Röentgen and Medicine

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Abstract

Remembering the centenary of the discovery of X-Ray, the author describes the way the discovery occurred evoking Wilhelm Conrad Röentgen outstanding qualities both as a researcher and as an individual.

The worldwide excitement caused by the discovery is mentioned and reference is made to the earlier X-rays applications made in Portugal by H. Teixeira Bastos, lecturer at the University of Coimbra.

The emergence of various X-ray diagnostic techniques is briefly reported with special mention to the contribution of Portuguese scientists to angiography.

The last part of this paper deals with the contribution of X-Rays to interventional radiology and radiotherapy.

On 8th November 1995, the centenary of the discovery of X-ray by Wilhelm Conrad Röentgen was celebrated. By happy coincidence, 2nd and 3rd February 1996 also marked a centenary milestone in the history of Portuguese Radiology, as I shall have occasion to mention later.

The discovery of X-ray was, according to many scientists of renown, the greatest discovery of physics. It inaugurated modern Physics and enabled men of science to finally investigate the nature of the matter, leading them into the deep mysteries of atoms. The role that it represents in Physics can be evaluated by the circumstance of no less than 21 Nobel Prizes that have been awarded for investigations on X-rays, or that are directly related to these radiations. In fact, the first Nobel Price for Physics, dated 1901, was awarded to Wilhelm Conrad Röentgen himself, for his discovery of X-ray. But its impact was not limited to physics, on the contrary, it had major repercussions on other sciences and technologies. Medicine was certainly the area to benefit most, but Astronomy, metallurgy, Archeology, Paleontology, the study of paintings and other art forms, are just some of the numerous others examples that we can mention.

Now that a hundred years have passed since that auspicious time, it is pertinent to remember Röentgen and his discovery, and reflect on what it represents for the evolution of Medicine.

We go back, then, to the year of the discovery: 1895. It was a very interesting year for a number of reasons: In 1895, in Vienna, Freud laid the foundations of psychoanalysis, in his "Studies on Hysteria"; in Paris, the Lumière brothers invented cinema, and in Venice, the first Venice Biennial Art Exhibition was inaugurated. Intellectual Europe was boiling with new ideas.

And in Physics? Physics in the 19th Century underwent prodigious development, and it could be said that that it was what largely illuminated the "century of lights". By the end of the nineteen hundreds, many scientists believed that the main facts and laws of Physics had been discovered. Little could they have imagined that one of the greatest scientific discoveries of all time was about to take place.

The history of the discovery is only partially known, as Röentgen destroyed many of his notes, and when he died, he left instructions that the same be done to the precious remaining notes that he had accumulated over his lifetime of intense scientific activity. Therefore, what we know today is what is told in the writings that he published, and in a few testimonies of this phase of Röentgen's life.

As in many other Physics laboratories in various parts of the world, Röentgen, at his laboratory in Wüerzburg, Germany, was also working on a very costly theme for the investigators, as it was a state-of-the-art area of Physics at that time: cathode rays.

As was known, cathode rays are electrical currents

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that are formed within a glass vacuum tube, when submitted to electrical discharges between to points: cathode and anode.

But creating the vacuum in a glass tube was a fastidiously slow process, using a special pump in which the mercury acted like a piston. It was the repeated rising and falling of the mercury reserve that gradually removed the air in the glass tube. It was a long process because it took considerable time to reach the necessary level of gas rarification.

Then it was necessary to supply high voltage electrical energy to the tube, for which Röentgen used a battery of accumulators and an enormous Ruhmkorff coil, a famous coil, of which only a few examples remain. One is housed in Portugal, at the Museum of Physics of the University of Coimbra, and is an item of incalculable museological value.

Once these conditions were in place, it was possible to pass the electrical current through the tube and produce cathode rays. These are invisible, but can be detected in various ways. One of its manifestations is that it provokes the appearance of fluorescent light in the glass tube. The color of this light also varies with greater or lesser energy from the bundle of cathode rays.

Some time previously, another German physicist – Lenard – had observed that if at the point of impact of the cathode rays in the tube, a window was opened and closed with a thin aluminum sheet, the cathode rays would pass beyond it and travel a short distance in the air. The presence of the cathode rays outside the tube was demonstrated with a piece of card covered with a fluorescent substance. When the rays hit this screen, the fluorescent light appeared. Lenard also observed that the cathode rays left impressions on photographic emulsions.

It should also be noted that cathode rays were not the only forms invisible radiation that were known at that time. Physicians were well aware, for example, that infrared and ultraviolet rays were also invisible.

Following this introduction, we are now prepared to witness the exciting discovery.

As was his habit when he approached a given line of investigation, Röentgen was repeating the most relevant previous experiments, precisely those of Lenard, so that based on the results of these, he could move on to new explorations.

At a certain time, as he later reported, he used a normal tube, without an aluminum window, and wrapped it in black card to eliminate any remaining light coming from the tube itself. We do not know for certain what the ultimate objective of this measure was. Was it simply to eliminate light from the tube, so as to be able to see more easily the fluorescence that emerged on the exterior screen, and thus be able to see more clearly the point where the cathode rays emerged? But Röentgen knew that the cathode rays only passed through a thin sheet of paper, and not through a card. Or, as has already been written, did Röentgen believe that by increasing the energy of the electrical discharges, the cathode rays would be capable of passing through the thickness of the glass and the card? What is certain is that by using the card and a glass tube without an aluminum window, Röentgen had already moved beyond Lenard's experiments, and was searching for something different.

Thus prepared, Röentgen made the current pass through the tube, having previously blacked out the room. And that was how he saw light emerging on the fluorescent screen that he had placed on a table. He switched the current on and off various times, and the phenomenon repeated itself. We can only imagine the tumult of ideas and feelings that Röentgen must have experienced as he witnessed this miracle. No doubt he would have found it difficult to believe what he was seeing. Could it be an effect of the cathode rays? But besides the thickness of the card and the glass, there was an additional obstacle: The distance at which the fluorescent screen was placed was greater than the distance traveled by the cathode rays through the air. But if these were not cathode rays, what other explanation could there be for that mysterious light? Another form of radiation? And if so, was it one that was already known about, or one that was entirely new to Science? Could it be something totally different from radiation?

In a conference given by Röentgen, and according to an eye witness, the wise German said that the discovery had happened by chance. It was only necessary to know what the chance was. In the midst of the uncertainties and divergent opinions on the theme, there was, however, a very acceptable hypothesis for the chance discovery that Röentgen had mentioned. Lenard had worked with a screen on which the fluorescent material was an organic substance. Röentgen used a screen of barium platinocyanide, which provides greater emission of fluorescent light. Now, it so happens that the material used by Lenard showed fluorescence with the cathode rays, but not with X-rays, as was later verified. On the other hand, Röentgen's screen emitted light when hit with the new radiation. And it is possible that herein lay Röentgen's chance discovery.

Whatever the case, Röentgen had stumbled upon something different, but which led to further questions and responses. Röentgen was not a man to draw hasty conclusions. Quite the contrary; he was a trained scientist, very meticulous, and when faced with an apparently new effect, he thought up successive experiments which he repeated to exhaustion, in an attempt to demonstrate that the effect was either an error in the experimental protocol, or did not exist, or if it existed, that it was something previously unknown. It was at this point that mere curiosity became serious scientific investigation, and chance providence was transformed into true scientific discovery.

Eager to find solutions to the unanswered questions, Röentgen literally shut himself away in his laboratory. As he said afterwards, he even moved his bed into his office, and had his meals there. Practically withdrawn from the world and captive to his scientific passion, Röentgen launched himself into a feverish period of work lasting seven weeks, with the same great meticulousness that he always practiced in his research. And so, he managed to explain the light that had so intrigued him: It was, in the end, the result of a type of radiation, hitherto unknown, acting on the fluorescent material. But he didn't stop there. He immediately began studying the various characteristics of these new rays. The volume and quality of the results he achieved during this brilliant investigation are astounding. However, Röentgen was not able to define, at that time, the exact nature of the X-rays. Were they emissions of particles? Were they wave-like in nature? Were they transversal or longitudinal vibrations? Faced with all these uncertainties, he associated the symbol X, for unknown, with the new rays. It was obviously meant to be a provisional designation, which clearly demonstrates Röentgen's humility, but through universal use, it became the definitive designation. Although throughout the work numerous experiments immediately began using X radiations, almost twenty years passed before Max von Laue would demonstrate the wave-like nature of the new rays, which were very similar to light, but with a much shorter wavelength.

During the course of Röentgen's investigations, the idea came to him that these X rays, that could cross the glass of the tube and the black card that covered it, might also be able to pass through other substances. So he experimented with all kinds of materials - wood, glass, metal, a book, etc. It was inevitable that Röentgen would also test the permeability on himself, and so he became the first person ever to have a radioscopic view of his own bones.

Then Röentgen came upon another problem: how to definitively document the images that appeared on the fluorescent screen. As he knew that the cathode rays left impressions on photographic film, he did not hesitate to try out the same process. And so the radiographic method was born. The radiographs that he obtained, of a compass, a box with weights of scales, and of the door of the laboratory itself, are well-known.

During his scientific odyssey, he kept absolute secrecy about what he was doing, with two exceptions. To his best friend, Theodor Boveri, he let slip the phrase: "I've discovered something extraordinary, but I don't know if my observations are correct". And to his wife, Ana Bertha, he confided that he was working on something that would cause people to say of him: "Röentgen has gone mad".

I have mentioned the radiographs obtained by Röentgen, but without doubt, the most famous was that of Ana Bertha's hand. We do not know what led him to make a radiograph of his wife, and not of his own hand. Some believe it was his wife's concern that led her to go into the laboratory to see what was preoccupying him so. It could be simply that on revealing the discovery to her, he wanted to demonstrate it, by obtaining a radiograph of her. It has also been suggested that Röentgen needed both hands to perform the radiography, and so he needed an assistant, his wife being the obvious choice to guarantee the secret that he wanted to safeguard. The radiograph of Ana Bertha's hand, complete with her ring, has become world famous, and was the first step in the greatest revolution seen in Medicine until today.

The history of the discovery of X-ray, as we have just seen, reflected Röentgen's enormous gifts as a researcher, and his fervent enthusiasm for research. In this regard, I would like to record the speech given by Röentgen in 1894 - one year before the discovery of X-ray -, on the occasion of his election to the position of Rector of the University of Wüerzburg. In this handover speech, Röentgen, citing the words of another university of Wüerzburg of the preceding century, said:

"Often, Nature reveals surprising miracles that are born out of the simplest observations, but which are only recognized by those with wisdom and investigative acuity and who consult experience, master of all knowledge".

But beyond his undeniable passion for scientific research, it is very natural that there was another reason for the frenetic pace of work that he imposed on himself. It lies in that fact that Röentgen was aware that the rays he had discovered were being produced daily in many laboratories throughout the world, therefore there was a risk that another scientist could announce the discovery before him.

We know today that various researchers stumbled upon X-ray, so to speak, but they were not capable of making the most of the excellent opportunity that chance had blown their way. Johnson, Goldstein, Hittorf and Lenard, like others, had also observed light in fluorescent materials placed near the tube. The famous William Crookes observed, at a certain time, that the photographic plates of his laboratory were sealed. He complained to the supplier and the Ilford firm, which manufactured that material, replaced the supposedly defective plates. But when the fact was repeated, the Ilford firm was now able to guarantee that the defect was not in the manufacture, but in something that was happening in the laboratory of Sir Crookes himself. Another famous lost opportunity occurred with Professor Arthur Goodspeed. At that time it was very common for those who worked with cathode rays to be assisted by a photographer. Goodspeed was studying the cathode rays, and the photographer William Jenkins, beside him, happened to leave two coins, by chance, lying on a photographic plate. When the plate was revealed, two round black spots emerged, to the surprise of both men. Unable to explain the incident, Goodspeed kept the photograph. It was not until six years later, when Röentgen discovered X-rays, that Goodspeed found the key to that mystery, along with the frustration of having missed the opportunity. His displeasure was mitigated somewhat, however, by the chance to claim the distinction of having made the first radiograph in the world, albeit without knowing it at the time.

Where, then, lay the merit of Röentgen? By chance, in that chance that had already knocked on so many doors, and in various ways? The key to the process of discovery is found in the response that Röentgen gave to an American journalist, who asked him: "When you saw the light emerging from the platinocyanide, what did you think?" To which Röentgen replied, simply: "I didn't think, I investigated it!"

Once the original investigation was complete, it had to be announced to the scientific world with all haste. The most prestigious German Physics Journal, os Annalen der Physik und Chemie, would certainly accept Röentgen's work, but the periods until publication were long. Röentgen therefore opted to take his work to the Wüerzburg Society for Physics and Medicine, of which he had been a member for twenty-five years, with the intention of presenting an oral communication that would then be published in the Annals of the Society. But when he went to see the President of the Society, on 28th December, he realized that the next opportunity to give the oral communication would not be until 23rd January. But Röentgen wanted the discovery to be recorded as having been made in 1895. Therefore, aware of the magnitude of the discovery, the president agreed to publish it immediately in the Annals of the Society, where it appeared on the last pages of volume 1895, with the title "On a new kind of ray".

The typographic proofs were delivered to him on 1st January, and immediately, Röentgen sent copies and radiographs to various European physicians, and even to an American, with whom he had maintained correspondence. One of them, Exner, lived in Vienna, and quickly arranged a small meeting with collaborators and friends, showing them the material he had received from Röentgen. One of these was the son of the Director of the journal Die Presse. And so it was in Vienna, through the above mentioned journal, that the news was published for the first time, on 5th January. The effect produced was like a bomb had been dropped. Long before the austere scientific publication announced the news to the world of Science, it had reached – with amazing speed for the era – every corner of the globe. The news was so amazing that a journalist added the following note: "It was not a joke, but a serious discovery, by a serious German professor". The news arrived in Portugal on 27th January 1896, though the newspaper Novidades.

However, as noted by Alte da Veiga, the news published in Novidades did not give any clues as to how the miraculous rays were produced. It was not until 29th January, also in Novidades, that some important details emerged.

Henrique Teixeira Bastos, Lecturer of Physics in Coimbra, at the Faculty of Philosophy, as it was then called, was a scientist who had perfect mastery of the Physics of cathode rays. It was not by chance that his laboratory contained Crookes tubes and a Rumkorff coil.

We do not know whether Teixeira de Bastos had read Novidades on that 29th, but we know, as reported afterwards in the journal O Século, that the physicist from Coimbra had begun his experiments on 2nd February, and that the day afterwards, he had obtained the first radiographs, on 3rd February - exactly 100 years ago.

Knowing that the tubes had to be prepared by removing all the air inside them, and that this was an arduous process that took several days, we can just imagine Teixeira Bastos, captivated by feverish excitement, vigorously pumping the mercury so that the tube would be ready for use as quickly as possible. This work was probably done between 29th January and 2nd February. On 2nd February, a Sunday, he began to regulate the electrical discharges in the glass tube, until he was able to produce the X-rays which, presumably, were detected with a fluorescent screen. And so it was on 3rd February, a Monday, with the help of the renowned photographer from Coimbra, Adriano Silva, that Teixeira Bastos produced the first "opaque body photographs", as the Press of the time called them. O Século of 1st March dedicated its entire first page to the new rays, illustrating the article with several photographs. Among them were some that Teixeira de Bastos had produced on the famous 3rd of February.

The University of Coimbra can also be proud of the fact that it was here that X-ray was used for the first time for medical diagnosis and for the teaching of Medical students in Portugal, and it was here that the first dissertation of "great conclusions" was written about the new form of radiation.

Following this comment on the start of Radiology in Portugal, I now go back to the time when the news of the discovery was published to the outside World. It was the first time a piece of scientific news had reached such a wide public. This vast repercussion gave rise to a kind of delusion.

Thus, someone wrote to Edison, who in the United States was carrying out important work on radioscopic screens, asking him to send half a kilogram of X-rays by return post. In England, spectacles were published and sold which supposedly gave the wearer X-ray vision. Another American sent Edison some binoculars, asking him to equip them with X-rays. This idea of X-ray binoculars also had an unexpected effect: A deputy in the State of New Jersey proposed a law prohibiting the use of X-rays in opera binoculars.

Thus, the notion that X-rays made it was possible to violate the physical intimacy by revealing what was hidden underneath the clothing was the aspect that most took root in those gullible souls. As Aires de Sousa (Father) reports, "fifteen days after the discovery, the so-called morality brigades were created in London, ready to die for the decency that had been so gravely threatened by Röentgen" and "a London firm took the opportunity to sell impermeable coats against X-ray ... which earned it a small fortune". The climax came when Pall Mall magazine advocated the idea of "destroying all works on X-rays and throwing into the sea all those who worked in this area".

But the delusions about X-rays were not limited to fears of indecent exposure. A newspaper in Iowa reported that a student had managed, using X-rays, to transform a simple piece of metal of no value, into pure gold. It was the discovery of the philosopher's stone ... The magazine Electrical Engineer reported that two Parisian doctors, Seguy and Quenisset, had observed that exposure to X-rays produced violent heart palpitations, and that it was only necessary to place a metal plate between the rays and the heart, for the palpitations to disappear. The well-known Science published, on 3rd March 1896, that in the College of Physicians and Surgeons, X-rays had been used to project anatomical diagrams directly into students brains, obtaining a much longer-lasting effect than the ordinary methods of learning Anatomy. It is clear, then, that concept of the almost miraculous powers of X-ray created a fertile ground where all sorts of fantasies took root and sprouted like mushrooms. In the climate of miracles, everything became possible, with or without X-rays. As Stefan Zweig aptly stated: "When a door to the unknown opens, a whole noisy multitude of curious people, dreamers, madmen and charlatans follow in the wake of the serious researchers" (cited by Ayres de Sousa, Father).

Röentgen was the exact antithesis of these people. It was a shock, therefore, from which he suffered greatly, to hear and see what was said and written about X-rays. Things reached such a point that Röentgen gave up trying to combat this collective madness, and took refuge in total silence about his discovery. The millions of letters that he began to receive each week, and which he simply burned in the heating brazier, and the inopportune and continual visits that destroyed in a few days his quiet life as a scientist and the intimacy of his home, lead him to flee to Italy, on a well-deserved holiday, and which enabled him to recover his tranquility and peace of spirit.

Returning to Wüerzburg, Röentgen distanced himself completely from the polemics and the curiosity from others about X-ray, which he continued to investigate, having produced two other works of merit on this subject.

The occasions when Röentgen spoke publicly about X-ray were few. The first was at the famous oral communication, scheduled for 23rd January 1896. It was at a meeting of the Wüerzburg Society of Physics and Medicine, and among those present was the famous Koelliker. After explaining his ideas, Röentgen gave a practical demonstration, taking a radiograph of Koelliker's hand. He presented the radiograph to his assistant, who broke out in enthusiastic applause. Koelliker proposed, there and then, that the new radiographs would be called Röentgen rays, and the ovation was indescribable. But this did not sit well with Röentgen's personality, and only served to make him even more closed about the subject of X-rays.

I cannot conclude these references to Röentgen without saying a little more about his character, his exemplary personality, whose wealth is already derived from some stages of his life that I have mentioned here; I will mention just three more.

When, at the age of seventeen, he took his pre-university studies in Utrecht, Holland, a colleague of his, skilled in drawing, drew a caricature in the class of a teacher whom all the students hated. When the teacher unexpectedly entered the room, Röentgen was standing near the caricature, looking at it with manifest satisfaction. Accused of being its producer, Röentgen denied the charge, and when prompted to reveal the true artist, he refused to do so. As a result, he was required to appear before the solemn council of professors, the concilium abeundi, where he once again refused to become an informer. The result was expulsion, which caused him serious academic prejudice for many years of his career.

The second stage I will mention here relates to the Nobel Prize award.

Röentgen accepted the award, but gave all the 50,000 Swiss crowns to his University. Finally, when repeatedly approached with requests to market his discovery, he always refused. It is worth citing one of these episodes, which occurred with Max Levy, of AEG, who put the same request to him. His response was as follows: "According to the good tradition of the German university professors, I understand that their discoveries and inventions belong to Humanity, therefore they should not be limited by patents, licenses or contracts, or controlled by any group".

Röentgen was like that, a man cut from a single cloth. His integrity of character was only paralleled by his dimension as a researcher. Happy science, Radiology that owes its birth to such an excellent representative of mankind.

I have spoken to you of Röentgen, I shall now speak to you of the consequences of his discovery for Medicine.

With the appearance of X-rays on the medical scene, the dream of viewing Man from the inside, without having to resort to autopsies or surgery, had become a reality. It was a huge step, the biggest taken in medicine since its earliest beginnings.

From the beginning, radioscopy was the usual method of observing patients by X-ray. Radiographs were rarer, and it was not until a few decades later that more radiographs were being carried out than radioscopy. The early images could only identify the bones of the extremities, against a more or less transparent background of soft tissues. With the appearance of more powerful machines it became possible to see the remaining body segments. But Radiology showed nothing more than the skeleton, the gases in the abdomen, the lungs and the mediastinum. The remaining organs showed up only as indistinct shadows, in which it was impossible to distinguish injuries, even severe ones.

With the appearance of contrast products, radiology took an enormous qualitative leap. Many organs that that had hitherto been invisible to X-ray became visible, some by very simple processes, others by far more complex mechanisms. Thus, the esophagus, stomach, intestines, bile tract, urinary apparatus, joints, salivary glands, uterus, ovaries, galactophorous canals and blood vessels, etc., became visible.

This period of Radiology was full of enlightened pages and others with some clouds, of brilliant men and of mean-spirited men, since the scientific community is made of the same clay as the rest of Mankind.

I would like to record three illustrative episodes from this saga, one of which relates directly to us here in Portugal.

In 1923, Graham, a well-regarded North American surgeon, formulated an ingenious hypothesis. If, as was already known, phenolphthalein is excreted by the liver, and on the other hand, it was also known that chloride, bromide or iodine solutions were opaque in the X-rays, why not use the phenolphthalein molecule linked to the iodine or bromide, and inject it into the bloodstream? It is added that Graham had also learned of a recent demonstration that the vesicle strongly concentrated the bile, by reabsorption of water. Thus, it would be possible to take the liver and excrete a substance which, benefiting from the vesicular concentration, should have good opacity to visualize the cholecyst. To verify this hypothesis, he handed over the experiments to his intern, Warren Cole.

Putting into practice the experimental protocol in dogs, it was only after a discouraging series of negative results, using around 200 animals that the first radiologically visible vesicular opacification emerged. Reviewing the protocol, Cole could see any difference between this dog and the others that might explain that isolated success. Questioning the animals' handler, he discovered that he had forgotten to feed the animal. The cause of the singular phenomenon had been discovered, and the way was definitively opened for oral cholecystography.

The second episode relates to the contrast study of the urinary apparatus. Important progress had been made with the creation of ascending pyelography by Voelker and Von Lichtenberg, in 1906. But Von Lichtenberg's glory was somewhat dampened by what happened with the advent of intravenous urogram. The North American, Moses Swick, who was an intern under him, was the author of the method during his time in Germany. Despite this, in 1929, Von Lichtenberg relegated his position to second place, and it was not until 1964 that the scientific world recognized Swick as the true discoverer of the method, after thirty-five years of being relegated to bitter forgetfulness, while Von Lichtenberg received high acclaim, thanks to the work of Swick.

The third reference relates to the discovery of cerebral angiography, carried out by Egas Moniz, in 1927, after successive experiments on rabbits, dogs, and human cadavers. The international repercussions of this technique, invented by our genial compatriot, are well-known. After him, other Portuguese scientists applied the same principle to various organic departments. This illustrious group of men came to be known by the name Escola Portuguesa de Angiografia (Portuguese School of Angiography). After Egas Moniz, the most sonorous name was that of Reinaldo dos Santos, but also Lopo de Carvalho, Pereira Caldas, Hernâni Monteiro, Sousa Pereira, Roberto de Carvalho, Aleu Saldanha, Aires de Sousa (Father and Son) and others also made important contributions for the demonstration of the blood circulation at macroscopic and submacroscopic level, and also of the interstitial circulation. Curiously, the Nobel Prize with which Egas Moniz was awarded did not take into consideration his splendid contribution to the progress of radiology, but rather, his work on prefrontal lobotomy, which today, has been abandoned.

I allude, in summary form, to the simple radiological methods that use contrast products. But are the contributions of X-rays in diagnostic medicine restricted to these types of tests? In fact, computer assisted tomography (CAT) also deserves mention.

The idea of using more sensitive detectors than radiographic film to show differences in density between the various soft tissues, the desire to obtain quantitative data on the value of attenuation produced by a given tissue, measuring it on a numerical sale of densities, and the intention, not entirely original, to obtain cross-sectional tomographic images of the human body were fulfilled in CAT, thanks to Cormack, and above all, to Hounsfield. The latter knocked on the doors of some radiological equipment manufacturers, but none was willing to sponsor the idea; and the idea was the only thing Hounsfield had. He lacked material support. And so, in desperation, he turned to other hypothetical investors, and unexpectedly, was welcomed by EMI, which was mainly focused on music ... Thus, he managed to construct the first prototype in 1972, the year in which TAC began a new era in medical diagnosis.

There is another advance that we also indirectly owe to Röentgen, this time in the area of the mentality, but which proved fruitful. Through his method, Röentgen demonstrated, for the first time, the possibility of using invisible energy to produce visible images of the interior of the organism. The mental perspective introduced by this new concept provided fertile ground for other methods based on the same possibility. Invisible energy, with infra-red rays, in thermography, mechanical sound vibrations, in the case of echography, and electromagnetic energy of radio waves, of which magnetic resonance is an example, have all been successively explored to produce diagnostic images. And the list doesn't end there: studies are currently underway on other forms of energy, like microwaves.

It is not my intention here to discuss these new imaging methods that were introduced after Röentgen, bringing a second revolution in medical diagnosis. I state only that the radiologists were particularly well-prepared, as experience has widely shown, to receive and master these new diagnostic techniques worthy of their intellectual perspective, faced with the conversion of invisible energies into images, to train in extracting from these all the information possible, and their special mastery of the planar anatomy on which the new methods were based. And so, radiology was transformed into the Imagiology that we know today, and which is in a constant process of rapid change. A major contribution to this process is seen in the field of information technology. The digitalization of the images enables a series of functions that was previously unimaginable: the direct and correct measuring of linear dimensions and angles, histographic profiles, three-dimensional reconstructions, the dynamic vision of a virtual journey through the human body, the transmission of images from a distance, etc.

It is also important to mention another new direction for Radiology that has been assuming an increasingly important role in Medicine - interventional Radiology. This concept includes diagnostic acts and therapeutic actions.

The first include biopsies, which are now performed on practically all the organs and structures. Imaging methods guide the biopsy into the lesions with enormous precision, and in these, enable the target to coincide with the more promising zones in terms of diagnostic results.

In terms for the therapeutic interventions of Radiology, the list of techniques and indications is increasing all the time. At a vascular level, it is possible to penetrate the blood vessels that supply an organ tumor to obstruct or inject medications directly into them in high concentrations, which the organism would be unable to bear if introduced by the systemic route. Thus, it is now possible to drain abscess and other collections of liquids with great safety and excellent results. Interventional Radiology enables zones of stenosis to be dilated, whether in the veins or in other tubular structures, which in some cases, is done using a balloon that is expanded to promote permanent dilation of the stenosis; where this is not possible, there is also the resource of the collection of resistant mesh stents, which guarantee the permeability of the previously stenosed zone. Another outstanding example — and I could mention many more — is the transjugular intrahepatic portosystemic shunt - TIPS.

By making many surgical interventions unnecessary with these alternative treatments, improving the conditions of patients who require surgery, but whose situation makes immediate surgery ill-advised, and enabling a more rapid and precise diagnosis through diagnostic acts guided by imaging, interventional Radiology is today a powerful tool for the Medical service, and is one of the main frontiers into which radiological science is expanding.

This essay would be incomplete without referring, albeit in two phases, to radiotherapy. X-rays provided inestimable service for many years, by the direct therapeutic action of radiation. But with the development of other forms of treatment, notably gamma radiation and bundles of particles, its use progressively and drastically decreased. Nowadays, with the appearance of machines that produce X-rays of a far higher energy than those previously used, it is possible that they may recover a new breath of radiotherapeutic life.

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The discovery of X-rays completely changed the face of Medicine. We have come so far since the pre-radiological era that it becomes difficult to evaluate in all its dimension of immense benefit that the Röentgen rays brought us. To use them in a discerning way to relieve the suffering of Mankind is the noblest homage we can pay to Wilhelm Conrad Röentgen.