Robots: Applications in Medicine

When an individual, yes, you or I are ill, we need care and we want caring providers. Thus, in the emotionally-charged environment of medical care in which personal attention is prized or sought, robots may seem out of place. but they have an expanding role to play. One does not usually expect a robot to exhibit caring, however robots enable care providers to become the caring professionals they want to be, by freeing them from important but less productive tasks that can be delegated to a robot. My first confidence that computer guided education created no barrier between doctors and gynecologic patients came after teaching medical students to do a careful but thorough internal pelvic examination with a simulator. When those students examined their first patients, they were able to identify the simulator-trained students, not by a better examination, but by better rapport! The prior learning had prepared the students to listen and focus on the person, more than on the pelvis! So it is with the role of robots useful in medicine. Let's examine how:

Robots are filling an increasingly important role of enhancing patient safety in the hurried pace of clinics and hospitals where attention to details and where reliability are essential. In recent years, robots are moving closer to patient care, compared with their previous role as providing services in the infrastructure of medicine. Examples of past use are in repetitive activities of cleaning floors and washing equipment and carrying hot meals to patients' bedside. What is new is finding them in clinical laboratories identifying and measuring blood and other specimen for testing, and in pharmacies counting pills and delivering them to nurses on 'med-surg-units' or ICU's. Or bringing banked blood from the laboratory to the ED, surgery, or ICU for transfusions. Robots are being used as very accurate 'go-fors'!

The packaging of medications is becoming automated as pills are counted, poured into chambers for subsequent dispensing, and distributed to patients, but only after bar-codes are read and correct identification of the patient is established. Robots are at the bedside lifting and rotating bed-ridden patients to prevent 'bed-sores', assisting the nursing staff which has less time for

direct patient contact, while saving their backs from injury. Another issue is the increasing body weight of patients who need to be moved, and the physical stress on the staff.

Virtual Presence Robots visit patient bedsides carrying the photo-image of their remotely-located physician or the floor nurse who directs the robot to view and even examine patients as the professional converses with the patient. Patient surveys indicate that patients prefer interacting with VPR's in circumstances such as weekends or during travel periods when their doctor is not on call, but is able to conduct hospital 'rounds virtually'. Soon, Robo-Nurses will come to record the pulse and breathing, and measure the blood pressure of patients who require this surveillance frequently. Don't forget that a professional controls these robots from a central location, and their voice and camera-vision accompany the robot. These VPR's extend the capability of care-givers, and cannot, of course, replace them.

In surgical education, hand-held robots enable learners to interact haptically (sense of touch) with virtual organs to achieve some sensation of surgical manipulations. Simple 'pen-type' or bimanual laparoscopic workstations allow a novice to palpate, incise, or suture virtual tissues and organs, while achieving the sensation of touch while engaged in such manipulations. Haptic devices are slowly and surely becoming common-place in surgical training programs around the world.

A perhaps unexpected area of robotic function is their passive role as a surgical assistant. Penelope, the Robo-Nurse has made her debut this Spring, replacing nurses who hand surgical instruments to surgeons at the operating table, wipe them clean, and return them for further use. Penelope also counts them, so 'lost instruments', and sponges, too, should be a thing of the past. Simpler robots are used as an *'iron intern'* to provide constant and steady retraction of organs during surgical procedures. Both of these application release nurses to do more productive work, or to provide a 'set-of-hands' when a skilled individual is unnecessary.

An early active robot, '*Robodoc*' was designed to mill perfectly round lumens in the shafts of fractured bones, to improve the bonding of metal replacements such as for femur heads, and knee joints. The future of this system remains uncertain because of questions about the ultimate beneficial outcomes. Yet, hundreds of patients have had the benefit of this precise treatment despite the $1 million capital investment cost. Another cost is the 'set-up' time required to assemble the robot and the CT scanner around the operating table where the patient is positioned. Another type of robot precisely cradles the head of patients undergoing brain surgery, instead of the former 'ring'of thorns' that was used. The path to corporate profitability is crooked, and often long, and I read that the Integrated Surgical Systems company has closed it's doors in June 2005, removing the continued supply of these systems. This experience underscores the risk of innovation.

The most surprising use of robots, perhaps, is their application in the actual performance of laparoscopic surgical procedures. There, the da Vinci surgical system increases human performance capabilities as they are more stable than is the human hand - eight-fold more stable, and equally facile as the human wrist. Today's surgeon can sit at a console away from the patient, even hundreds of kilometers away, directing robots that hover over patients to conduct selected procedures. Stereo vision provides a 'real-world' view on the display monitor.

Many types of procedures can be done by surgical robots, ranging from cardiac artery splicing to release of spinal nerves, or removal of prostate glands. An expanding role for these systems is in telesurgery serving remote, rural areas, and exclusive environments such as aboard military ships or submarines. Examination of the outcomes indicates that the surgical results are at least equivalent to non-robotic, minimally-invasive approaches for these operations. Data are emerging that demonstrate beneficial results of the current practice, but the experience is small for making sweeping predictions. Clearly, the physical stress to perform surgical operations is reduced, so surgical robots are appreciated by surgeons who work more safely and proficiently! These systems cost approximately $1.4mil and add 30-40% to the OR

time costs for set-up. Experimental systems are being evaluated that allow a surgeon to conduct brain surgery while situated in an open MRI machine where real-time images guide the neuro-surgeon as s/he conducts procedures.

These systems are the basis for tele-surgical practices in which they are sited remotely, often in hospitals distant from skilled surgeons who may assist a local surgeon (tele-assistance), teach the surgeon (tele-mentoring), or conduct critical portions of surgical procedures (tele-surgery). Surgeons utilize tele-strators placed over the operative site to describe a proposed action, much as sports announcers use the device to explain a play or high-light a player during sports broadcasts. This practice of tele-'assistance' is growing as the medical-surgical profession explores the potential of incorporating the use of surgical robots onto surgical practice.

One can 'look into the future' to see that advances in imaging, modeling of tissues, and display systems will enable future surgeons to operate on a patients' hologram, edit the 'tape', and play the edited version in the robotic system the next day in the surgical suite, as the surgeon 'stands by'.

Another application of robotic technology is in medical team-training with virtual robotars that have been programmed, including vital signs, to represent potential patients requiring emergency diagnosis and treatment. SUMMIT has become the leader in implementing the Emergency Medicine Crisis Resource Management (EMCRM) method of training in 3D Virtual Worlds as had earlier been established in Simulation Centers with high-fidelity manikins. Adopted from Anesthesia Crisis Resource Management (ACRM), these are methods first utilized by the aviation industry in flight simulators. The current SUMMIT emphasis, jointly with Forterra, Inc., a video-game company, is on training First Responders at terrorist events.

These represent some of the current uses of robots in medicine, and issues of value arise. Is the cost-benefit ratio for the medical enterprise positive? Are the alternatives to using robots equally safe or less safe, and is unexpected harm to patients possible? How many procedures are required to be performed before proficiency is achieved? As with all emerging

technologies, their role must be defined, the cost-benefit ratio established, and their perceived value widely accepted before we can expect to find many of them on our next visit to our local hospital.