
The Evolution of Medical Imaging Technologies: Electric Meat and the Physician's Shifting Gaze

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Abstract:

The artifacts produced by medical imaging technologies raise questions about our physicality and what it means to be human. Looming death, the promise of healing, and perhaps ultimate transcendence compel us to allow the shift in medicine from human-driven to device-driven. It's conceivable that the radiographic image, or at least the perception brought about by the imagery of our inner selves, helped take us to that place. While both the patient and doctor currently remain necessary to the medical experience at some level, the imaging technologies make their location, time, and place less relevant, and lessen the significance of physical human interaction. At some point, the machine must analyze the patient and the doctor must analyze the machine's analysis, i.e., the images, but we face the possibility that never the two shall meet. Regardless, the medical images offer rich, complicated visual rhetoric from which to understand ourselves.

Keywords: medical imaging, visual rhetoric, medicine, physician patient relationship, digital, technology, photography, x-ray, MRI, CT scan, PET scan, science, medicine, radiology, radiological images

Abstract :**L'évolution des technologies d'imagerie médicale: Chairs électriques et changement du regard des médecins**

Les artéfacts produits par les technologies d'imagerie médicale soulèvent des questions sur notre physicalité et ce que cela signifie d'être humain. La mort imminente, la promesse de guérison, et peut-être la transcendance ultime nous obligent à accepter le passage d'une médecine où l'homme est la première motivation à une médecine où l'outil devient la motivation. Il est concevable que l'imagerie radiographique, ou du moins la perception qu'entraîne cette dernière de notre intériorité, nous ait poussé à prendre cette voie. Alors que la présence du patient et du médecin restent pour le moment nécessaires, les technologies d'imagerie rendent les interactions humaines de moins en moins importantes. A un certain point, la machine doit analyser le patient et le médecin doit analyser l'analyse de la machine, c'est à dire, les images, mais nous sommes confrontés à la possibilité que jamais le médecin et le patient ne se rencontreront. L'imagerie médicale offre une rhétorique visuelle riche et complexe qui nous permet de nous comprendre nous même.

Mots clés: imagerie médicale, rhétorique visuelle, médecine, relation médecin patient, technologie digitale, photographie, radiographie, IRM, balayage tomographique par ordinateur, tomographie par émission de positons, science, médecine, radiologie, images radiologiques

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Introduction

The artifacts produced by medical imaging technologies raise questions about our physicality and what it means to be human. Looming death, the promise of healing, and perhaps ultimate transcendence compel us to allow the shift in medicine from human-driven to device-driven. It's conceivable that the radiographic image or at least the perception brought about by the imagery of our inner selves, helped take us to that place. While both the patient and doctor currently remain necessary at some level, imaging technologies make their location, time, and place less relevant and lessen the significance of physical human interaction. At some point, the machine must analyze the patient, and the doctor must analyze the machine's analysis, i.e., the images, but we face the possibility that never the two shall meet. The medical images created from these encounters can offer rich, complicated visual rhetoric from which to understand ourselves.

Advances in radiology –including uses for magnetic resonance imaging (MRI), computed tomography (CT or CAT) scans, nuclear medicine, and ultrasonography– give physicians a window into the body that shows objective evidence of disease and decreases their reliance on the patient's subjective complaints. The time when doctors had only their five senses and the patient's own observations to diagnose ailments is long gone. The stethoscope, which remains a symbol of authority, now hangs on a doctor's neck more than it is pressed to a patient's chest. With technologies that allow a view of the human body from the inside out, images provide the doctor with more information than does the patient himself.

The capture of reality in an image has always fascinated us. It preserves us indefinitely; there is no doubt we existed, if for just that moment. According to Lyotard (1984), the photographic and cinematographic productions gave us something that we wanted; they preserved "various consciousnesses from doubt" (p. 74). We must exist. The radiographic image – which we could consider the über photo, if it were a photo at all – might do the same, though it is a visual rendering of data produced by the body rather than what most people consider "reality". Understanding something of the x-ray, CT scanning, and MRI helps us to see how the technologies have affected society over the past century and how the mere possibility of the images may affect our consciousness.

Brief history of medical imaging

Physicist Wilhelm Conrad Röntgen devised the x-ray machine in the late nineteenth century, receiving the Nobel Physics for the discovery in 1901. The technology fascinated scientists and the public. His contemporary, physicist Joseph John Thomson (1896/1999), discoverer of the electron, spoke about the significance of the “Röntgen rays” at Cambridge University. “This discovery, as you see, appeals to one of the most powerful passions of human nature, curiosity, and it is not surprising that it attracted an amount of attention quite disproportionate to that usually given to questions of physical science” (p. 100). In an 1896 headline, the science publication *Nature* hailed the x-ray as “a contribution to the new photography” (Lockyer, 1896/1999, p. 101). While science was giving birth to radiology, views of the body began to change. People could see beneath the surface of a living person. In 1896, Scientist William Lockyer (1896/1999) describes the result of an early x-ray image of Mrs. Röntgen's hand (Figure 1):



Figure 1: X-ray image of Mrs. Röntgen's hand (Röntgen, 1896)

“It will be seen that the flesh is very nearly transparent for these rays, while the bones, the gold ring, the piece of wire and the glass tube are practically opaque. The ring and wire, which were naturally in contact with the flesh of the fingers, appear in the illustration as if suspended in the air.” (p. 101)

The flesh becomes transparent.

In a related development even before Röntgen's discovery that would ultimately lead to the field of radiology and an understanding of the human body, Charles Babbage was taking steps to create an infallible machine. In *The Difference Engine*, Doron Swade (2001) tells the story of Babbage's quest to build the first computer in the early 1800s. He describes Babbage's motivation: "The 'unerring certainty' of mechanism would eliminate the risk of human error to which numerical calculation was so frustratingly prone. Infallible machines would compensate for the frailties of the human mind and extend its powers" (p. 1). Over a century later, those infallible machines would eventually merge with imaging technologies to transform modern medicine.

Amidst the development of the x-ray, the world was discovering electricity, telephones, automobiles, air flight, the vacuum cleaner, and the teddy bear, and experiencing the inexorable march of technological progress (even if it was an exercise in running in place, borrowing from the Red Queen hypothesis of evolution) (Ridley, 1993). While medicine was also making great strides, gender issues arose and society struggled with the notion of a male doctor examining a female patient's erogenous zones. There were charges of seduction and sexual abuse (Ehrenreich and English, 1978, p. 54). "How could a woman, especially a lady, expose her most private parts to his peerings and pokings?" The controversy paved the way for female doctors who crusaded at the time "for female health, for morality, for decency" (Ehrenreich and English, 1978, p. 55-56). In a fortuitous way, the development of the x-ray around this same time seemed to allow doctors to see the inner workings of their patients of any gender with neither doctor nor patient experiencing the discomfort, displeasure, or shame associated with the physical exam.

The x-ray captivated people's attention. In 1897, x-ray images were used to find bullets in the Balkan War, and some believed the technology could "transmit thoughts, restore vision to the blind, [and] raise the dead" (Smith, 1995). X-rays took on rather Frankensteinian implications, all the while intriguing and beguiling the public. It took years—actually until around 1970, when the practice totally went out of use—before the side effects of radiation convinced the public that they did not need to x-ray their children's feet to ensure a set of well-fitting shoes.

In the mid-1970s, the CT scan came into use, which combines computer and x-ray technologies to provide cross-sectional images of any region of the body. Arun Dhand, M.D., a physician at Ormond Beach-based Gastroenterology Consultants, has been a gastroenterologist for over 25 years. He says that, over that time, imaging technologies such as CT scanning have considerably enhanced his ability to identify disease and made diagnoses more accurate. "A

patient may present with abdominal pain and weight loss, with normal physical exam, and if I suspect serious intra-abdominal disease, a CAT scan of the abdomen may find a tumor that I can't feel," Dhand says. "What the human hand can't feel, the CAT scan or MRI can feel for you."

CT scanning has recently become popular as a "wellness" diagnostic tool to search for problems in the body where no symptoms exist. Ironically, its use has recently been linked to an increase in the chances that a patient will get cancer. A study by the journal *Radiology* (Brenner and Ellison, 2004), shows that a single CT scan can increase a patient's chances of getting cancer by .08%, and an annual CT scan for 30 years would increase the lifetime risk of cancer by about 1.9%. Nonetheless, in our vigilance against disease, the scans have become one more tool to insure our wellness. Oprah Winfrey had a whole body scan on her television show a few years ago, causing its popularity to soar. Dr. Wiesman of the Austin Radiological Association projects that "if a large enough population does wellness CT scans, we're going to increase the number of tumors in the population as a whole" (McArthur, 2004). In any case, the machines work quickly, are relatively accessible, at least to those in most Western countries, and continue to scan for disease in a healthy population. However, outside of sonography and mammography, most scanning is done when a patient presents with symptoms. It may only take a few minutes to scan a patient's head or abdomen. After that, the radiologist and treating physician can view a digital image almost immediately. "If a patient had a CAT scan at 10:00 a.m., at Memorial Hospital, I can look at it at 10:05," Dhand says. "I generally look at the films before I make my rounds, so I can correlate a patient's clinical picture with the scans."

When CT scanning came into wide usage, magnetic resonance imaging was in its early stages. MRI uses a giant magnetic field –with strength of more than eighty-thousand times that of the earth's magnetic field– rather than radiation to peer into the previously impenetrable. Jim Feeney (1996) offers a beautiful technical description:

"All atoms consist of outer shells of negatively charged particles called electrons buzzing around in diffuse clouds, and a dense central portion called the nucleus. Some of the nuclei behave like small bar magnets and when placed in a powerful magnetic field, about half line up in the direction of the magnetic field and about half line up in the opposite direction. By providing energy in the form of radio waves these tiny magnets can be caused to change orientation, to resonate absorbing energy at a resonance frequency that depends directly on the strength of the magnetic field. While the magnetic field is changed slightly this resonance frequency also changes in a predictable fashion. [...] More than half the human body is composed of water which as everyone knows has two atoms of hydrogen joined to one atom of oxygen – H₂O.

Fortunately, hydrogen has all the right properties to demonstrate the magnetic resonance effect. So your body contains more than one thousand billion billion water molecules, each acting as a sensitive radio transmitter capable of reporting on its location, its state and its surroundings.”

This is the human body: electric meat. While scientists have understood, relatively, the basic composition of the body for generations, medical imaging provides visual evidence. The MRI, for example, breaks us down to our nuclei, our smallest known part.¹ It performs the ultimate deconstruction. One of the most exciting applications of MRI is the study of the human mind. In contrast with other imaging technologies, MRI lacks the health hazards of radiation and actually has no known negative side effects at this time (except for the patient whose body contains any type of metal). The medical community met the development of MRI with skepticism, but it has since emerged as a very powerful and widely used imaging tool (Feeney, 1996).

Doctors have dozens of other radiological technologies at their disposal. Mammography and sonography are the most common. Sonography uses sound waves to construct an image. A study of the types of procedures used by diagnostic radiology practices showed that 95% of those surveyed used mammography, and 94% performed sonography (Sunshine and Cypel, 2004, p. 1193). Both of these systems are used primarily for wellness checks; mammography evaluates for breast cancer and sonography is most commonly used to view a fetus in utero. The technologies are often serving a healthy population, who wants to stay that way, but sees their demise on the horizon. For these healthy people, technology offers insurance against the insidious advance of disease in the body. For the unhealthy, a surgeon can use visual technologies that convert the patient's corporeality into a data cloud or code that the surgeon then essentially rewrites to eliminate the error of illness. A laparoscopic surgery experience illustrates how the surgeon tethers himself to the patient through the visual technology. Here, the camera becomes the surgeon's eye and the patient's interior is viewed through a monitor.

Observations from the OR

The patient lies in the shape of a cross, on her back with her arms extended, in a chilly, well lit room. A cap covers her long, straight blond hair. The 38-year-old woman's curvy body is draped in sterile blue sheets. Dr. S, an anesthesiologist, stands by her head inside a half circle

¹ Our smallest known part, notwithstanding quirky quarks and other tiny things that very few people understand.

of monitors and other medical equipment. A surgical technologist tends instruments on a tray while the patient, still awake though tranquilized, mentions that she used to smoke, but that she has quit smoking, and that she is nervous about the surgery. She is real.

At 9:35 a.m., Dr. S glances at colored bars on a screen. He is monitoring the multi-function machine that displays the patient's vital data—the data that divulges whether the patient is functioning properly, imminently dying, or dead. She is currently alive. The machine detects and converts heart function, oxygen saturation, carbon dioxide levels, airway pressure, and blood pressure into digital data and displays the information on a screen in an audio/visual format. Dr. S hears a rhythmic beep as he watches lines and numbers on the computer monitor that assess the patient's physical well being. He could just as easily monitor the patient from another room. Her corporeal presence is not strictly required.

"It will tell me that I have a problem even before I can imagine it," Dr. S says of the multifunction monitor.

Dr. S says this with some irony, as patients' lives depend on their physicians' imaginations—the minds that can envisage the modification of the human body from the inside out. The anesthesiologist and surgeon's imaginations must also predict thousands of possible outcomes to individual actions and decide exactly how to proceed when any one or combination of those outcomes occurs. An inventory of medical technologies has helped physicians in both regards, including the system used by Dr. S.

While understanding the full meaning of this data requires extensive training, the monitor makes it quite clear when the body's functions have gone awry. The normal lines and beeps emanating from the machine have cadence; they are musical, in a sense. The rise and fall of the stomach, the thump of the heart, and the pulse that lightly beats against the skin are the body's beats. On Dr. S's monitor, the rise and fall of lines on a screen and the steady beep of the machine give observers a baseline by which any deviation triggers alarm. The anesthesiologist says deaths attributed to anesthesia have dropped from 1 in 10,000 to 1 in 250,000 over the last decade in large part due to these systems. Generally, though, each patient cares about the 'one' more than the 249,999 others. Dr. S covers this patient's face with a mask and she slips into unconsciousness. He inserts a tube into her throat and tapes her eyes closed. The patient communicates through her data and lies at the will of those she has entrusted with her care.

A surgical technologist adjusts the patient's blue sheets. He opens the patient's dressing to expose a rectangular area on her abdomen, which will serve as the surgeon's doorway to the internal body. A sheet is raised at an angle above the patient's neck to obstruct her view of the surgical area in the unlikely event that she awakens from anesthesia in the

middle of the operation. Seeing one's own viscera can be traumatizing. Despite the popularity of medical reality shows that show surgeries on various body parts in full, fleshy detail, the recognition that we are electric meat does not come easily. This is particularly true of those knowing that a sharp, metal blade has pierced their flesh.

Everyone in the room wears a face mask to help prevent infecting the patient with germs, a risk reduced by the small incisions of laparoscopic surgery compared with the traditional procedure. Conversation flows easily between the surgical team members, though it takes practice to communicate without the usual facial expressions –visual cues– to understand meaning. People who work the operating room learn to express and interpret emotion through their eyes. Raised eyebrows, crinkled eyes, widened eyes, or a slightly prolonged stare take on heightened meaning in the OR.

At 9:50 a.m., Dr. D, a general surgeon and, reportedly, a concerto pianist, enters. His colleagues, employees, and patients seem to venerate him, stating that he has exceptional skill in the operating room though lacks affability. Surgeons are often thought of as controlling and cold. Watching the reverence with which one is treated by other medical professionals in the sanctum sanctorum of the operating room may explain how such arrogance would develop; however, there is no conclusive evidence to suggest that the stereotype is true. Fixing flawed bodies is the test by which surgeons are judged. It takes nerve. While a chilly disposition may not be an admirable trait, this patient appreciates the conceit that allows her surgeon to drive a scalpel into her body and come up aces. A scrub nurse dresses Dr. D in a gown and gloves.

"Tell me what I'm doing," Dr. D says with a clout particular to surgeons.

He is doing a laparoscopic cholecystectomy – gallbladder surgery guided by a camera. Surgeons perform thousands of these surgeries every year; they have replaced the traditional cholecystectomy, which required a five- to eight-inch incision, greater recovery time, more time under anesthesia, and greater risk to the patient. Gallbladder removal overall is the most common surgery in the world. Losing the organ itself seems to pose no risk. The gallbladder is a pear-shaped organ that stores bile produced by the liver before dumping it into the small intestine, but the body seems to get along fine without it. Sometimes, as in this case, small stones form that cause an obstruction that discomforts the patient, usually after eating fatty foods.

For weeks, this patient had complained of severe upper-abdominal pain at night. She saw her physician, who ordered a hepatobiliary iminodiacetic acid (HIDA) scan to evaluate her condition. During this procedure, a radioactive tracer was injected into her body through an IV line, which collected in her liver and gallbladder and gave off gamma rays. A special camera

took pictures of these rays. Her radiologist and physician then had images that indicated a need for gallbladder removal and referred her to a general surgeon.

The surgeon draws lines on the patient's body with a marker. He then uses a scissors-like tool to cut a hole in her belly button; he cuts three more small holes in her abdomen. He inserts the laparoscope, a tool with a small camera connected to it, through the navel.

"Kill the light," Dr. D says.

The light that shines on the patient dims. A technologist takes hold of the camera. In some ways, the success of the operation depends upon him, though he serves at the behest of the surgeon. The surgeon's gaze shifts from the patient to the color monitor that displays the magnified images of the patient's innards, illuminated by a small light attached to the camera. Carbon dioxide is pumped into the abdomen to help the surgeon see and maneuver the terrain. At 9:55 a.m., the cameraman moves the camera through the inside of the patient. Veins, an artery, yellow fat, and flesh become visible. Soon, the liver appears on the screen, as does the pancreas. Dr. D uses pinchers inserted through one of the incisions to move things out of the way.

With seemingly little effort, Dr. D finds and separates the gallbladder from the liver and ducts. Watching the camera all the while, he staples the cystic duct that delivers the bile and uses a hook electrode to burn the edges of the gallbladder. Throughout the procedure, he makes decisions based on the screen's moving images about what looks normal and what does not. He must decide what should be cut, pushed away, stapled, or otherwise attended to and what must not, under any circumstances, be disturbed. The surgeon toggles between the video representation of his patient and her physical body, with a predilection for the visual representation. He cannot obtain enough information from the flesh as a whole, so he must turn the patient's body into a visual signal, magnifying the fragment of her that requires revision. Her body as a whole provides superfluous information that hinders the surgeon's ability to solve the problem at hand – her defective gallbladder. Her body sends redundant signals. Therefore, he must dispense with the body as a whole and focus on fragments of it, visually captured and reconstructed on the screen by the imaging technologies. He studies her as a text in need of revision.

One of Dr. D's colleagues, another general surgeon, says that a difference between operating based on a screen image and navigating the actual body is a change in one's sense of touch. The traditional cholecystectomy is a visceral operation; surgeons delve more blindly into the abdominal cavity, relying heavily on the sensation in their fingers to decide where they are in the body and what to do there. With the prevalence of video-guided surgery, the body becomes the source of the image and the surgeon must focus on the image rather than the

body itself. The surgeon has a new medium – that of the screen or monitor – which communicates a continuous stream of information about the patient in the form of moving images. If a photograph or the series of still frames that comprise film are generally considered artifacts of the past, perhaps we could deem the surgeon a historical revisionist. The body is itself a text—forever changing, subject to revision, unknowable. Surgeons not only “read” and interpret it, but physically participate in the body’s making and unmaking, “authoring” or “coding” us through their clinical interventions.² The study of medicine becomes digital media discourse.

The surgeon revises this patient so that her bile can flow freely. Through a hole in her upper chest cavity, he pulls out three slimy, cherry pit sized stones and a bile bag. He breaks the bag onto the patient’s chest and a primordial greenish-yellow fluid flows out. Dr. D removes the offensive gallbladder through the hole and finishes the operation. The camera and other instruments are pulled from the patient’s abdomen. At 10:05 a.m., the lights are turned back on. The images vanish from the screen and all attention reverts to the body on the table. The surgeon sews the patient’s wounds with blue thread and leaves the room.

The body’s visual rhetoric

The human spirit, or at least the human, wants more than anything to exist. Currently, that existence as we know it relies heavily on the human body. What is the purpose of medical imaging technology above and beyond finding heart defects, stones bathed in bile, and secret festering tumors? “To fuse the machine and the visceral, and ultimately to challenge mortality and prolong life [...] Scanning devices such as MRI, PET, and electron microscopy present fascinating interior landscapes never seen before,” states Michele Theunissen, curator of an exhibition on art, medicine, and the body. Theunissen questions whether the technology will change the way we imagine ourselves, or whether we will “remain foreigners to the medical depiction of our bodies” (quoted in Wilson, 2002, p. 193). These machines offer us the truth, and despite the fact that most of us have an utter lack of understanding about how they work, we have great faith in their results.

Radiological equipment shows the human as it has never been seen before. Yet, an MRI, CT, or x-ray image shows nothing that looks even remotely like flesh and blood. It offers a pixilated version of the body. Consider Seltzer’s (2004) poetic description of what a surgeon

² Medical and personal narratives fuse here, stories bound together by a spine.

sees after just opening a living body with a scalpel. "And there is color. The green of the cloth, the white of the sponges, the red and yellow of the body. Beneath the fat lies the fascia, the tough fibrous sheet encasing the muscles. It must be sliced and the red beef of the muscles separated," says Seltzer. He goes on:

"Deeper still. The peritoneum, pink and gleaming and membranous, bulges into the wound. It is grasped with forceps, and opened. For the first time, we can see into the cavity of the abdomen. Such a primitive place. One expects to find drawings of buffalo on the walls. The sense of trespassing is keener now, heightened by the world's light illuminating the organs, their secret colors revealed—maroon and salmon and yellow. The vista is sweetly vulnerable at this moment, a kind of welcoming. An arc of the liver shines high and on the right, like a dark sun. It laps over the pink sweep of the stomach, from whose lower border the gauzy omentum is draped, and through which veil one sees, sinuous, slow as just-fed snakes, the indolent coils of the intestine." (p. 80)

Medical images do not replicate or illustrate the visceral beauty and complexity that Seltzer describes. Radiological machines create a digital image of a patient, which resembles a machine more than the patient. Are we all turning into machines? In *How We Became Posthuman* (1999), Hayles discusses Hans Moravec's belief that this is true. "Humans can either go gently into that good night, joining the dinosaurs as a species that once ruled the earth but is now obsolete, or hang on for a while longer by becoming machines themselves," Hayles states, summing up Moravec's views (p. 283). While radiology has not turned us into robots, it is possible that our power to see inside is changing our views on the body as a machine.

The idea of the human body as a mechanism is old; Leonardo da Vinci, for example, described the body as a machine and created magnificent art by interpreting its machinations. Radiological images reinforce the idea of the body as a machine and as art and offer us new views into ourselves. These images change the way we see ourselves and our diseases. The images may be a digital representation of the human form; or, perhaps the digital is real and flesh represents us outside of the computer. Whatever the case, we do not see flesh in a CT scan. We see intricacy, nuance, circuits, and bursts of color, and we also see hollowness. Where is the ghost in the machine? Stephen Pinker (2002) asserts that no ghost or mystical spirit resides within us, and that that idea bothers people: "It can indeed be upsetting to think of ourselves as glorified gears and springs. Machines are insensate, built to be used, and disposable; humans are sentient, possessing of dignity and rights, and infinitely precious" (p. 10). He explains that regardless of our religious faith, or lack thereof, most people choose to

believe in some type of immortality or soul, and the idea that our body is a machine upsets our beliefs about human purpose, such as love and art. "And of course if the mind is separate from the body, it can continue to exist when the body breaks down, and our thoughts and pleasures will not someday be snuffed out forever" (p. 10). We want everlasting life and to know with certainty that our soul, if not our body, lives on.

Nietzsche describes the "internalization" of man and man's development of a soul. "The entire inner world, originally as thin as if it were stretched between two membranes, expanded and extended itself, acquired depth, breadth, and height, in the same measure as outward discharge was *inhibited*" (2004, p. 84). He contends that no order exists in reality, and it is the purpose of art to make that order. Medical body images have moved into the realm of art, and make order of what we are closest to –ourselves– but have never seen. Artists are using the images produced by the machines (perhaps even the machines themselves) to give order to the human, just as artists have always done through painting, sculpture, and photography. "More than making visible the invisible, art needs to raise our awareness of what firmly remains beyond our visual reach but which, nonetheless, affects us directly," says artist Eduardo Kac (quoted in Wilson, 2002, p. 91).

Alexander Tsiaras did just that with his remarkable exhibition at the National Museum of Health in Washington, D.C., and his book *The Architecture and Design of Man and Woman*. Tsiaras has assembled 500 color images constructed from digital slices of the human body, using most of a 10,000 volume library of anatomical images from various research centers. He describes the images as "reconstructions of scans" rather than photographs or pictures (quoted in Squires, 2004). The reconstructions offer what we still cannot achieve to a great degree in reality. A *Washington Post* journalist, Sally Squires (2004), describes one of the pieces:

"The images startle, their subject appearing at once familiar and foreign. It is the human body as you've never seen it, with its intricate layers of tissue, bone, and skin – and most of the vital systems in between – simultaneously and gorgeously rendered in images whose color, clarity, and depth evoke the masterworks of Renaissance painters."

"This is where art meets science" (Tsiaras quoted in Squires, 2004). Tsiaras uses images that are hundreds of times higher in resolution than typical medical images, and constructs them in three dimensions. He and his colleagues produced one image that shows a body's range of motion by taking a spiral, whole body CT scan and removing the muscles, fat, and other body tissue, leaving the skeleton. They then merged that image with a performance of a fast motion dance, creating a remarkable representation of the human in motion. Some of

his pieces show only body parts. "Twisted vines that snake along a forest's strange and spongy floor are actually capillaries running through the thyroid gland," describes Squire. "What appear to be irregular stacks of wooden planks are the building blocks of collagen and bone." Tsairas explains the work of creating this art as "looking at God's puzzle" (quoted in Squires, 2004). A puzzle is meant to be solved, or at least indicates that a solution exists. Medical imaging takes the puzzle of our bodies and attempts to find a solution. The machine captures the image, converts it into tiny data, and puts it back together on the screen to give us new information about our physical state of being; the process used in this text also breaks images into smaller pieces and reconstructs them to create meaning and change the way that we address problems.

Medical imaging technologies are changing the way that we look at our bodies and our doctors. We can see our bodies as they are and as they are not. The images are digitized and electronic and yet reveal the very corporeal imperfections of the flesh. We do recognize the power of medical technology over our lives, in that it can seek and destroy disease and lengthen our lives. It cannot at this time, however, offer us freedom from suffering or immortality. It cannot do exactly what we want it to. Pinker (2002) says that "images are said to have insidious power over our consciousness" (p. 213). He describes a postmodern view that we inhabit a world of images rather than a real world with images in it: "In other words," states Pinker, explaining a theory that he ultimately disagrees with, "if a tree falls in the forest and there is no artist to paint it, not only did the tree make no sound, but it did not fall, and there was no tree there to begin with" (p. 213). Few would assert that if we did not have a representation of our inner selves, we would somehow exist less or fail to exist at all. But medical imaging does offer us more of an understanding of ourselves and how our bodies function. The images show us that we are not special and that we are. The ability to see all of our body's gears, wires, and pumps that keep us functioning on earth, helps us understand the secret lives of our bodies, ourselves.

Expanding use of medical imaging

The radiology has moved from the x-ray of 1896 to a mystical myriad of body imaging technologies, including PET scanning and applications in nuclear medicine and many subspecialties and variations of the primary radiological functions. While some of these imaging capabilities have been around for years, recent advances and an aging population are fueling the demand for them. In the past, radiology departments had darkrooms that developed each

film and produced a physical image and many still do. These films have to be manually carried from place to place and stored for years. Lost films are not uncommon. The transition from film to digital storage makes using the images easier, cheaper, faster, and more efficient. Dan Miles, M.D., radiologist for Daytona Beach-based Radiology Associates, explains how not only the prevalence, but also the capabilities of radiology have increased, partially as a result of the transition from film to digital imaging. "The technology of the CT scanner, for example, has improved so we can take thinner and clearer images than we could before," Miles says (2004, Oct. 31 - Nov. 14, personal interview). From the development of HDTV to hi-resolution miniaturized portable device screens, digital images are becoming crystal clear on media in popular culture and medicine.

Use of medical imaging technology has risen sharply over the past several years as a result of the benefit in diagnosis and even treatment of ailments with interventional radiology. Financial motivation is also a factor. While insurance companies and medical guidelines that regularly deny claims may discourage some excessive scanning, the expensive machines needed for these services make money only when they are in use. These fiscal needs combined with litigation-wary physicians and a patient-base savvy enough to know that machines can see where their doctors cannot creates a situation where the use of medical imaging will continue to increase.

At this point, patients still expect their doctors to physically examine them. This could, theoretically, change. Imagine a time when a patient would receive scans in a radiology department based on a physical complaint, such as pelvic pain. A gynecologist would view the images in her own office, confer electronically with the radiologist, and then prescribe treatment without ever meeting the patient. So far, this does not happen to a large extent. "Certain things are time honored. You still have to be able to sit down with your patient, talk to your patient, examine your patient," says Dhand. "The question is whether the new technology will change the patient/doctor relationship."

It is true that doctors may now order a scan before seeing a patient, i.e., sending a neurological patient for a CT scan before seeing the neurologist, but Harry Black, associate medical director and chief of general surgery for Florida Health Care Plans in Daytona Beach, says that such situations are atypical, and we are not on the cusp of eliminating the doctor or patient:

"I don't think we're anywhere close to taking the clinician out of the picture. It helps clarify for me something that I may have operated on routinely ten or fifteen years ago. Now on the basis of the scan, I figure out now if I need to operate. It doesn't take

the physician out of the decision-loop and it doesn't take the patient out, either."
(2004, Oct. 31-Nov. 14, personal interview)

Black uses radiological results to aid in his decision-making process, but the technology is nowhere near being self-sustaining – the machines aren't thinking yet, in a practical setting at least.

Doctor-as-god, inscribing machines, bodily revision, and the patient's voice

The machines are not thinking, but they are inscribing, according to Hayles (2002). The medical imaging machines fit into the category of "inscription technology," in that they "*initiate material changes that can be read as marks*" (italics in the original) (Hayles, *Writing Machines*, p. 24). If Black, a surgeon, is one of Hayles' post-humans, he might also be an inscribing machine in that he initiates changes in his patient's bodies that can be read as marks. Beyond the physical body revision, he leaves marks that he and others read later. The incision, for instance, is viewed as evidence and later read, in a follow up visit, in terms of how it has changed (i.e., is it healing well? any evidence of infection?). The patient may also read the incision as symbolic of infirmity, physical vulnerability, or something representative of the surgical experience.

To the patient, doctors and their technologies are becoming integrated, their powers pooled. The CT scanning machine and other equipment have become a gateway to health. In many cases, the patient endures the radiating of her body so that the machine may light up the cancer, heart murmur, blockage, or various other ailments. "[O]ne result of the new noninvasive imaging technologies in the area of medicine is the capability of turning a person inside out ... It conjures up foreboding visions of an all-powerful observer who has instant visual access to the anatomy, biochemistry, and physiology of a patient," says Victoria Vesna, an artist and professor at UCLA (quoted in Wilson, 2002, p. 152). Vesna questions access to areas that used to be private, but are now open for unprecedented surveillance. The public seems willing to sacrifice access to their most private places in exchange for life. We don't want to die. If we submit to the machine, we may beat death for a little while longer.

While doctors have always used technological tools, the power and possibilities of seeing inside the living human body through radiation, ultrasound, and magnetic resonance gives them a divine authority that exceeds historical precedent, and paradoxically, makes them less germane to the patient/doctor relationship. Patients' expectations of doctors are shifting.

With the development of computer-aided diagnosis, algorithms that detect abnormalities, and technologists evaluating images, the doctor becomes technically less relevant, but more mysterious – a God-like entity behind-the-curtain. The opportunity to accept the role of an omnipotent power has always been tempting. German physician and professor, Linus Geisler (1991), says that doctors must resist the temptation to play God:

“The seed of temptation is laid in the nature of the medical profession, in that the doctor finds that he is regarded as god, or that he becomes like one. As more and more technical power is available to the doctor, he is in increasing danger of being regarded in the role of god, whether or not he is in agreement.”

If the view of doctor-as-God increases in relation to the power of medical technologies, it is consistent that we may be seeing the technologies as a part of the doctor. Some doctors readily consider the stethoscope, the eyepiece, and the scalpel as sometimes powerful extensions of themselves. Surgeon and author, Richard Seltzer, M.D. (2004), describes the scalpel in his essay “The Knife”:

“I still marvel at its power—cold, gleaming, silent. More, I am still struck with a kind of dread that it is I in whose hand the blade travels, that my hand is its vehicle, that yet again this terrible steel-bellied thing and I have conspired for a most unnatural purpose, the laying open of the body of a human being.” (p. 79)

A surgeon lacking a scalpel has never been much use and might admit as much. But, doctors appear to distinguish between tools and machines; tools are an acceptable extension of self, while the idea of a machine as a tangible part of the doctor may be considered a failing. And, in medical imaging, not only does the focus shift from the doctor to machine, but then from machine to a mere image – a visual representation of the patient. The tool requires touch, while the doctor –or even an un-god-like technologist– operates the machine from afar. To move from tool to machine takes the management of medicine from the Taylorism described by Jon McKenzie in *Perform or Else* (2001) to a performance management model. According to McKenzie, Taylorism produced centralized bureaucracies controlled by a few. “Performance Management, in contrast, attunes itself to economic processes that are increasingly service-based, globally oriented and electronically wired” (p. 6). This type of system empowers people, i.e., patients, with information that allows them to contribute to decision-making. McKenzie goes on to state that computers and electronics, along with telecommunications, provides us with the most profound technological performance (McKenzie, 2001, p. 11). Certainly medical

body imaging technologies fall into this category, though there is not necessarily a one-to-one correlation between performance management and the shift in medicine arising from technological advances. The doctor still holds the key to the machine, and by extension, the key to a patient's health. That may change as the patient-as-consumer undergoes a shift in expectations of medical care and access to health.

Many people believe that their "right to health" is being denied when they are unable to receive the medical care that they feel they need. Waits for a mammogram can be weeks or even months in the U.S., and then the scans must be interpreted by a radiologist. Few patients would permit a non-doctor to use the scalpel during an operation, but when a medical process requires no touch or invasiveness –no violation of the body– a patient's expectations may be different and open the door for trained technologists to administer and review medical images without the direct supervision of a trained radiologist.

Before the late twentieth century, most doctors relied heavily on physical exam, observations, and intuition, where they listened to patients' complaints and performed a sort of laying on of hands to diagnose, and sometimes treat, illnesses. The doctor touched each tool he used –scalpel, speculum, stethoscope– which in turn touched the patient. Each tool was a physical extension of his hand, eyes, or ears. The patient was integral to the exam, the diagnosis, and the treatment, at least in terms of a physical presence. Even if Victorian anxieties about the reproductive body sometimes proscribed a 19th century physician from touching his female patient, her physical existence remained relevant to his diagnosis. Physicians of that era approached their patients "through observation and examination" and "engaged in activities that were primarily mental and visual" (Rosenman, 2003, p. 378). The physician could hear the patient's complaints and see the patient's body. The requirement for a physical patient is changing. A radiologist, by definition, would be hard-pressed to aid patients without an x-ray, MRI, or CT scanner. A cardiac specialist without an electrocardiogram (EKG) would have few patients. These machines are becoming more familiar to the patient, as the doctor becomes more remote.

The patient's role in diagnosis of disease has traditionally been one of acquiescent contributor –a data provider– but now he may be even less relevant to his diagnosis.³ Traditionally, a patient described her symptoms, disrobed, and submitted to a physical exam.

³ Sontag (1978) points out how certain medical conditions, specifically tuberculosis and cancer, have historically been used as metaphor to the detriment of the patient. Cancer is "an evil, invincible predator" (p. 7) reflective of a condition that implies a moral judgment. Rosenman (2003) describes how the Contagious Diseases Act in the Victorian age "authorized surgeons to forcibly treat prostitutes for venereal disease by painting their genitals with mercury" (p. 367). These are small examples of how the patient is often a footnote to her own medical condition.

Dhand points out that a neurologist, for example, may not see a patient now until after viewing a scan of her head (2004, Oct. 31-Nov. 14, personal interview). But despite an acknowledgment that medical technologies are vast, impressive, and change the practice of medicine, most doctors strongly contend that neither the physician nor the patient is irrelevant to the process of diagnosis and treatment. Black says that while imaging technologies are an integral part of medicine, they have not superseded the patient's own voice. "You're not going to do the test unless the patient complains," says Black. "[The scan] helps define the complaint in a more complete way. The patient interaction is very important, because it helps the doctor hone in on what tests can be useful in making the diagnosis."

The patient's voice that once called for palliatives and cures now calls for something else. Patients want reassurance that they are well, a demand unheard of in the past. Doctors help us accomplish this and let us see inside of ourselves. While some doctors may hide behind the curtain, the curtain of the human body opens, and this is changing what we expect of our body and its infirmities. Geisler says that our repression of suffering, an agnostic society, and the human effort to become God-like, "coupled with a fixation on the dazzling possibilities raised by high-technology medicine" has changed the way we approach illness. In addition, as a society, we feel that we have a right to health, which Geisler says is illusory. He cites a hospital chaplain, W. Stroh, who states that "Life is not a court where one can prosecute one's claim to health." Perhaps now those claims to health may be processed through insurance companies rather than some existential entity. Patients have access to the machines that may be intended as insurance against suffering and death. If we can only *see* the problem, certainly it can be eliminated. What we cannot see frightens us the most (even if some patients avert their eyes).

With technologies that can peer behind skin through bones into body organs and even brains, a patient can literally observe a reproduction of his disease. Previously, a doctor might feel a lump or diagnose a clogged artery based on the patient's symptoms, but now disease poses for the camera. There are few places to hide. A doctor shows the patient an MRI of her right breast and circles in red the whitish mass identified as cancer. The tumor that might kill her in six to eight months appears as a small twinkle on a computer monitor. With a few mouse clicks in Adobe Photoshop, the patient herself could wipe out the offending cells. With machines the size of rooms and computer systems that hold more knowledge about metastatic breast cancer than a thousand physicians, with laparoscopy, radiation therapy, a massive assortment of drug choices, and the progress of interventional radiology, would the patient be unreasonable to expect sure cure? Cure or not, the patient has now seen inside herself, assuming her doctor has allowed her access. The patient now has a textual version of herself, concrete and immutable, disease and all.

Ong (1982/2003) describes writing as having restructured our consciousness as a society. The form that writing takes –a book or other text– cannot be refuted, because the author has removed herself from the work. “There is no way directly to refute a text. After absolute and devastating refutation, it says exactly the same thing as before. This is one reason why ‘the book says’ is popularly tantamount to ‘it is true’,” says Ong. He points out Plato’s contestation of writing over orality. “Writing destroys memory. Those who use writing will become forgetful, relying on an external resource for what they lack in internal resources,” says Ong, summarizing Plato’s argument (p. 78). The medical image of a tumor offers that irrefutable proof; the interpretation may be wrong, but the image remains irrefutably a freeze frame of our body in time. Ong also contends a close connection between writing and death: “The paradox lies in the fact that the deadness of the text, its removal from the living human lifeworld, its rigid visual fixity, assures its endurance and its potential for being resurrected into limitless living contexts by a potentially infinite number of living readers” (p. 80). Technology is manifestly artificial and its artificiality is natural to humans, but that artificiality serves us well. Using technology enriches the human psyche and intensifies our “interior life” (p. 82). Medical body imaging literally radiates the interior life of our bodies and offers us proof that we are complex, exceptional creatures, even if we’re not.

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Notes

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