The New Kids on the Block: Emerging Medical Technologies

The most innovative and effective medical technologies of this century.

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Emerging from the computer-savvy era of compact touch-pad phones, crystal-clear television screens, and speedy computers is perhaps one of the more humanitarian applications of technological expertise. In a nation where the leading causes of death are heart disease, cancer and stroke, early and efficient detection of injuries and illnesses is crucial for successful treatment and recovery (cdc.gov). The advents of nanotechnology, biotechnology, and medical devices have significantly enhanced the ability of medical professionals to accurately diagnose and treat patients. It is too easy to underestimate the tremendous assistance that medical technology offers the American healthcare system. Detecting bone injuries and cancers has become a matter of turning on an X-ray machine. The recording of abnormal heartbeats and electrical signals would have been flawed by human error had the electrocardiogram not been incorporated as the standard for patients needing heart monitoring. By the end of 2006, the medical device market was worth $86 billion and employed over 400,000 workers in the bioscience sector. Yet the demand for technology, especially nanotechnology, is projected to grow by more than 17 percent annually, reaching $53 billion in 2011 (The Freedonia Group 2007). The medical community is on the fringe of delving into a new age in which advanced medical technology will make detecting disease easier and treating illness more effective. Topping the list of these cutting-edge medical devices are six new technologies that have proven to be both practical and effective.

Imagine a camera that can travel inside a gastrointestinal tract and film everything it encounters, including dangerous tumors. In 2001, the FDA approved a new technology called capsule endoscopy, which is used for diagnostic imaging of the gastrointestinal (GI) tract. Given Imaging became one of the first companies to develop an endoscopic capsule device, appropriately named the PillCam, as a way of detecting Crohn's disease, Celiac disease, benign and cancerous tumors, ulcerative colitis and other diseases of the stomach and small intestine. The PillCam requires a patient to fast for 10 hours prior to its use. The vitamin-sized capsule is swallowed and travels throughout the GI tract over an eight-hour time span. A single camera inside the capsule takes two snapshots every second, accumulating about 50,000 pictures by the end of its journey (Bren 2005). The images taken with the camera are sent to wire sensors found on a belt worn around the patient's waist. The images are compressed into a sequential format that plays like a video and reveals continuous footage that can be used for diagnosis by a physician. The PillCam passes out of the GI tract via excretion within 72 hours. PillCam Colon and PillCam Esophagus are also products of Given Imaging that offer a more specific target of imaging. In 2006, a reported 39.5 million people visited a doctor with symptoms of a digestive disorder. Since its release, approximately 700,000

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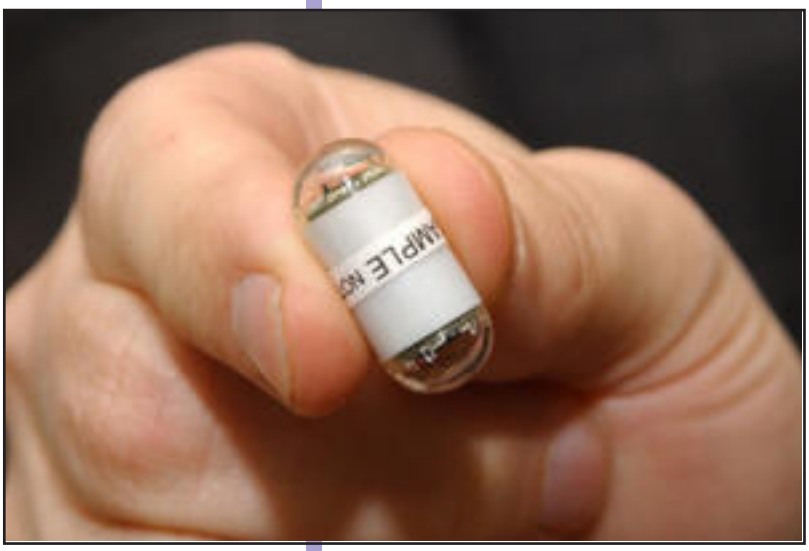
patients have completed the PillCam procedure (GivenImaging.com, 2008).

Other companies like Given Imaging have emerged with their own capsule endoscopy systems. The Sayaka capsule from the Japanese RF System Lab uses similar procedures as the PillCam, but incorporates a different internal mechanism in the capsule. A rotating camera inside the Sayaka capsule captures 30 two-mega pixel images per second (RF Systems Lab 2008). The capsule takes about two minutes to travel just one inch in the GI tract. Every 12 seconds, it completes a full rotation, producing a detailed view of the tissue walls. It is powered by induction charging, a method that eliminates the need for bulky batteries and instead uses off-site magnets. A vest with a coil continually transmits the power necessary to keep the camera motor running. Because the camera rotates 360 degrees, the Sayaka capsule is able to achieve a more complete and vivid record than that of the PillCam. Information obtained is wirelessly transmitted to an antenna in the vest and saved to a memory card.



http://medicine.creighton.edu/surgery/esophagus/pillcam.htm

The PillCam pictured is swallowed and used to take pictures of patients' GI tracts to detect diseases.

While a case ulcerative colitis may be simple manner of detection and treatment, life-threatening viruses are far more elusive, and quick detection and treatment is vital. In 2003, an outbreak of SARS in south China spread to neighboring countries, causing significant alarm to world health leaders who suspected a potential epidemic. The Center for Disease Control obtained samples of blood from patients inflicted with symptoms of the unknown virus at the time to Joseph DeRisi, a researcher at the University of California, San Francisco. DeRisi had invented a device called the ViroChip and within 24 hours determined that the SARS virus was a coronavirus, a type of animal virus. By identifying the type of virus, DeRisi helped to pinpoint what treatment methods were likely to stop the virus from spreading in the body. The ViroChip is composed of DNA fragments of every virus ever discovered (about 22,000 viral sequences) that are printed on a glass slide (DeRisi 2008). DNA from biological samples are mixed with a fluorescent dye and then placed on the ViroChip. Sequences of genes in the viruses found in the biological sample that share similarities with the fragments of viruses printed on

the glass slide glow due to their complementary ends that stick together. It is from these small fragments of printed viruses that the ViroChip is able to identify which viruses are in a given sample. However, the ViroChip can even find undiscovered viruses. Due to the fact that viruses evolve from each other, pars of their genome will remain unchanged and tend to match up with viruses implanted on the chip, revealing whether a certain virus has mutated. With the SARS virus, the samples were placed on the ViroChip and determined to match up to a known coronavirus. This allowed for public health professionals to quickly assess who had SARS and to begin a program of vaccinations and treatments. The ViroChip is now being used to study Plasmodium falcinarum, the parasite that causes malaria. Specific genes from the parasite have been isolated and matched with the disease and are now being added to the chip to effectively diagnose malaria.

The ViroChip is remarkable not only for its accuracy, but for its speed. Identification of a virus through the patient's blood can take considerably longer. Tests for Epstein-Barr virus and the HIV virus, for instance, involve checking for specific antibodies to the virus in the blood. These tests take time to withdraw the blood, scan the sample, and then diagnose the results, which delays the onset of treatment. With the ViroChip, a sample of the infected blood can be placed on the chip, and a virus can be detected with a simple indicative glow within a short time frame.

Perhaps even greater of a threat to human health than viruses is cancer, which causes around 13% of deaths in the United States (WHO 2006). Cancer occurs when there is an uncontrolled growth of cells that tend to destroy neighboring cells or spread to various parts around the body. Most cancers form tumors, which are clear indications of either benign (non-spreading) or malignant (spreading) cancer. Detecting tumors has thus become a standard for indicating the presence of cancer. Women are taught to give regular breast cancer self-examinations to feel for unusual lumps that could be tumors. Likewise, men are taught to regularly check for testicular cancer by checking for abnormal growths. Tumors that are not close to the surface of the body are more difficult to detect and require advanced imaging since they cannot simply be felt by touch. A team of European researchers working on project TAMIRUT has recently developed a method of detecting tumors using ultrasound. Ultrasound technology is frequently used for pre-natal imaging to determine the health and sex of a fetus in the womb. Because the sound waves are harmless and do not cause cancer themselves, ultrasound technology is both effective and safe. High frequency sound waves are aimed at the body and a probe is used to measure how they bounce off of different tissues. Standard ultrasound techniques are not typically used towards the detection of tumors. Project TAMIRUT, however, uses a microbubble medium that binds specifically to target pathogenic cells in the body by being attached to antibodies (TAMIRUT.net). The micro-bubbles are filled with a gas that changes the reflection of ultrasound waves that are sent back to a measuring probe. The result is a sonogram image that reveals the surface of a possible tumor.

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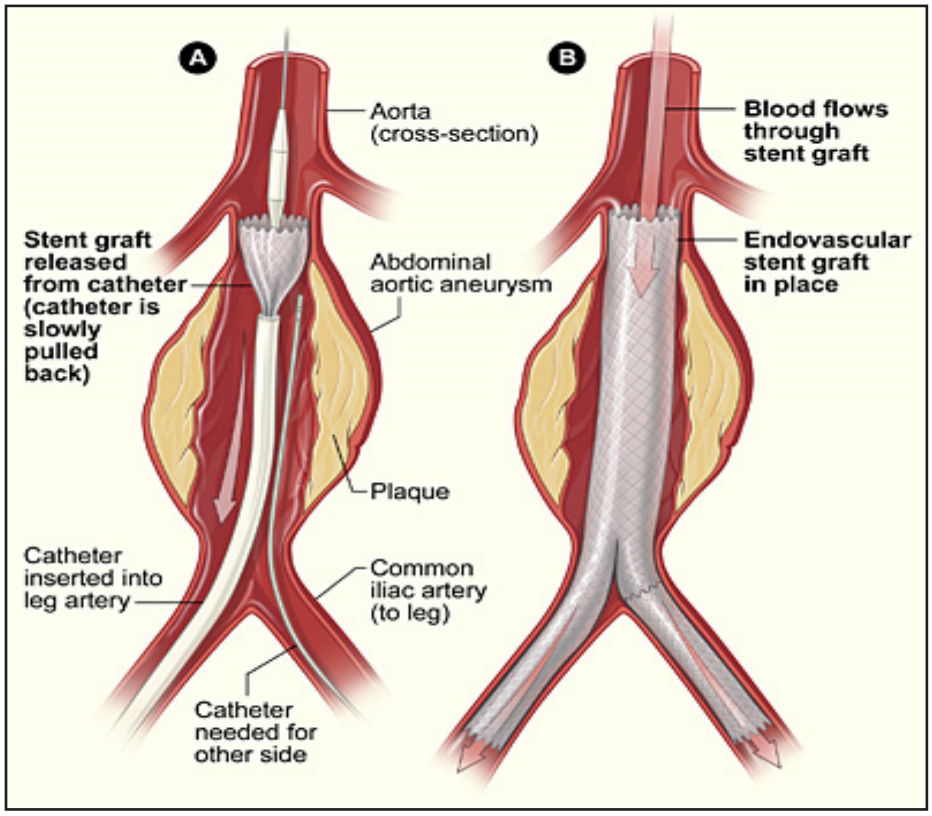
Detecting tumors, viruses and digestive disorders are only useful if they lead to effective treatment. Some diseases arise abruptly and evade even the earliest of detections of abnormality. One such disease is abdominal aortic aneurysm. It is estimated that around 5-7% of people above the age of 60 in the United States will have abdominal aortic aneurysms, an enlargement or



http://www.nhlbi.nih.gov/health/dci/images/aneurysm_endovascular.jpg

A stent-graft is used to hold the vessel open and prevent rupturing

weak area in the main blood vessel that carries blood from the heart to the rest of the body. Over time, the abdominal aortic aneurysm beaks down due to thinning of the vessel lining, putting the patient at risk for a rupture, which has a 90% mortality rate due to severe bleeding. Around 15,000 Americans die each year from an abdominal aortic aneurysm (Society of Thoracic Surgeons). The advent of stent-graft technology has significantly improved the likelihood of surviving. In this procedure, a long, thin tube called a catheter is used to place a stent-graft near the aneurysm to keep the vessel from rupturing. A stent-graft is a tubular metal sheath attached to the walls of blood vessels to keep them open. However, the stent-graft procedure is sometimes ineffective at stopping the vessel from expanding or rupturing, requiring frequent follow-ups and internal imaging procedures to check for expansion. To monitor for pressure changes and potential rupturing, EndoSure, a new medical technology, can be used. EndoSure is a pressure measurement system designed to measure the pressure of vessels during endovascular abdominal aortic aneurysm repair (CardioMems 2008). A miniature wireless sensor with radiopaque marking is implanted in the aortic wall during stent and graft. Changes in internal pressure of the aortic vessel result can be detected by the implanted sensor and sent wirelessly to an antenna placed over the patient's abdomen. An electronic module analyses the pressure in waveform and numerical form. EndoSure enables physicians to make speedy and efficient assessment of an aortic aneurysm by wirelessly receiving information from the implanted sensor. Mean pressure, systolic pressure diastolic pressure and heart rate are all included in EndoSure's measurement system (CardioMems 2008). The impact of such technology is that rupturing aortic aneurysms become less of a danger and more easily detected.

Another leading medical advance is Prosurgics' FreeHand, which works to make minimally invasive surgery easier for surgeons. Minimally invasive surgery is a surgical technique in which a small incision is made in the abdomen in or-

der to perform an operation. Since the physician cannot visibly see enough of the abdominal cavity through the incision, the surgery is completely dependent on a camera to go inside the abdomen and send back images. Prosurgics developed a miniature camera that has proven to provide camera assistance during long procedures in which human error would otherwise potentially lead to mistakes. The so-called FreeHand can be used for several general surgery procedures, including hernia repair, appendectomy and spleendectomy. OB/GYN, bariatric and urological surgery is also possible with the FreeHand. A wireless hands-free controller worn on a head band over the surgeon's cap controls the movement of the camera (FreeHandSurgeon.com). When the head of the surgeon tilts in either direction, the camera responds by panning or tilting. To zoom, an activation foot pedal must be tapped to switch to zoom mode. Moving the head down zooms in and moving the head upwards zooms out. The hands-free head movement used to control FreeHand allows surgeons to receive reliable visualization of the operation.

While minimally invasive techniques try to reduce the size of incision made during surgery, the PlasmaJet system aims at reducing the impact of the incisions themselves. Plasma Surgical was recently given the "Innovation of the Year" award of 2008 by the Society of Laparoendoscopic Surgeons for their PlasmaJet system. The PlasmaJet is a surgical system designed for coagulation and cutting during surgery. Intense energy released from a fine beam of pure plasma is concentrated onto target tissue to make clean, dry cut that coagulates surrounding liquids. Instead of an electric current that can cause deep burns and tissue damage, the PlasmaJet depends on electrically neutral plasma. When aimed at tissue, the PlasmaJet offers clean cuts that diffuse surrounding fluids through the kinetic energy that is released (PlasmaSurgical.com). It is ideal for when blood management is an issue during surgery since it rapidly creates a flexible coagulating layer. The PlasmaJet System is hand-held, leaving the movement of the cut up to the surgeon.

The leading medical technologies in the recent decade have revolutionized the way the American healthcare system operates. Diagnostics has been made easier with imaging that reveals internal tumors through ultrasound, digestive disorders through camera optics, and viruses with ViroChips. Medical technology has also transformed treatment methods. EndoSure attaches stent-grafts to the inner walls of aortic aneurysms to keep track of pressure and prevent possible ruptures. FreeHand assists surgeons in visualizing the abdominal cavity when it is not easily visible. PlasmaJet uses robotic technology to make clean and effective cuts. Technology has transformed the way the medical community is able to diagnoses and treat disease. Using robotics, cameras and biosensors, it is likely that disease will become more and more manageable. Accordingly, medical technology has proven and will continue to prove that technology greatly enhances human survivability and health.

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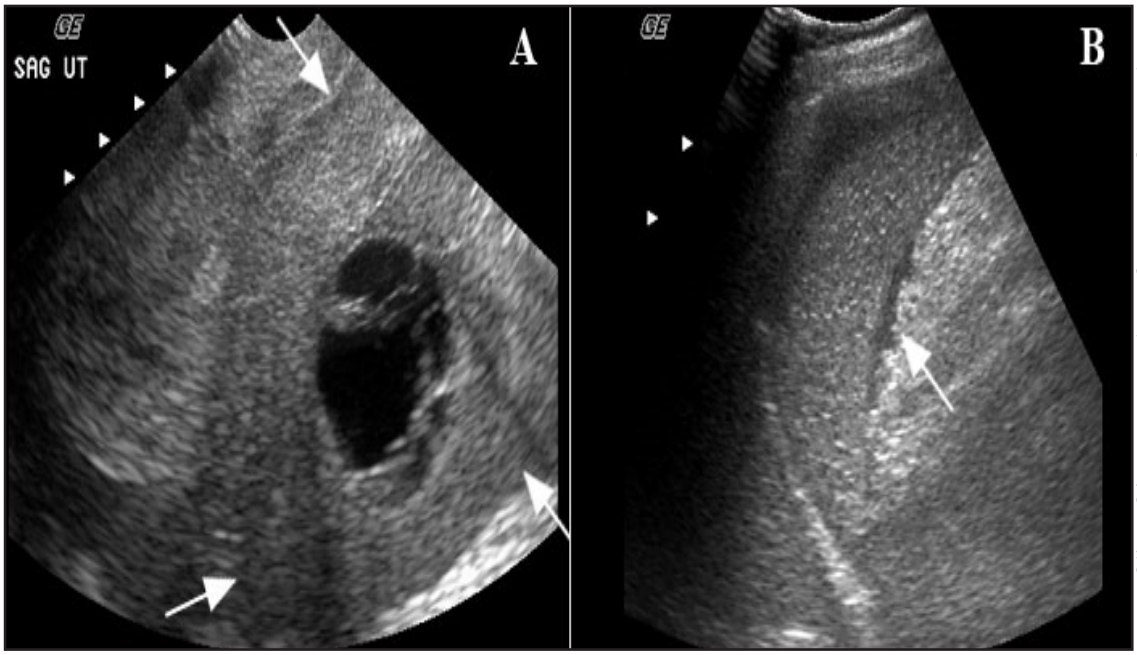

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Ultrasound technology is now being used to detect tumors and cancerous cells.

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