Let Magic Happen: Adventures in Healing with a Holistic Radiologist

Introduction

There is almost a sensual longing for communion with others who have a large vision. The immense fulfillment of the friendship between those engaged in furthering the evolution of consciousness has a quality impossible to describe.

—Pierre Teilhard de Chardin

Although the term *holistic radiologist* may sound like an oxymoron, the foundation of all radiologic diagnosis is pattern recognition, which is a right-brain function. For that reason, it may not be so paradoxical that a radiologist would be attracted to a more intuitive, holistic worldview. I am one of a growing number of medical imagers who have deviated from the straight and narrow path of conventional radiology into the non-linear realm of alternative healing. Soon you will meet the handful I know, along with a host of other engaging characters who have embraced an unconventional approach to life, health, illness, and even death. Be prepared to have some of your fundamental beliefs about how the world works challenged in the process.

So how did someone who claims to be a "holistic radiologist" get into such a high-tech field to begin with? During medical school at the University of Pittsburgh, I went through the usual existential crises of a student searching for a career path and area of specialization. Some of my fellow medical students knew exactly what they wanted to specialize in before their pre-med days. The surgeon wannabes had loved dissecting the frogs in high school biology. The future internists had walked around as kids with those plastic stethoscopes in their ears. I went to medical school because I was good in science and wanted to work with people. There were no medical role models in my family for me to pattern a career after.

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The summer after my freshman year of college I worked as a hospital orderly, which was a harsh and humbling initiation into the world of geriatric medicine. There I learned to do for the elderly what they couldn't do for themselves. These tasks qualified me for the esteemed title of "bedpan commando." One of my other duties at Allegheny Valley Hospital was to take deceased patients to the morgue in the basement in a cleverly disguised cart. It had a false top covered by a clean white sheet designed to look like it was just an empty cart. Such chores were not usual summer fare for a young college student. After that job, I was frequently asked whether or not the experience had influenced my decision to go into medicine. My standard response was maybe, but all I knew for certain was I sure as hell didn't want to be an orderly.

On an airplane trip home from my second semester at Duke University, I met pediatric endocrinologist Allan Drash, a diabetes expert at the Children's Hospital of Pittsburgh. I wound up working in his lab the summer before medical school. At his clinic, I saw him evaluate obese kids brought by their parents in hopes of finding metabolic explanations for their weight gain. The fact was that most of the patients were junior couch potatoes who ate too much sugar and exercised too little, but I was intrigued enough by the problems of growth and development we encountered that I soon came to consider a career in pediatrics. Much to my surprise, my own pediatrician, whose son had followed him into pediatrics, advised me to find a different field.

Despite those discouraging words, I was still interested in child development. I contemplated a career in child psychiatry in medical school, but when I did my general psychiatry clerkship at Western Psychiatric Institute, I found it was heavily drug-oriented with a revolving door atmosphere. Unstable adult patients came in, got medicated, and went back out the door to dysfunctional life situations where they deteriorated again. In child psychiatry, it was disturbing to me to discover that the parents had worse problems than the kids. On top of that, sometimes the "shrinks" seemed to be stranger than the patients.

With all these disheartening experiences, I became depressed during my surgery rotation in the dead of winter at the Oakland VA Hospital in Pittsburgh. Lack of sunlight was probably a contributing factor, with me going to work before the sun came up and coming home after it went down. Adding to the depressing atmosphere, many of the patients were cigarette-smoking alcoholics who had lost limbs due to diabetes rather than war injuries. It was like a scene from the classic medical school parody I was reading at the time, *The House of God*, by Samuel Shem, the pen name for Harvard psychiatrist Steven Bergman.[i] His book was mandatory reading for all medical students when it came out in 1978. Written with a twisted sense of humor, elderly patients were referred to as GOMERs, his acronym for Get Out of My Emergency Room. I began to think I would never find a specialty where I could survive, not to mention thrive.

My sense of not fitting in to the medical system began during my physical diagnosis training in the second year. I remember being brought to tears by my initial attempts at doing a history and physical when I became caught up with the patients' stories and was chastised for failing to gather all the necessary objective information from the physical examination. Getting to know the person who had the disease was an optional luxury. This situation was worsened by the additional emphasis on the data from lab tests. Reducing human beings to a set of numbers was another step down the slippery slope of depersonalization that was standard operating procedure in medical education.

Collecting all the lab reports was considered the scutwork to be done by medical students in the hospital hierarchy, but it unexpectedly turned out to be my saving grace during my surgery rotation. One of my tasks was venturing down into the bowels of the hospital to review the radiology studies. I eventually noticed that going into the radiology department for X-ray rounds was my favorite event of the day. Seeing the insides of people indirectly through the use of dense ingested barium to coat their intestines was a whole new approach to the understanding of anatomy for me. The double-contrast studies done with the addition of air could be considered almost artistic as the radiologists painted the stomach and colon in a shimmering white. Radiology was a natural fit for me. I had been a top student in my anatomy lab course during my first year, and I was very visually oriented.

I also recognized radiology as an opportunity to have a well-defined brief interaction with anxious patients and put them at ease with the skillful use of technology. The added bonus was that it was relatively free from all the hassles usually associated with the hospital environment. There were no worries about ordering the wrong drug dose or keeping track of a myriad of data points in the charts. Unfortunately, my escape from that stressful system came at a price, as most of my encounters with patients were completely depersonalized as flat two-dimensional gray and white images. Patients became this damaged knee or that torn shoulder or this broken bone without my ever seeing their faces or hearing their voices.

This book will follow my path back to personalized holistic medicine as guided by many gifted teachers. It will also chronicle the mysterious and unpredictable process through which modern medicine has evolved toward integrative medicine in the past few decades. While *Let Magic Happen* may seem like a strange choice of a title for someone specializing in high-tech MRI, my experience of numerous magical synchronicities along the way has made all the difference. That said, MRI also has its own magical qualities. It involves working with strong invisible magnetic fields and inaudible radiofrequencies in a superconducting scanner that makes strange loud noises. After all, as *2001: A Space Odyssey* author Sir Arthur C. Clarke's Third Law states, "Any sufficiently advanced technology is indistinguishable from magic."[ii]

While I am quoting Clarke to conclude this introduction, let me invoke his other two laws in proper order. The First Law advises, "When a distinguished but elderly scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is probably wrong."[iii] The Second Law tells us that "The only way of discovering the limits of the possible is to venture a little way past them into the impossible."[iv] These laws are actually quite relevant to my experiences in the early days of my careers in radiology and integrative medicine. The first two chapters will start with "the limits of the possible" in conventional medicine before we get to "the impossible" in later chapters on holistic medicine.

Some of the names and identifying descriptive details of patients and students in the book have been changed to preserve their anonymity. In the rest of the cases, patients and students gave their explicit permission to use their actual names. For deceased patients, their surviving family members gave permission. My teachers and colleagues have also reviewed the information relating to their stories, as well as the techniques in the appendix.

Fasten your seat belts. As you turn the page, you're starting a rapid trip through a past high-tech wonderland to a future where the words of Hippocrates, the father of medicine, are true once again: "It is more important to know what sort of a patient has a disease than what sort of a disease a patient has."

Chapter 1: Seeing Inside the Body

The true human successes are those which triumph over the mysteries of matter and of life.

—Pierre Teilhard de Chardin

We wheeled the heavily laden patient transport cart silently through the halls of Presbyterian University Hospital. It was late at night, and we were on the way to the computed tomography (CT) scanner. Chuck Spritzer and I were two of the four medical students in the University of Pittsburgh Class of 1981 planning to go into radiology, which was an unpopular specialty at the time, populated largely by foreign medical graduates. Our patient from Dr. Nikolajs Cauna's service was unresponsive and unaware of our intended destination.

The new scanner was a major technological breakthrough. Radiologists had previously focused on making diagnoses by simply shooting a beam of X-rays through the body to expose a radiographic film on the other side. The usual result was a two-dimensional (2D) negative of everything within the body that blocked the radiation, with variations in density based on the molecular weight of the intervening structures.

Chuck and I had met the first day of medical school when we were both wearing Duke Basketball T-shirts. We were surprised that we had never encountered each other before during our four years of undergraduate pre-med training. Even stranger was the fact he had majored in biomedical engineering, and all my friends and roommates had been in the same major. I had majored in chemistry, however, and lived on the West Campus, while he had lived on the East Campus. During our first two years of med school, our shared passion for basketball led to many regular lunchtime trips to the gym to play. Now, we were teammates on a unique academic project exploring a new way to see inside the body.

The CT technologist and Bill Hirsch, another fourth-year student going into radiology, were waiting for us at the scanner. Bill, with his neatly trimmed beard, was the third musketeer on our team. A fourth musketeer, Mike Minton, also helped with the project, but eventually chose to go into anesthesiology instead of radiology. Our patient was participating in a special imaging project we were undertaking under the direction of Dr. David Herbert, Director of CT. He had assigned us this patient earlier in the day. Unfortunately, the patient was unable to move on his own, so the transfer from the cart to the scanner table proved to be quite a challenging task. We had to lift what amounted to about 200 pounds of dead weight while being careful not to drop him. To accommodate the fact that he had no control over his bowels, we had first completely covered the scanner table with a clear plastic sheet.

The push of a button on the side of the scanner brought the table to life. It slid our patient into position within the large, metallic donut housing the X-ray tubes and detectors. Crosshair laser beams from the device crisscrossed his chest, providing the anatomic landmarks at which to begin the scan. We all moved out of the scan room and into the control room, which was shielded from the radiation. The tech activated the keyboard of the brand new state-of-the-art General Electric (GE) 8800 scanner, and the system whirred smoothly into motion. The invisible internal components of the machine began rotating once a second, reminding me of the activation of the ancient intergalactic portal in the movie *Stargate*. Rather than opening up a time travel wormhole to another part of the universe, however, the CT scanner gave us a glimpse into the inner world of our patient. The earlier generation of scanners had been clunky and slow, taking several seconds per scan, resulting in motion artifacts if the patient shifted position during the study. Motion sometimes resulted in blurring of the images making them unreadable. Within the next 15 minutes, we rapidly obtained a perfect set of one-centimeter-thick images from the patient's diaphragm to the base of his skull without any artifacts.

The development of CT signaled the beginning of the digital revolution in medicine. It was invented in 1971, when I was a junior in high school, by Sir Godfrey Hounsfield, who was a co-winner of the Nobel Prize for the new technology during my second year in medical school. His innovation was to use an X-ray tube moving in a circle around the patient and aimed at a matching rotating digital detector on the other side. The computer then reconstructed the information obtained from many different angles into an image that represented a single cross-sectional plane through the patient's body. For the first time, we could actually see real anatomic structures inside the body. Due to the primitive technology, it took quite a while for the computer to process all the images.

Once the study was completed and while the images were being reconstructed, we lifted the patient off the scanner, laid him back on the cart, and took him to his new room in the hospital. It was a bit chilly, but his roommate didn't seem to mind. Back at the scanner, we spent some time analyzing the images in preparation for the second part of the study coming the next week. Ten days later, we went back and got the patient from his room for the second procedure in Dr. Cauna's lab. His level of consciousness had not changed. Bill and I transferred him onto the custom-designed table while Chuck and Mike got the equipment ready. When we completed the positioning process, Chuck flipped the switch and the big band saw roared into action. The whirling blade circling around the saw soon became a blur, moving much faster than the inner workings of the CT scanner the week before. We all held our breath in anticipation as it inched closer to the patient, who was unaware of our concerns. He didn't flinch when the saw blade cut into the side of his chest at about the same level as the laser beam during positioning for the CT scan.

We all recoiled as we watched strange, pink, human sawdust issuing forth from the bloodless wound. After ten days in the anatomy lab freezer at minus-nine degrees Celsius, our "patient" was as hard as a redwood log. Anatomy lab assistant Jan Hart had carefully guided us through the process of appropriately handling the body of the man who had died just before the CT scan and had graciously donated his flesh and bones for medical research. As first year students, we had all done standard anatomic dissection guided by Dr. Cauna in the main lab nearby, but nothing had prepared us for this macabre magic act of cutting a frozen cadaver in half to match the noninvasive task we had accomplished by CT the week before.

Bill, Mike, and I slid the table back one centimeter and made the next parallel cut further into the chest, creating what was essentially a grotesque slab of human steak. Chuck carefully photographed the first frosty slice while we began identifying the various anatomic structures. The chambers of the heart, the aorta, the lungs, and the muscles of the chest wall were now displayed in unfamiliar cross-section. Our assignment for this radiology elective was to create one of the first pictorial atlases of CT anatomy. We began by arranging photographs of the sections of our patient next to his actual CT images made before freezing. The act of meticulously labeling all the pictures made us appreciate the elegant technology of CT, which allowed such *in vivo* dissection on non-frozen human beings. Medicine was changed forever by Sir Hounsfield, and so were we.

One of our rewards for completing the project successfully was acceptance for three of us into the radiology residency program at the University of Pittsburgh. There we all gained extensive clinical CT experience on real patients whose bodies were only momentarily and metaphorically frozen by the rapid action of the scanner.

Anatomic Initiation

Looking back on it now, I can appreciate the underlying symbolic meaning of the project as a step deeper into the depersonalized realm of modern medicine. It was in effect a rite of passage, like a Skull and Bones ritual. Initiates have to procure a fresh corpse, subject it to a high-tech procedure, bury it in an icy crypt for a week, and then saw it in half during an occult ceremony in the depths of a dungeon. A person who was once living and breathing was turned into slabs of frozen meat like one might find in a butcher store. In fact, the whole scenario had a strange secret society aura about it. Images and pictures from the project are still on display in the anatomy lab at Pitt for the use of current students who are finding their own paths through the medical underworld. CT, while being a major diagnostic advance, was also notable for contributing to our beginning to look at the body from an unnatural cross-sectional perspective.

The original initiation in the dissection of cadavers that we went through in 1977 as first year medical students preserved some respect for the integrity of the different organs as parts of a whole. In contrast, the CT images show a slice of the liver next to a part of the spleen and a sliver of the pancreas. It takes a skillful act of visual gymnastics to perceive each individual organ as a separate entity, let alone see the big picture of the entire human being. That said, the first-year anatomy rituals also provoked a certain degree of gallows humor in us. The most memorable example was when we dressed up the dry skeletons in costumes for Halloween. These acts gave us some emotional distance from the jarring confrontations with the harsh realities of death and dismemberment.

My first exposure to dissection had actually come when I was a pre-med student and visited the county coroner's office in downtown Pittsburgh. I already had experience transporting corpses as an orderly, but I wasn't sure how I would deal with my first autopsy. It was done on an elderly man who had been found in a field a few days after being murdered, so he already looked somewhat inhuman. The autopsy technician was kind of matter-of-fact about the whole deal. He first cut the scalp away from the skull, pulling it down over the face so I could no longer recognize the subject as a person. The violent noise of the cranial saw came next as he cut into the skull and removed the brain. What I was seeing and hearing was tough for me to process, and it was made worse by the fact that between steps, the technician was munching Dunkin' Donuts from a box on an adjacent table.

During the second-year pathology rotation, we were all required to attend a certain number of autopsies. By that time, I was well down the path of desensitization, so seeing bodies opened up and organs extracted was becoming commonplace. The organs would all be put on a scale and carefully weighed, bringing up visions of the Weighing of the Heart Ceremony in the *Egyptian Book of the Dead*. In that ancient ritual, the heart was balanced against the weight of *ma'at*, the principle of truth and justice, which was represented by a feather. Hearts heavy with wrongdoings would be devoured by Ammit, the gobbler, a terrifying composite animal, parts crocodile, lion, and hippopotamus.

During the autopsies, we occasionally discovered truth and justice when we found causes of death that had been overlooked while the patients were still alive. This was the final gold standard of diagnosis. Prior to CT, it was not uncommon for significant tumors or abscesses to be completely hidden from what had been the state-of-the-art diagnostic tools of an earlier era. Nowadays, unfortunately, the pendulum has swung the other way. There seems to be some sort of peculiar competition to see how many CT scans can be obtained on terminal patients near the end of life. These are often the final acts of dehumanization before we let the patients die in peace. Such contemporary abuses are a manifestation of our culture's death denial trance. However, in the early days of CT there was no question that it represented a major breakthrough in medicine.

We all got to listen to horror stories told by the senior faculty neuroradiologists about extreme diagnostic procedures from the not-so-distant "good old days" of radiology. Patients with undiagnosed neurological conditions often had to undergo the most onerous of all tests, the notorious pneumoencephalogram. This involved a spinal tap similar to a myelogram, but instead of dye, air was introduced into the spinal canal. With the patient tilted into an upright position, the air ascended up the spinal canal to surround the brain, allowing X-ray visualization of the otherwise invisible three-pound lump of gray and white matter. Spinal taps alone are not pleasant procedures, but the addition of air commonly resulted in severe headaches and vomiting. Perhaps that is the reason pneumoencephalography was included in the movie *The Exorcist* in 1973, performed on Linda Blair's possessed character, infamous for her green pea soup projectile vomiting.

During the first three years of our residency, we were all enamored with CT scanning due to its ability to replace many of these invasive and painful tests from radiology's past. CT scanning also opened up new areas for diagnosis, such as diseases of the muscles and the bone marrow, which previously had been hidden to plain radiography. My history of sports injuries as a pole vaulter in college led me to develop an interest in the specialty of musculoskeletal radiology, a field which was revitalized by CT. I had experienced a number of nagging lower leg problems that kept me grounded for weeks at a time. These included a collapsed metatarsal arch, hamstring tendonitis, and multiple ankle sprains. During those years I only had one encounter with radiology when I missed the landing pit from 15 feet in the air and landed on my ankle, a stunt which is not recommended in the training manuals. The pain was real, but the X-rays revealed nothing, leading me to wish there were more effective ways of making musculoskeletal diagnoses.

Due to this interest in sports medicine, I had considered going into orthopedic surgery at the start of medical school. I spent a summer in the orthopedic research lab at Pitt that involved gowning up and going into the operating room to retrieve synovial fluid specimens. I soon realized, however, that I didn't like the formalized rituals of surgery. Accidentally touching the sterile glove of orthopedic chairman Albert Ferguson with my ungloved hand and contaminating him during a case didn't help, either. That summer I also did surgery on rats, which involved anesthetizing them briefly with gauze soaked in ether while drilling holes into their femurs. I always came home reeking of ether as I recovered from the secondhand anesthesia myself, which took several hours. I eventually realized I could pursue my sports medicine interests in radiology without having to endure the ordeals of the operating room.

One of the challenges in musculoskeletal radiology is mentally stacking up the multitude of cross-sectional images to visually recreate a three-dimensional (3D) perspective, especially with complicated fractures. At the request of my colleagues in orthopedics, I did research during my residency on creating 3D CT scans of pelvic fractures using a new software program, which had been created by the Medical Image Processing Group at the University of Pennsylvania.[v] We had one of the only copies. Loading the raw images from a reel of magnetic tape, I would start the program in the evening, and it would run all night long, taking hours to generate a set of 3D images. The surgeons were thrilled with this new way of looking at these fractures, but then they handed me another, more challenging request. They wanted me to remove the femur so they could actually see into the hip joint the same way they would see it during surgery.

Gabor Herman and Jay Udupa were the highly sophisticated computer science professors who had written the software program. I flew to their lab in Philadelphia, carrying a tape loaded with images from one of our patients. It took me an entire day to remove the femur from the 3D images by using their interactive research program and laboriously moving the cursor to outline the bone on each 2D CT image. It was worth the effort, as the resulting 3D image wound up on the cover of a surgical textbook and was seen by orthopedists all over the country.[vi] In 1984, I showed the first 3D CT movie of a hip fracture rotating in space at the Radiological Society of North America (RSNA) meeting.[vii] Now after years of refinement, the 3D process only takes a few seconds on today’s computers. However, the early 3D movies were just as magical to the audiences then as movies like *Avatar* are today, minus the funky glasses.

Three-dimensional imaging was actually a step in the right direction away from a fragmented perception of the body and toward a more holistic view, albeit a digital one. Sometimes on 3D images of the face there was a sense of almost being able to recognize the patient as a real person. This was a little bit eerie at first. Similar software has also been applied to *in utero* ultrasound with the intention of seeing what the baby looks like, including showing the face and fingers. This phenomenon has resulted in some unexpected feedback from the womb. There are YouTube videos of babies who appear to be giving ultrasonographers the middle finger. You can just imagine them saying, “Get that invasive beam of sound out of my face and leave me in peace here in my safe place.”

The Ground Floor of MRI

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I thought 3D CT was the end all and be all. When I saw the first grainy MRI images produced by crude prototype machines in 1980, I declared that magnetic resonance imaging would never amount to anything useful. Then in 1984, MRI was approved by the FDA for human use in this country, and Harvard radiologist Jeffrey Newhouse gave a talk about MRI physics at our residency program. I was immediately hooked by the elegance of the technique and decided to learn everything I could about it. Fortunately, one of the inventors of MRI, Paul Lauterbur, was a Pitt alumnus, and he was invited back in 1985 to give a workshop on MRI physics. His first paper on MRI was rejected by the prestigious journal *Nature* with the feedback that the pictures were too fuzzy. His famous response is often quoted, "You could write the entire history of science in the last 50 years in terms of papers rejected by *Science* or *Nature*." He and Peter Mansfield were co-winners of the Nobel Prize in 2003.

The University of Pittsburgh got its first MRI scanner in the spring of 1985 and established the Pittsburgh NMR Institute. Nuclear magnetic resonance (NMR) is the chemical analytic technique that was the precursor for MRI. As is typical of high-tech innovations in the modern era, the senior faculty knew less about the new technology than the younger generation. As a result, three fourth-year residents were assigned to run the scanner. Bill Hirsch and I were two of the first three, and I was soon coming home obsessed with MRI pulsing sequences, dreaming about them at night, and waking up still thinking about them the next morning. I had gotten married during medical school, and my wife listened patiently to my technical babbling. Before that, I had excelled in my physics courses as an undergraduate, perhaps because I inherited a knack for it from my father, who had earned his Ph.D. in physics from nearby Carnegie Institute of Technology (now Carnegie Mellon University). I had also enjoyed learning about NMR during my organic chemistry pre-med courses.

In contrast to CT, MRI doesn't involve any ionizing radiation, which has known harmful effects on chromosomes. It relies completely on the resonance properties of the hydrogen protons in the body, which precess like tops at a specific frequency when placed in a strong magnetic field. The hydrogen protons in fat and water in the body tissues align with the field when the patient enters the large magnet. Next, the resonant radiofrequencies emitted from the antenna within the MRI scanner are temporarily absorbed by the patient's protons. It is similar to the famous Ella Fitzgerald commercial in which the wine glass shatters after absorbing the sound energy of the note she sings at the resonance frequency. However, rather than shatter, this absorbed energy just causes some of the protons to immediately reverse their orientation to the magnetic field. Over the next few seconds, the protons flip back and release the temporarily stored energy, which is detected again by the antenna.

The location of the protons in the body within a particular imaging slice can be determined by the application of a small magnetic gradient superimposed on the main field during the initial radiofrequency transmission. This difference in field strength will cause protons in the head to spin faster than those in the feet. Only the protons within a thin cross-sectional slice in the body will be spinning at the actual resonance frequency, thus allowing the computer to figure out where in the body the information came from to reconstruct an image. No band saw or X-ray beam is required. These temporary shifts in field strength occur very rapidly and generate the characteristic staccato knocking noise heard by patients inside the scanner.

The particular radiofrequency used is proportional to the field strength of the scanner. In a typical 1.5 Tesla (T) magnet, hydrogen molecules resonate at 63.9 megahertz (MHz), which is very similar to the VHF signal broadcast by your local TV stations. For this reason, MRI scanner rooms are carefully shielded in copper to keep any interfering radiofrequencies out. As a reference, 1 T equals 10,000 gauss, while the earth's magnetic field measures between 0.3 and 0.6 gauss. The strength of an average refrigerator magnet usually is between 10 and 100 gauss.

The unit of field strength was named after the Serbian creative genius Nikola Tesla in 1960, just in time to resurrect his name from obscurity after his death in 1943. I misspelled his name as "Telsa" the first time I heard it, but never made that mistake again as he became one of my electromagnetic heroes. To me, he was somewhat like Magneto from the *X-Men* movies, equally eccentric, but more benevolent.

Tesla's life story is wonderfully recreated in the 1980 movie *The Secret of Nikola Tesla*, featuring Orson Welles as J. P. Morgan, one of his benefactors. As a young man in Europe, Tesla saw a picture postcard of Niagara Falls and declared that he would someday harness its energy. He later had an intuitive vision that led to the design of the alternating current electric generator. True to his word, in 1895 he installed a hydroelectric generator at the famous falls to provide power to Buffalo, New York. I used to begin all my MRI lectures with a picture of Tesla sitting in his laboratory in New York City with bolts of electricity flashing all around him. One of the more fascinating and enigmatic characters in the history of science, Tesla is also reported to have investigated X-rays before Wilhelm Roentgen and radio before Guglielmo Marconi. Tesla said his greatest invention was technology that could send power around the world without wires. Why Tesla's revolutionary technology failed to become a commercial product remains steeped in mystery like most of the rest of his life.

I had my own career mysteries to contend with at the end of my residency, as I had a year to wait before I could leave Pittsburgh to do a musculoskeletal radiology fellowship. Fortunately, I was accepted as one of the first two fellows at the Pittsburgh NMR Institute, along with Manny Kanal, who had been the third resident MRI operator and also one of my medical school classmates. Manny, one of the front row group in the first two years of med school, was notorious for asking overly eager, anticipatory questions of the professors. At the same time, he undermined the preconceived notions of the back row group that Chuck and I were in by regularly joining us at the gym for basketball games. Much to our surprise, he distinguished himself as “chairman of the boards” thanks to his long wingspan, which allowed him to capture every rebound.

At the end of our fourth year, we had to master other boards and make the June ritual pilgrimage required of every radiology resident to Louisville, Kentucky, for our rigorous oral certification exams. After we had successfully run that gauntlet of professional credibility, and just before we were to start in July, radiology chairman Bert Girdany, called us into his office. Dr. Girdany told us he had good news and bad news. The new director for the Pittsburgh NMR Institute, Jerry Wolf, was a famous MRI researcher, but not a clinical radiologist. They had been unable to recruit any additional clinical MRI faculty to teach us, so we were promoted to staff as instructors of radiology. As it turns out, this was a major blessing in disguise, since we received a priceless on-the-job education. We learned as we went and consulted the growing MRI literature on a daily basis in order to be able to make the proper diagnoses. Eventually we even accumulated enough skill and knowledge to make our own original contributions to the radiology journals.

My particular interest was in musculoskeletal MRI, so I persuaded my orthopedic surgeon friends to send me patients with bone and soft tissue tumors and spine and joint problems. At the time, the gold standard for evaluating joints like the knee was arthrography, which is performed by poking a needle into the joint and injecting iodine dye under X-ray guidance to reveal the meniscal tears. Arthrography is painful for the patient, labor intensive for us, and not very accurate. I remember wrestling many large patients by the leg on the X-ray table to contort their knees into the proper position for filming the menisci during the arthrograms. That was no fun for them or me.

General Electric, the manufacturer of our brand new 1.5 T Signa scanner, had given us one of their specially designed experimental surface coils to test on the joints. The initial MRI images of the knee we obtained in 1985 using that innovative antenna technology were spectacular beyond my greatest expectations. For the first time, it was possible to see everything inside the knee, including the menisci, ligaments, articular cartilage, bone marrow, synovial lining, and tendons. My first MRI paper was one of the original descriptions of the noninvasive diagnosis of meniscal tears, which many of the senior radiologists thought was impossible at the time, in alignment with Clarke's First Law.[viii] I also published the first paper on the MRI diagnosis of spinal tumors in neurofibromatosis. Some of these nerve tumors were very disfiguring, and this bizarre disease has been speculated to be the cause of the grotesque musculoskeletal deformities of John Merrick, made famous in *The Elephant Man* Broadway play and Hollywood movie.[ix]

Scanning Not-So-Normal Volunteers

One of the common rituals in the early days of MRI was that whenever there was an unexpected opening in the magnet schedule, someone would volunteer to be scanned. We used volunteer subjects for educational purposes to test the latest new pulsing sequence or technical innovation. Our motto was "An empty magnet is an unhappy magnet." Since there were no known health effects from MRI, the members of our staff had all been in the scanner on numerous occasions, and we were always on the lookout for other potential volunteers. When

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Gary Marano, a visiting neuroradiologist from West Virginia University, volunteered for a scan of his cervical spine, we didn't hesitate. He didn't have an MRI machine yet at his institution, so he was spending time learning with us. We wanted to test another of our new surface coils, which were designed to dramatically improve the image quality of the spine.

We asked Dr. Marano to remove his watch and credit cards to prevent damage or erasure, and then opened the big door to the scanner like a vault at a bank. Dick, one of our techs, positioned the coil under his neck on the gantry table and carefully connected the coil wire to the outlet, making sure it wasn't looped or in contact with Gary's skin. Next Dick activated the table to slide Gary into the center of the magnet, and the narrow scanner bore closed in around him. Dick left the room and closed the door securely behind him, then sat down at the console and touched the plasma screen to begin programming the scan. With all its latest bells and whistles, the new scanner looked like something out of a *Star Trek* episode. The magnet made its typical rhythmic knocking during the first scan, which lasted about five minutes.

We collectively gasped at the high quality of the first images and also at the unexpected large disc herniation bumping into Gary's spinal cord. We debated whether to say anything to him right away, but decided to continue with the other sequences as if he were a real patient. The scan went on longer than he probably expected, so he may have wondered what we were seeing in the control room. When he came out of the scanner, we showed him the images. He was shocked, as he had no symptoms, but then recalled having received a neck injury playing football years before. He was fortunate to have a relatively large spinal canal that allowed room for the disc protrusion without causing any significant neurological injury. The next time we saw him driving his car, however, he was a wearing a cervical collar just to be safe.

Over the next two decades, a number of important papers were published in the medical literature documenting an unexpectedly high incidence of abnormalities among asymptomatic MRI volunteers. The studies were done of the cervical and lumbar spine, knee, and shoulder. One paper in the *New England Journal of Medicine* in 1994 showed lumbar disc herniations in a quarter of their asymptomatic volunteers. The authors concluded, "Given the high prevalence of these findings and of back pain, the discovery by MRI of bulges or protrusions in people with low back pain may frequently be coincidental."[x] This surprising information is particularly important to the average patient with low back pain, since the chances of finding an abnormality are relatively high. Unfortunately, it may be preexisting and may or may not account for the symptoms. This ambiguity of cause and effect needs to be taken into consideration in any discussion of therapeutic options. Surgery may appear to fix a disc herniation, but the symptoms may or may not improve as a result of the intervention.

My own first practical experience with back pain came in college during my summer as a hospital orderly. One of my tasks was to help get patients out of bed the day after surgery so they could go to the bathroom. Near the end of the summer, I was called by the nurses to do the heavy lifting on a friend of my parents, Bob Gearinger, who'd had surgery the day before. Bob was a big guy, and I struggled to balance him and not drop him on the floor as he got out of bed the first time. In my effort to avoid a potentially embarrassing calamity for me and a disastrous accident for him, I strained my back. It didn't have a chance to heal as I kept reinjuring it due to the endless number of patients requiring my assistance. I consulted a physician and was put on muscle relaxants without much relief from the pain, but I was soon so spaced out I had to quit the job early. That was my first encounter with the side effects of powerful pharmaceuticals, a warning of things to come. The injury occurred before the days of MRI, and I'm sure now that it would have been negative in my case, as muscle spasms typically do not show up in diagnostic imaging examinations.

The relationship between anatomical abnormalities and symptoms is a complex one, and there are four different combinations of possibilities worth considering. First, as the MRI papers tell us, you may have an abnormality without symptoms. Second, you may have pain due to inflammation, which may or may not show up on an imaging exam. Third, you may have instability or weakness due to a mechanical abnormality that can be diagnosed with radiology. Fourth, there is pain with no detectable imaging abnormality due to an enigmatic condition like fibromyalgia, basically consisting of muscles spasms all over the body. Knowing which category you are in can make a significant difference in determining the best options for treatment. Some physicians may be so narrowly specialized that the big picture of your life never comes into focus. In that case the old cliché may come into play: “If all you have is a hammer, everything looks like a nail.”

In the first case, it is important to consider that when symptoms do develop, there could be a coincidental abnormality already present. In the second case, there are so many good nonsurgical approaches to inflammation that surgery is often an overly aggressive solution that may make the problem worse. This also applies to inflamed nerve roots in the spine due to compression by discs. The great majority of inflammatory conditions resolve with time, given appropriate supportive care or alternative therapy. In the third case, there may be no choice except surgery, assuming all conservative measures have failed. In the spine that means severe nerve root compression causing significant weakness or bowel and bladder dysfunction. In the joints, when there is locking, instability or severe weakness, cartilage, ligament or tendon repair may be necessary. In the fourth case, when there is pain with no visible anatomical abnormality, then alternative methods are likely to be the most fruitful. Of course, I was aware of none of this information while I was in medical school and residency. I had to learn it all the hard way through another personal health crisis.

Shouldering My Burdens

During the summer of my last year of residency, I woke up one Saturday morning with unexplained shoulder pain. Trying to get out of bed, I felt a strange pop, which was a little disconcerting. But I went out to play basketball anyway, as I sometimes did on the weekends. By the end of the game, I thought my shoulder was going to fall off. After suffering for few weeks, I saw an orthopedic surgeon, but didn’t get a satisfactory answer as far as a diagnosis. Diagnostic possibilities included bicipital tendonitis and impingement syndrome, but these mechanical sounding words did not do justice to the painful condition that was limiting my physical ability to do my work in radiology. Next, I was put on a powerful anti-inflammatory medicine, Indocin, but it gave me little relief from the pain. Instead ulcers erupted in my mouth as a full blown attack of one of the worst side effects of the drug. By the end of the week, my mouth was so inflamed I could barely talk or eat. Yes, it took me that long to realize I should quit taking the drug.

Unfortunately, I knew nothing about alternative medicine at the time, so after an entire year of pain, I still thought drugs or surgery were the only answer. Back then, we were just beginning to experiment with relatively crude MRI exams of the shoulder, so the images I did of my shoulder were not particularly valuable diagnostically. I didn’t see a major mechanical problem and couldn’t tell if there was any inflammation. I knew just enough about the shoulder to be dangerous to myself. I talked one of my orthopedic colleagues into operating on me. The only abnormality he found when he did an arthroscopy of my shoulder was bursitis, inflammation of the tissue just outside the shoulder joint referred to as a bursa. The rotator cuff tendons were intact, so he just resected the inflamed bursa. It took me weeks to recover from the surgery, and I was left with chronic shoulder pain. Knowing what I know now, I would never have chosen surgery for an inflammatory condition. It took years of suffering before I began to understand the mind-body-spirit roots of my shoulder pain and for my shoulder to begin to heal.

I had to wait until the following year when I moved to Philadelphia to start my exploration of holistic medicine. My wife and I went there as a step up on our career paths for both of us. Upon arriving in Philly, I began a musculoskeletal radiology fellowship at the University of Pennsylvania, which was the Mecca for MRI at the time. My motivation for going to Penn was to work with the influential researchers and pioneers in this brand new field of imaging. Oddly, the two MRI scanners at Penn were housed in an unusual pyramid-shaped building. There were little pyramid logos everywhere, plus small crystal pyramids on the desks of all the top administrators. Perhaps that should have been a clue that my career was going to take a strange turn in Philly. However, despite those mysterious omens, I spent a productive year during my fellowship. Writing more knee MRI papers kept me busy, along with the search for my first real job in academia.

I enjoyed working at Penn and got a job offer that fall to stay on as a junior faculty member for the following year. However, I hesitated to accept it. I was afraid I would have trouble being seen as more than just a glorified fellow if I took a job where I had been a trainee. Of all the medical schools in Philadelphia, I really wanted to work at Thomas Jefferson University Hospital, which was considered an up-and-coming program. I was encouraged to apply there by a friend on their faculty, ultrasound and MRI specialist Don Mitchell, who had written the first papers on MRI of the hip the year before as a fellow at Penn. I had a good first interview with the chairman, David Levin, but later heard from Don they were no longer looking for a musculoskeletal radiologist. I remember feeling depressed when I left for Chicago to present my paper on MRI of neurofibromatosis at the annual RNSA meeting. My expectation was that I would return with no job option other than staying on at Penn. Much to my pleasant surprise, David Levin was waiting for me when I came down from the podium after giving my talk. I accepted his job offer on the spot and spent the rest of the year preparing to work at Jefferson.

That decision had a domino effect, as my turning down the Penn job opened it up for someone else. Michael Zlatkin arrived from San Diego at the end of that year to take the position after having done research on shoulder imaging during his fellowship. Even though we were at rival institutions, I knew intuitively that we should be friends, and we were close Philly colleagues for the next four years. While I was at Jefferson and he was at Penn, Michael published one of the first papers on MRI of rotator cuff tears. It came out the same month as mine did on the identical shoulder topic in a different journal.[xi] He went on to write a textbook, *MRI of the Shoulder*.[xii] I also published the first paper on MRI of the shoulder in baseball players while working with Phil Marone, the team doctor for the Philadelphia Phillies.[xiii] I loved working with my radiology and orthopedic colleagues at Jefferson. It was a great first job.

The highlight of my academic career in radiology at Jefferson came in 1989. Michael Zlatkin, course director for GE's First Nationwide Video Teleconference on Musculoskeletal MR Imaging, invited me, Don, and six of the other top musculoskeletal MRI radiologists to GE's radiology headquarters in Wisconsin. It was a surreal experience rehearsing to present in front of a green screen like a weatherman. My image was superimposed on the slides that were going to be projected to audiences in hotels around the country. There was some discussion beforehand about how the viewers at the remote locations would actually know whether they were really watching a live teleconference. For all they knew, it could have just been a series of sequential videos taped earlier and strung together.

As the leadoff speaker, I told my colleagues not to worry, that I would handle it. I started my lecture with my usual first slide featuring Nikola Tesla. Next I turned to the camera, pointed to the audience, and gave them my best *Saturday Night Live* imitation—"Live from Wisconsin, it's Saturday morning!" The GE folks in the room were momentarily stunned by my unscripted act, but everyone else started laughing, and it got the show off to an authentic, albeit unconventional, start. The videotape of the presentation ran on a continuous loop in the GE booth at the RSNA meeting later that year. Looking back on that morning, I guess the spontaneous detour off the beaten path that gave me my 15 minutes of fame was a preview of coming attractions.

Introduction

[i] Samuel Shem, *The House of God* (New York: Dell Publishing, 1978).
[ii] Arthur C. Clarke, *Profiles of the Future: An Inquiry into the Limits of the Possible* (New York: Harper & Row, 1973), 36.
[iii] Ibid., 14.
[iv] Ibid., 21.

Chapter 1: Seeing Inside the Body

[v] D. Lawrence Burk, Jr., et al., "Three-Dimensional Computed Tomography of Acetabular Fractures," *Radiology* 155 (1985):183-186.
[vi] Dana C. Mears & Harry E. Rubash, *Pelvic and Acetabular Fractures*, (Thorofare, NJ: Slack, 1986).
[vii] D. Lawrence Burk, Jr., et al., "Acetabular Fractures: Three-Dimensional Computed Tomographic Imaging and Interactive Surgical Planning," *Journal of Computed Tomography* 10 (1986): 1-10.
[viii] D. Lawrence Burk, Jr., et al., "1.5 Tesla Surface Coil MRI of the Knee," *American Journal of Roentgenology* 147 (1986): 293-300.
[ix] D. Lawrence Burk, Jr., et al., "1.5 Tesla Surface Coil MR Imaging of Spinal and Paraspinal Neurofibromatosis," *Radiology* 162 (1987): 797-801.
[x] Maureen C. Jensen et al., "Magnetic Resonance Imaging of the Lumbar Spine in People without Back Pain," *New England Journal of Medicine* 331 (1994): 69-73.
[xi] D. Lawrence Burk, Jr., et al., "Rotator Cuff Tears: Prospective Comparison of MR Imaging with Arthrography, Sonography, and Surgery," *American Journal of Roentgenology* 153 (1989): 87-92.
[xii] Michael B. Zlatkin, *MRI of the Shoulder*, (Philadelphia: Lippincott Williams & Wilkins, 2003).
[xiii] D. Lawrence Burk, Jr., et al., "MR Imaging of Shoulder Injuries in Professional Baseball Players," *Journal of Magnetic Resonance Imaging* 1 (1991): 385-389.