform microsurgery on the heart.

At least one tool that doctors might employ in telesurgery has already hit the market. For a mere $19,500, consumers can buy a personal haptic interface device known as PHANToM. Haptic means "relating to the sense of touch."

"The device has enabled users to interact with and feel a wide variety of virtual objects and will be used for control of remote manipulators," such as those required for telesurgery, assert coinventors J. Kenneth Salisbury and Thomas H. Massie, both of MIT.

Massie, a graduate student, started SensAble Devices in Vanceburg, Ky., to market the PHANToM under license from MIT. He has received 18 orders, primarily from researchers who will write their own software to develop commercial applications for the tool.

The entire PHANToM package includes a small mechanical arm, an amplifier interface to run the arm, a port for a personal computer, and the software that controls the whole works. It looks like a desk lamp with an arm where the bulb normally goes.

PHANToM tracks the motion of the user's fingertip, which is placed in a thimble on the mechanical arm. The computer exerts an external force on the finger, "creating compelling illusions of interaction with [seemingly] solid physical objects" that appear on the computer screen, Massie and Salisbury will report in November in the proceedings of the fall meeting of the American Society of Mechanical Engineers.

Users can replace the thimble with different tools, such as a scalpel or screwdriver. They will feel as though they are using the genuine item, says Massie. And they can run two PHANToMs at once, one on each hand. The device comes in different sizes, enabling people to pick up virtual-reality objects as big as a basketball.

PHANToM conveys the sensations of softness, hardness, friction, and "other mechanical attributes of virtual objects," says Salisbury. "Think of touching the world through a metal thimble," he explains. People can even feel like they're stroking something. But Linus of the "Peanuts" cartoon might be disappointed with PHANToM: It conveys neither the warmth nor the fine texture of a fuzzy blanket.

Some aspects of PHANToM may take getting used to, Salisbury and Massie acknowledge. Manipulating objects in ways not possible in the real world — for instance, putting your hand through a basketball and feeling the other side, and doing so with only the fingertips — can feel odd. But people can learn to operate PHANToM "with relative ease," they contend.

What will house the equipment the surgeons will handle? The operating room of the future, of course. Architect Kenneth L. Kaplan of MIT and his colleagues will create a room that includes virtual-reality and telesurgical technology. He hopes to have it built at Massachusetts General Hospital within 5 years. The researchers plan next year to show off some of the technology that will go into the room, adds Rattner, who oversees the project at the hospital.

Rattner considers himself the reality check for these forward-thinking scientists. They "have some great ideas, [like] 'Wouldn't it be nice if the operating room were like the cockpit of a fighter bomber?" he asserts. Anything that does not save money while also improving health care won't fly, he adds.

Rattner questions whether operating rooms will need extensive remodeling. "Problems that people feel exist with current surgical rooms may not be as serious as they think."

Kaplan shares some of Rattner's skepticism about these high-tech plans. He says someday telesurgery may work; however, "the technology is still quite costly, and people's learning curve is still quite down."

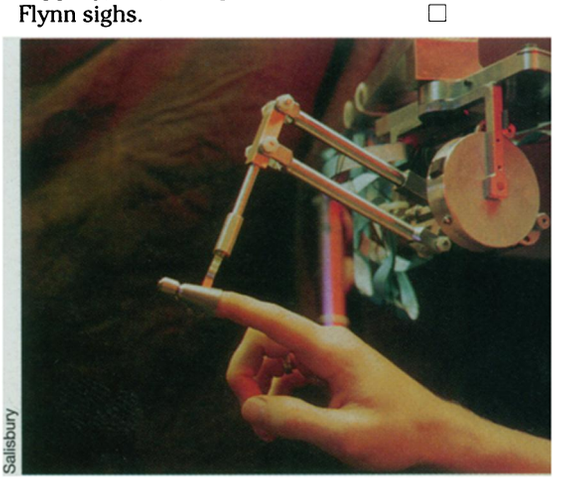
Although telesurgical tools may eventually have a host of uses, they will never replace the surgeon, experts contend. "I think it's extremely unlikely [that such devices] will do procedures on their own," Satava asserts. Mechanical arms, however, may perform a simple task independently, such as creating a hole in a person's hip during a hip-replacement operation.

Hunter agrees that mechanical contraptions like these might eventually perform simple procedures without a person to guide them. However, he adds, "we are not advocating that these systems replace surgeons."

One unusual surgical assistant of the future may be a spin-off of Cleo, an MIT microrobot. Cleo's kin would take orders from a Boston-based doctor as it travels through the colon of a sick person in Alaska, snapping pictures and snipping polyps.

MIT graduate student Anita M. Flynn and her colleagues are trying to create robots that would do just that and more, she says.

At present, the 1 1/2-inch-tall Cleo follows lights, runs a maze, and picks up aluminum balls, among other tricks. Unfortunately, she can't yet handle the messy, slippery, soft, damp world of intestines, Flynn sighs. □


Salisbury

The personal haptic interface device, or PHANToM, lets users feel virtual-reality objects. Among other functions, it could give surgeons the sensation of touching real tissue, say its inventors, who are developing larger versions of the tool. The device allows users to move their wrists freely.