Film as an Instrument of Research and Teaching in Cardiology

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A) SINCE THE BEGINNING OF THE SCIENTIFIC FILM TILL THE SEVENTH ART

Since the beginning of human history the oral transmission and the representation of images precede the written language. Numerous representations of anatomical character and traumatic pathology can be observed in the prehistoric cave paintings of different cultures.

At the very start of the development of the written language appear texts about diseases and remedies. A constant concern about life, death and disease can be appreciated on the inscriptions, paintings and hieroglyphics remaining from Mesopotamia, Egypt, Greece, Rome, Far East, and pre-Columbian civilizations of America. Many of them show a teaching intention, but most of them deal with privileged information reserved to circles of power, where secrete knowledge, art and magic intermingle.

Many centuries passed before the first incunabula appeared, printing improved, and an adequate scientific development and craft industry arrived making possible instruments and procedures useful as authentic supports for teaching, medicine, and other kinds of knowledge in the corresponding ages.

Book is the first external memory of humanity with enough capacity to accumulate and transmit knowledge in the form of text and fixed images. From the Middle Ages to the Age of Enlightenment it underwent important modifications. It left behind the time when it was a privilege restricted to kings, monks and erudite courtiers, becoming an encyclopedic support for all kind of knowledge, and starting as an accessible means for an increasing sector of people, in addition to turning into an entertainment vehicle.

Speech, blackboard, copybooks and books will continue being the exclusive tools of the teacher until the 19th century. But this century brought new possibilities focusing communication and teaching.

The oldest-known records of equipment that can considered important complements for teaching can perhaps be found in the *dark chamber* of Leonardo da Vinci in the 15th century, and in the *Magic Lantern* of the Jesuit Atanasius Kircher in the 16th century.

During the 16th, 17th and 18th centuries the optical instruments were improved, allowing authentic developments related with the world of audiovisuals as we now know it, and in this history medicine and physicians had a special prominence.

Physicists and physicians discovered the phenomenon of the persistence of images in the retina. The first documented observations related with it were presented in 1765 by the chevalier d'Arcy at the Academy of Sciences of Paris. He studied the time a burning ember fixed in a revolving wheel needed to go from being seen as an isolated image to being seen as a circle. Many years later, an English physician, Peter Mark Roget (1779-1869), presented in 1824 at the Royal Society his observations about the optical illusion produced when looking at the movement of the axes of a cart wheel through a fence. He analyzed the phenomenon and reproduced it experimentally employing a perforated cardboard disk, and a mobile paper strip, using the produced illusion to calculate the duration of the impression left in the retina by the images. Other two English physicians, William Harvey Fitton (1780-1861), and John Ayrton Parish (1785-1856), were competing for the invention of the *Taumatrope*. This was a very popular toy consisting of a disk with a drawing on the obverse, and other drawing on the back, that were observed as superimposed images when making it to go around perpendicularly to the plane of the paper.

Physiologists and opticians demonstrated the possibility of generating the illusion of movement. This was discovered independently and simultaneously by a Belgian physiologist, Josef Antoine Ferdinand Plateau (1801-1883), and an Austrian mathematician, Simon R. Von Stampfer (1792-1864). In the same year 1833 Plateau announced his "Fenaquistiscope", and Stampfer his "Stroboscope". With these inventions the cartoons were born. (Figure 1)

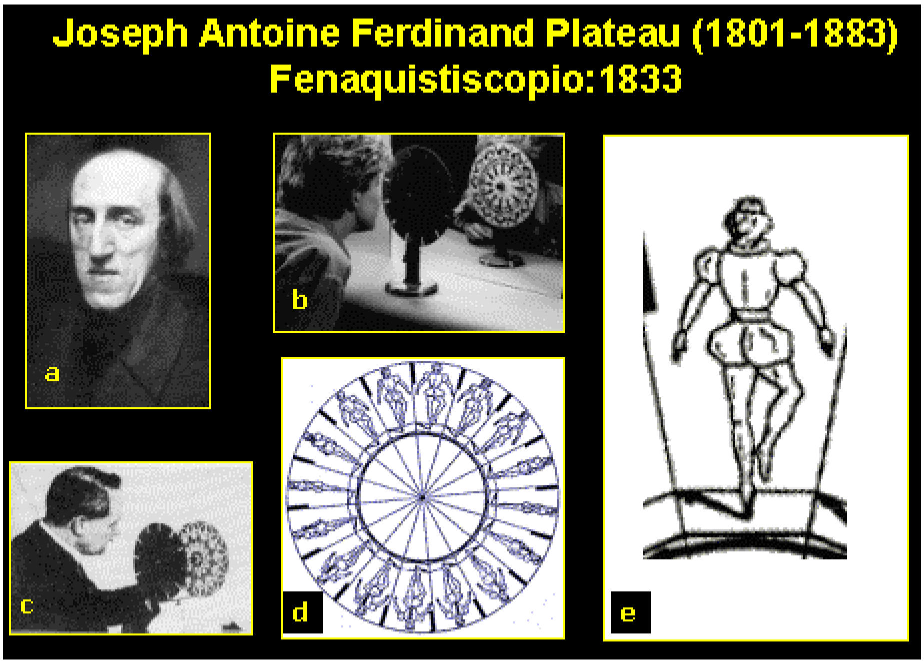
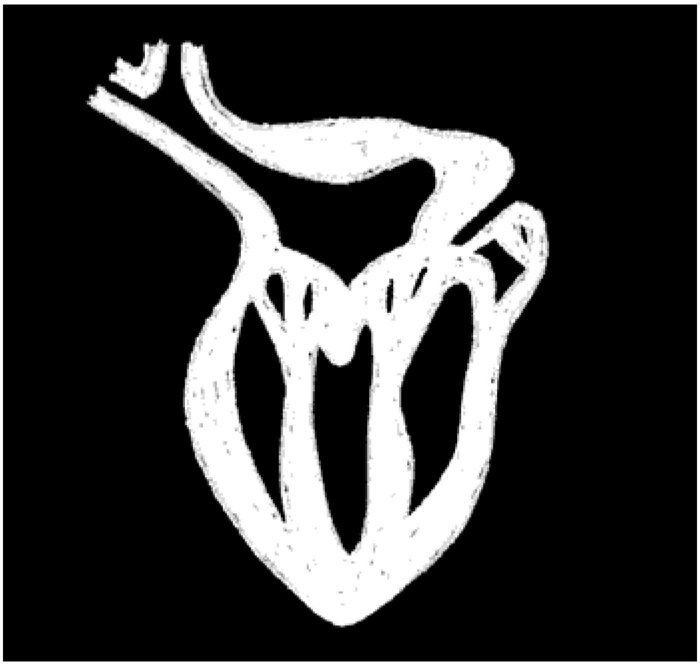


Figure 1

The first who applied these inventions to teaching in medicine was the Czech physiologist Evangelista Purkinje (1787-1869), who improved a Stroboscope which he named "Forolit", and drew different disks to show his disciples several movements, as those of the beating heart. (Figure 2, Video 1)

Figure 2



Video 1

All this happened close in time, and preceded the development of photography by Nicèphore Niepce (1765-1833) and Louis Jacques Daguerre (1789-1851). It was also when, together with the Industrial Revolution, very near in time Samuel Finley Breese Morse (1791-1872) invented the telegraph, and Thomas Alva Edison (1847-1931) discovered light and phonograph. All these findings made possible recording and reproducing images and sounds, as well as the transmission of sounds.

The discoveries and inventions were soon applied to enjoyment, but their first applications had always a scientific or teaching intention, in many occasions directly related with medicine. The best examples regarding this are the extraordinary contributions of Étienne Jules Marey (1830-1904). Marey was a physician who devoted his whole life to the study of movement. He designed and built numerous devices to analyze the human and animal movements: pneumatic graphic systems (1870), photographic gun (1882), fixed plate chronophotograph (1884), and paper chronophotograph (1888) (Figure 3). He applied his inventions to study the human movements, the flight of the birds, the movements of fishes, and those of the microscopic beings. Marey invented film and many of its special techniques, as the mirrors chamber, which later constituted the base of the procedures of high speed filming, and intervalometry to study the slow phenomena. All this happened many years before the brothers Auguste and Louis Lumière sent forth and showed his "Cinematogragh" in a session that took place at the Grand Café de Paris the 28th of December of 1895. Marey never marketed his discoveries, and he did not show any interest either for filming everyday life scenes or for making his inventions popular. He was only interested in the scientific applications.

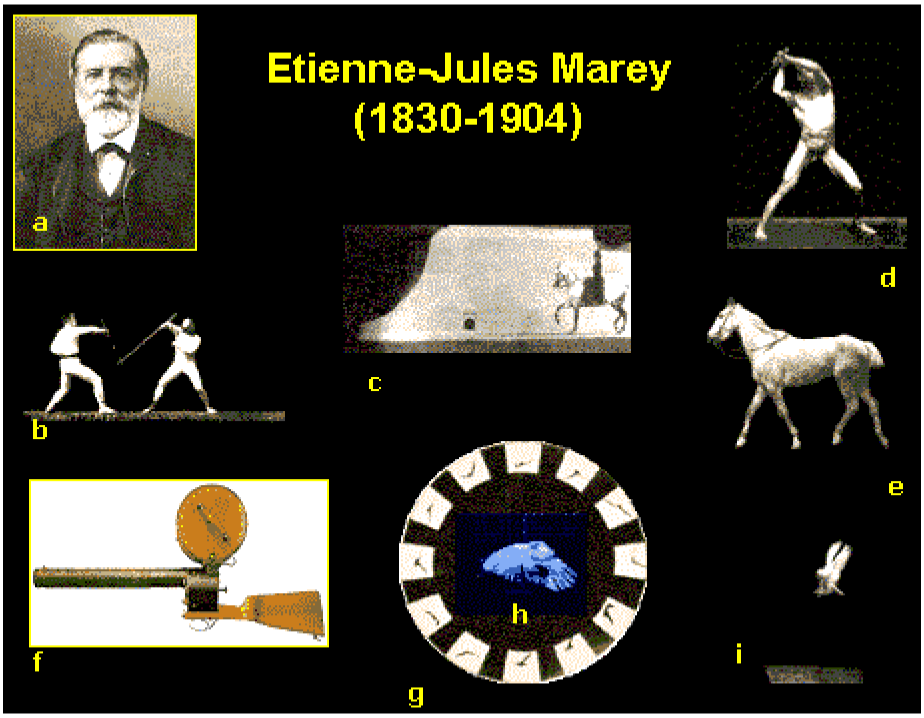


Figure 3

In his Institute of Physiology formed numerous professionals, as Lucien Bull, who invented the fast camera, Carvallo, that invented roentgen-cinematography, or Comandon, who improved and applied cinephotomicrography to study microbes, parasites, and physiologic processes in numerous fields of medicine.

Cinematography became vertiginously popular, and at the beginning of the 20th century, at the same time as the show movie films, its applications multiplied in every field of science: biology, botany, ethnography and anthropology.

In the medical field, surgical film started to be appreciated and had a boom. The first surgeon who filmed his operations was Eugène Louis Doyen (1859-1916). Given the limited sensitivity of films he had to operate in the sunlight, and to do it quickly because the best cameras of his time accepted only films for a few minutes of filming. At the International Congress of Surgery that was held in Madrid in 1903, Doyen emphasized the importance of cinema *"because it permits the precise communication to other professionals of the employed techniques, it is a valuable instrument for surgeon to improve his own operations, and it is the best procedure for teaching surgical techniques"*. A great amount of the surgical material filmed by the pioneers got lost. However, among the conserved films, operations of a lung hydatid cyst, and of a hernia carried out in 1900 by the prestigious Argentinian surgeon Alejandro Posadas can be found. He filmed in the sunlight at the hospital coutyard, with the collaboration of Eugenio Py, who was the first motion-picture cameraman in his country. Posadas, like Doyen, was convinced about the subsequent importance of film for professional communication and teaching in surgery.

The popularity of show movies pushed into the background the scientific interest and teaching possibilities of the procedures originally developed with the discoveries of Marey, and in some academic environments the audiovisual records and movie projections were even accepted with reluctance, because image and sound were linked to fun. Film did not look a serious thing for classrooms. This feeling existed during many decades, in such a way, that until a few years ago a great part of our academies of medicine did not accept their members to present lectures with films. Notwithstanding, in some countries the most famous personages in sciences, medicine, art, and humanities were subscribed to scientific publications concerned with moving images, and the most prestigious publications at the end of the past century and at the present century have paid special attention to filmed matters.

B) IMAGING AND MEDICINE

Nowadays, one of the phenomena marking the everyday work of physicians is the requirement of diagnostic imaging: photography, radiography, thermography, echography, computed tomography, magnetic resonance imaging, fibroscopy, and numerous dynamic studies (endoscopic, radiologic, gammagraphic). They represent an essential support in the hospital practice.

Auscultation, blood pressure measurement, electrocardiography or conventional radiography continue being irreplaceable procedures, that have been improved with the new technologies making possible, for instance, maintained monitoring, and the telecommunication of records.

Without playing down the importance these resources have, there is no doubt that in the middle of the past century an exponential development was produced improving and using the imaging techniques in most of the medical societies, and this was particularly in the cardiology sphere.

After all, we cannot be surprised about the exponential development of dynamic imaging procedures in medical diagnosis and research on the whole, and in cardiology in a particular way, because in the medical area a close relationship exists between form and function at every level: organic, tissular, cellular or molecular.

In traumatic pathology, the relation existing between lost of form (discontinuity of a vessel, a nerve, a muscle or a tissue) and lost of the corresponding function is clear. Pathological anatomy evidences the relation between form and altered function at tissue and cell levels in most of the processes, even those with scant macroscopic expression, and we know now that the metabolic and biochemical pathological processes have also a molecular morphologic expression when the function of an effector, receptor, antibody or allosteric enzyme is modified.

From all the mentioned facts we can expect that the demand of imaging procedures in medicine will continue increasing.

C) THE SPECTACULAR DEVELOPMENT OF THE IMAGING PROCEDURES IN CARDIOLOGY

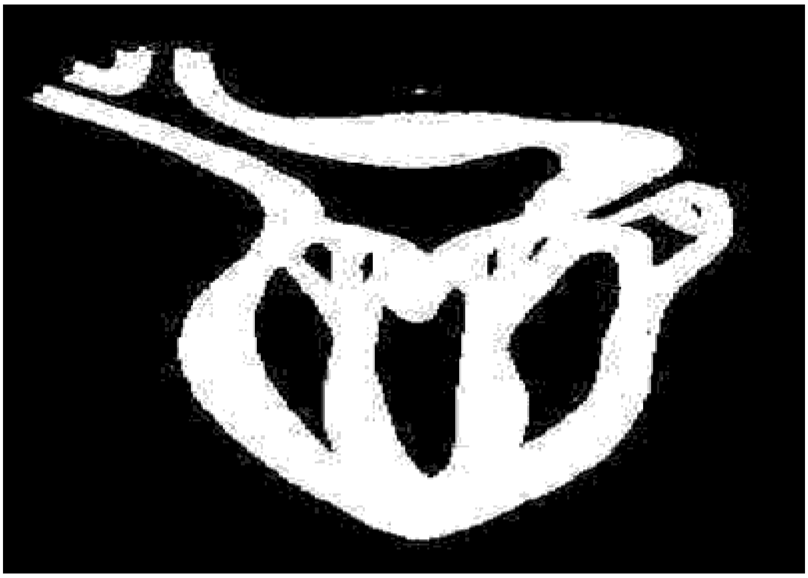
It would be enough going over the imaging procedures forming part of the now existing armory used by the cardiologist.

Radiology: radiography, radioscopy, vascular arteriography, coronary arteriography, quantitative coronary arteriography, digital subtraction coronary arteriography, cine angiography, digital subtraction cine angiography, angiocardiography, computed tomography (CT).- Echocardiography: M-mode echocardiography, real-time two-dimensional echocardiography, Doppler echocardiography.- Nuclear imaging: gammagraphy, radionuclide angiography, scintigraphy chamber, single-photon emission computed tomography (SPECT), positron emission tomography (PET), magnetic resonance imaging (MRI).

From the symbioses between physics, mathematics and computer science rose the procedures of imaging reconstruction and treatment attaining the methods in vanguard nowadays.

But we must not forget that most of these techniques need to be combined with cinematographic recording procedures (optical, magnetic or digital), in order to provide the dynamic imaging of the processes we wish to study. (Figure 4, Video 2 - Video 3 116KB - Video 4 97KB - Video 5 549KB [Windows Media or Quick Time necessary])

Figure 4


Video 2

We shall review below succinctly the foundations and historical landmarks of some of the aforementioned methods.

Radiology

When studying the penetration of the cathodic rays, the German physicist Wilhelm Konrad Roentgen (1845-1923) discovered a new class of radiation capable of going through a variety of objects, impressed exposed photographic films, and produced shades on a fluorescent screen.

The discovery of X-rays by Roentgen in 1895 made possible the development of radiology, and afforded the first imaging procedure allowing medicine to explore the interior of the body. Radiography provided static images, snapshots of dynamic processes. The main technical challenge was at the beginning the improvement of the contrast, and then to diminish the patient exposure, once the iatrogenic effects of radiation were known.

Rapid successive achievements were the improvement of the emission sources, the development of more sensitive emulsions, the films with guard grille to leave out the diffuse radiation, and new procedures improving resolution to study soft parts, as xerography. Before these problems were solved, procedures useful for dynamic studies had already been developed.

Experimental roentgencinematography began in 1897 in Scotland, with J. Macintire, and was improved in the first decade of 1900 by the works of Carvallo, J. Comandon and A. Lomon in France, P. H. Eijkman in Holland, F. M. Groedel in Germany, and L. G. Cole in the United States. Film recording enriched research and diagnosis in the area of radiology since the beginning. The procedures employed by the pioneers exposed to large doses of radiation. Several decades passed before combining the knowledge of electronics, television and image magnetic recording made possible the development of the electronic image intensification and amplification techniques. Nowadays, these techniques are useful in carrying out dynamic explorations with contrast applying short exposure times, and very low doses of radiation.

The exploration of the vascular apparatus with radiopaque contrast constitutes one of the most important chapters in the diagnosis of numerous morbid processes. In 1939, Castellanos, a Cuban physician, proposed the "quantified angiography", that was made real as digital angiography by Mitrette and Saudelman in 1980.

D) CONTRIBUTIONS OF SURGERY

The conventional procedures were enriched making possible surgical practices as catheterization for selective administration of contrasts. In 1929, the German surgeon Werner Forssmann carried out on he himself, the first catheterization. First of all he got to be dismissed from the hospital, but later his merits were recognized and was awarded with the Nobel prize of Medicine in 1956, shared with A. F. Cornaud and D. W. Richards. He was not concerned with diagnosis, but therapeutics, searching to easy an efficacious way to administering medication in conditions leading to cardiac arrest. But he paved the way to numerous procedures that were developed by other physicians. Outstanding names in this task were, among others, A. Blallock, R. Bing, H. Taussig, L. Dexter, J. Warren and E. Stead in the United States, P. Maurice and L. Lenègre in France, and J. McMichael and E. Sharpey-Schaefer in the United Kingdom. Advances arise always from work done, but chance plays some times favoring it, as it happened for selective coronary angiography when Mason Jones Jr observed how the images obtained while exploring a woman patient in whom the catheter had accidentally moved towards the right coronary artery became sharper. Advances starting in this field with the therapeutic concern of Forssmann, prepared the ground for other achievements that came many years later, as that of the percutaneous transluminal coronary angioplasty, carried out by the German cardiologist Andreas Grüntzig. ...

Coronary arteriography and angiocardiography were improved thanks to the magnetic recording and the computerization of images, giving rise to digital subtraction procedures. In this rapid succession of achievements the concept of scientific film (recording and visualization of the variations in the forms), has been indispensably linked to the scientific-technical progress in cardiology.

E) FROM PLANIGRAPHY OR OPTICAL-MECHANICAL TOMOGRAPHY TO THE COMPUTED TOMOGRAPHY (CT).

Radiological techniques achieved the exploration of the interior of the organism, and the assessment of static or dynamic morphologies of the explored area providing images projected on a plane. The possibility of carrying out sections to obtain spatial reconstructions gave rise to different optical-mechanical equipments or tomographs, as those built by Franck in Germany, in 1938, or by Bocage in France. The attainment of a sharp spatial reconstruction of the analyzed anatomical structures arrived many years later with the computed tomography scanning, that started to be used in 1973, and was developed by A. McLeod Cormack and G. Newbold Hounsfield, who were awarded with the Nobel prize of Medicine in 1979.

F) ECHOGRAPHY

The physical foundations of sound transmission arose from the studies made by a Swiss physicist Daniel Colladen in the lakes of his country in 1822. The theoretical groundwork came from England with the "sound theory" established by Lord Raleigh in 1877, and from the discovery in France of the piezoelectric effect by Pierre and Paul-Jacques Curie brothers in 1880.

Sounds travel through many materials, including those composing the human body. When they find media having a different density or interfaces, they are reflected towards the place of origin, producing an echo. Ultrasounds are generated by a piezoelectric quartz as short wavelength sounds, with a high-frequency from 2 to 5 Mhz and higher. They are beyond the limit of the audible sound, but penetrate the tissues reflecting multiple echoes when reaching interfaces.

Many studies and technical developments followed these principles before the first applications with diagnostic intention in medicine were attained, initiated in 1945 by John Julian Wild, a British physician settled in the United States, who was also the same person using the term *echography*. With the collaboration of J. M. Reid he obtained in 1952 the first transversal section images. Echography was first of all applied to obstetrics and gynecology, but soon it invaded the fields of many other specialties.

Echography can obtain images combining real time and two-dimensional analysis, measure the blood, associate other resources, as electrocardiography, endoscopy or Doppler, and employ vascular contrast substances.

Echography originated in the work of the Swedish investigators Inge Edler and Helmut Herz in 1954. They showed that there was a relation between ultrasonic echoes and heart structure and function. Within a few years echocardiography improved with several procedures: M-mode recording, real-time two-dimensional imaging, Doppler echocardiography, duplex echography and, finally color-coded Doppler imaging.

To detail all the mentioned procedures exceeds the purpose of this presentation, but I should not like to avoid the importance the applied research of the Doppler effect have had in the development of the vascular exploration techniques and echography. When the Austrian physicist Christian Doppler described in 1839 the effect with his name, he could not foresee the impact his observations would acquire in scientific fields as different as astrophysics and medicine. When ultrasounds are reflected in the interfaces, their echoes are reflected with the same amplitude of the employed ultrasounds, but the frequency is equal only when reflected from stationary objects. When the reflecting interface moves towards the source, the wavelength shortens, and the reflected frequency is greater than the transmitted frequency. And when the reflecting interface moves away from the source, the wavelength becomes longer and the reflected frequency is less than the transmitted frequency. The phenomenon is independent of amplitude. The change of the frequency between the emitted ultrasound and the reflected ultrasound is called Doppler effect.

Doppler echocardiography: The Doppler effect permits to know the movement, the path, and the speed of the interfaces, and to hear simultaneously with the image the variations of the sounds the Doppler effect produces.

G) NUCLEAR CARDIOLOGY

The discovery of the natural radioactivity by Henri Becquerel and Maria Curie in 1898, and of the artificial radioactivity by Frédéric Joliot and Irène Curie-Joliot in 1935 marked the beginning of nuclear medicine.

The demonstration by Hevesy, in 1913, that the radiation emitted by a radioactive substance inside the body could be detected outside of it, can be considered as the starting point of gammagraphy. It was necessary to design sensitive detectors, first using photography films, later, since 1910, devices as the Geyger-Müller detector, and then the Hal Angeran gamma-camera, that was developed in1958, and is the precursor of the present equipments of computer-processed digital information. A long path has been covered demanding the obtention of proper radioisotopes in line with the developed techniques in order to make possible their application in the regular medical practice.

R. W. Parkey, F. J. Bonte, S. L. Meyer and colaborators published in 1974 a new method of radionuclides imaging using the so called "hot spot scan", employing substances marked with technetium-99m (Tc-99m).

Cardiology employs radioiosotopes with relatively low energy, and semidesintegration period or mean life of 6 hours, considered of small risk for health. They are injected in the organism and their pass through the heart cavities and lungs is scanned by radiation emission with a scintillation crystal counter. The crystals may be composed by potassium iodide activated with thallium, when they are excited by radiation they emit light radiation (photons), Photons are amplified one million times by a photomultiplier, and collected as electrical pulses.

Single-Photon Emission Computed Tomography (SPECT)

It can de considered that in similar way as computed tomography (CT) derived from radiology, tomographies of single-photons or positrons came from gammagraphy.

SPECT gives a three-dimensional image of the heart. It uses rotatory gamma cameras. Radionuclides employed are pyrophosphate marked with Tc-99m or thallium-201.

Although it is still used, the results are no very useful in cardiology because heartbeats produce blurred images with exposures higher than one second.

The first scanner for ultrafast computed tomography was developed by the Mayo Clinic researchers E. L. Ritman, R. A. Robb, S. A. Johnson, and collaborators in 1978. They called it "dynamic spatial reconstructor", and was used for research purposes. Furtherly they developed commercial ultrafast CT equipments, as the "Imatron scanner C.100" made by Douglas Boyd. Scanning of 100 milliseconds is possible.

Positron-Emission Tomography (PET)

Positrons are electrons with a high-energy positive charge. They are emitted by short half-life radionuclides. So short, that many of them need to be produced in the same place where they are used, to be applied immediately, because their half-life may be counted in seconds or a few minutes. Only a few of them have a relatively long half-life, as ^{18}F, can be produced by central cyclotrons, and are distributed to the hospitals requesting them. Although most of them are produced in cyclotrons, rubidium and some other can be elaborated also in more simple generators.

The 1022 keV positron is unsteady and decays in an annihilation reaction producing two 511 keV gamma rays leaving the nucleus in opposite directions, at an angle of 180º. They are collected by detectors conveniently situated at both sides of the body, having validity only those pairs received simultaneously.

Among the radionuclides employed in PET are ^{11}C, ^{15}O, ^{13}N, ^{18}F, ^{82}Rb, and ^{81}Rb.

The first positron images were obtained in Boston and Saint Louis, United States, in 1953. The advanced technology required by these expensive equipments, the necessity of a cyclotron at disposal, and the complicated maintenance, limited the diffusion of the procedure, that was at first carried out in only a few hospitals sponsored by companies concerned with advanced technological research, and in some laboratories, as Donner in Berkeley, California.

The procedure allows studying physiological and pathological processes producing films of the metabolic processes originating in the studied organism.

After some research done in animals, positron-emission tomography was assayed in patients with coronary arteries alterations by P. Camici, L. I. Araujo, T. Spink, and collaborators in 1986, employing [^{18}F]-fluoro-deoxyglucose (FDG) and ^{82}Rb.

PET allows the three-dimensional study of heart perfusion and myocardial metabolism. By comparing the regional distribution of the perfused $H_2{}^{15}O$ with the myocardial zones capturing ^{81}Rb, ischemic areas may be observed by the defects on the ^{81}Rb scan, whose uptake is correct in the healthy myocardium.

The first Center of Positron-Emission Tomography in Spain was inaugurated in Madrid in 1995, at the *Universidad Complutense de Madrid*.

H) MAGNETIC RESONANCE IMAGING (MRI)

Magnetic resonance phenomenon was discovered in 1946 by two Americans, Felix Bloch, at the Stanford University, and Edward Purcell, at the Harvard University, both awarded with the Nobel prize in 1962. In the magnetic resonance phenomenon some atomic nuclei exposed to strong magnetic fields absorb radiofrequency energy that is subsequently emitted as radiofrequency signals that can be captured by an antenna. The absorption energy frequency was called magnetic resonance, and because it came from the atomic nuclei was called nuclear magnetic resonance.

Nuclear magnetic resonance was employed in chemical analysis during many years.

The fact that the nuclear magnetic resonance signals differ according to the atomic composition, the number of the type of atoms investigated, and the environment around them, made think that it could be applied to the study of the body organs. In 1971, R. V. Damadian, while analyzing the nuclear magnetic resonance of hydrogen atoms, found differences between the rat normal and cancerous tissues.

Several studies preceded clinical application. In 1973, the American Paul Lauterbur oberved that nuclear magnetic signals could produce images. Using different methods, the Swiss Richard Ernst, and the English Hinshaw and Moore obtained nuclear magnetic resonance images.

In 1976, the English Peter Mansfield obtained the first human image with nuclear magnetic resonance. And Hounsfield, Young and collaborators, from "EMI Medical", built the first whole body recording apparatus, that was used during several years at the Hammersmith Hospital, in London. The superconducting magnet for the machine was made by "Oxford Instruments".

In 1979, R. C. Hawkes made tomographies of the human head. And in 1981, R. Steiner and G. Bydder made a nuclear magnetic resonance tomograph that was also used at the Hammersmith Hospital.

The wide clinical use began in 1983, when the American College of Radiology gave Nuclear Magnetic Resonance official acknowledgment as standard technique in medical diagnosis.

In Spain, the use of nuclear magnetic resonance began at the Medical Center of Nuclear Magnetic Resonance of Barcelona.

The vertiginous technological development of the imaging procedures employed in cardiology shares in the daily work routine of the educator numerous challenges common to other specialties.

I) THE PROFESSIONAL PRODUCTION OF MEDICAL AUDIOVISUALS

Scientific audiovisuals in general, and medical audiovisuals in particular, have been made freelance. Out of the commercial spheres, It lacked institutional support and official structures making easier the sophisticated techniques, available information and accessible conditions. This is the situation in which many audiovisuals have been produced, and physicians have had an important role in this matter acting at the same time as producer, scientific advisor, scriptwriter, film director, cameraman, image and sound technician, speaker, and informant. On many occasions the scientific content is elevated, but as they were mostly shot using domestic formats, it was not possible at least their professional post-production to take advantage of the images. On the other hand, the autodidactic producer generally is not familiar with the regulations of the scientific audiovisuals, he is unaware of the image and sound language, and makes a bad application of music, technical resources, and effects. He frequently inserts his own images and sounds in productions taken from for a television program, without noticing that he is infringing royalties.

The importance of audiovisual media led the advanced countries to develop very soon centers making easy the production of scientific audiovisuals for research, teaching and popularization. In Germany, the *Institut für den Wissenschaftlichen Film* (IWF) counts on 150 persons having at their disposal the most sophisticated equipments, and devote themselves to producing research and higher education audiovisuals for all fields of science. Their productions are carried out maintaining close ties with scientists specialized in the different matters, expert audiovisual technicians, pedagogues, and informants. They produce about 100 films every year, all of them in professional format. Most of the titles pass to forming part of the Cinematographic Encyclopedia, with copies at the disposal of all the German universities, and to collaborating with the universities and scientific institutions all over the world. In France, the *Centre National de la Recherche Scientifique Audiovisuel* (CNRS Audiovisuel) carries out for France a similar task to that of the IWF in Germany, giving special attention to the international diffusion discoveries and medical and scientific contributions made by the French. people. The United Kingdom also counts on numerous centers for producing higher education audiovisuals, and on institutions as the British University Council, coordinating the exchange and diffusion of the productions of all the country. The Netherlands has a special tradition in attending to the better use and exchange of medical audiovisuals, so that all the universities have at their disposal a joint fund with the productions they make, and there is a working group collaborating with the International Association for Media in Science (IAMS), concerned in promoting the teaching use of experimental research audiovisuals. Mosts of the large hospitals count on installations and equipments that are a model of production and resources organization, as for instance in the *Audiovisual Centrum* at the Amsterdam Universitary Hospital.

Scientific film in general, and medical audiovisuals in particular have been much helped by several scientific and professional associations, and by the festivals and contests of scientific audiovisuals: International Scientific Film Association ISFA (1947-1992) became in the International Association for Media in Science IAMS (1992); Asociación Española de Cine Científico ASECIC (1967), Semana Internacional de Cine Científico de Ronda SICIC (1978), now named Festival Unicaja; Bienal de Cine Científico Español de Zaragoza (1983); VIDEOMED-Badajoz (1985) actually VIDEOMED takes place in several countries as Argentina, Cuba, Ecuador, México or Uruguay. Many film festivals related with medicine or health sciences are represented in the World Association of Medical and Health Films WHAMF (1990).

The proper exploitation of professionals and resources is especially important in a time originating an authentic audiovisual revolution in medicine.

J) IN THE ERA OF COMMUNICATION AND IMAGE

During the last three decades, the development of computer science, the advances in telecommunications, the organization of data bases, the possibility of image and sound digitalization and transmission between the most remote places of the world through telecommunication expressways, and the creation of users networks, originated new possibilities for the transmission of knowledge at all the levels.

Computer science has had also a vertiginous history. The most remote precedents are the so-called analytical machine of Charles Babbage (1791-1871), and the tabulators of Herman Hollerith (1860-1929). Since then, several generations of computers succeeded one another at a dizzy pace: the first one, based on the vacuum valve, arised in 1946; the second one, founded on the transistor, began in 1964; the third one, between 1959 and 1971, based on the properties of semiconductors, made possible the progressive miniaturization of equipments; the fourth one began in 1971, and includes the large scale integration of the semiconductor modules. We are facing a fifth generation allowing to reach speeds higher than 100 million instructions per second, what means a new conception of software, where the signal transmission will be optical instead of electronic.

The advances in computer science were closely linked to research applied to military and spatial purposes, but it was quickly directed towards popular use, so that from a little more than twenty authentic computer machines in the whole world in 1953, we have passed to several tens of millions computers.

Parallel to the advances in computer science have run those of television and telephony communication systems. We have passed, within a few years, from the submarine cable to the satellite transmission and the information expressways, allowing real-time and sound communication making possible the development of data base-users networks in the whole world. When, in 1960, the Advanced Research Projects Agency, of the Department of Defense of the United States, promoted a project ensuring communications in a nuclear war situation, it could not imagine that had opened up the way to the Internet. In 1960, the network counted on 200 central computers, and their use was strictly restricted to the U.S. Department of Defense. In 1985 it opened the access to research centers all over the country, in 1990 it offered the possibility of connecting with other nations, counting on 300,000 central computers, in 1996 more than 3 million computers were connected to it, and the users network continues growing exponentially.

In medicine, computing and communication represented an unprecedented advance opening new diagnostic, therapeutic and teaching possibilities.

Only a few years ago it was unthinkable to speak of tele-lectures, tele-explorations, tele-diagnosis, tele-assitance, tele-surgery, tele-operations, tele-robotic, tele-presence, or virtual reality. Nowadays they are real, and improving at a vertiginous rhythm. The *Advanced Research Project Agency* in the United States keeps the leadership on these subjects. In the field of applications to surgery, most of the research is being done in military hospitals, as one in Monterey (California). This center brought on the *tele-presence*, set to become the base of further improving the minimal invasion surgical procedures. It combines stereoscopic vision, stereophonic sound, tactile sensors, robotics, and laparoscopy equipment and instruments, allowing surgeon operating in quite similar conditions to those of conventional surgery.

At the opposite extreme, virtual reality opens new possibilities to teaching, simulating situations making easier the interactive practices using imaginary three-dimensional models improving day after day.

We are in the interactive communication era. This phenomenon has been produced because the wide projection of the computing and audiovisual resources toward the people in profitable terms for a consumer economy. The existence of a market generated interests promoting the production of elements of genuine interest to transmitting knowledge, but we are facing a situation giving rise to new and numerous problems. For example, the offer of equipment for teaching is enormous nowadays, being very difficult distinguishing what is important and what is incidental. The changes in the equipments are produced so quickly that the yesterday leading equipments become soon antiquated. This happens for the autocopying blackboards, static slide projectors, transparencies overhead projectors, diaphoram equipments, cinematographic projectors, videos, video-laser or multimedia computing resources with CD ROM, DVD...

It is very difficult for the educator to take a decision about what is the most convenient equipment he or she needs, and when wishing to be updated on the latest developments the educator finds overwhelming offers, many times incompatible. This makes, for instance, the equipments and structures of the universities in a given community to be quite different.

It is important to take advantage of the resources at disposal, and to stimulate in the environments close to us the production of their own resources. A formula to do it is promoting the creation of coordination, production, and professional post-production units. These units permit to take advantage of resources at the disposal of the hospital, faculty or medical society. They make easier the collaboration with the physicians to organizing sound and image files, elaborating mono-conceptual and thematic audiovisuals of basic, clinical, and surgical character, and facilitate the technical information necessary for the selection of standardized equipments and systems. Through them it is possible to establish equipments and exchanges with institutions already having videocinema collections of medical subjects.

Many years have already passed since teaching in medicine changed its guidelines, going from the intention of teaching everything to organize teaching searching. Presently, the educator must provide the pupil not only with references of books and works, but also of audiovisuals and data bases addresses.

In this and many other fields of science and technique we have the privilege of contemplating advances continuously exceeding all forecasts. We cannot waste resources making learning easier and more pleasant, but must not either forget that all these media will continue being only a complement of the task the teacher must promote and coordinate.

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Addresses of institutions related with medical audiovisuals

p.j@abdos1.chu.ulg.ac.be World Association of Medical and Health Films (WAMHF)
videomed@dip-badajoz.es VIDEOMED-Badajoz
ismaalv@mi.madritel.es Asociación Española de Cine Científico (ASECIC) servicio.cultural@cai.es Bienal de Cine Científico en Español
jmorenop@unicaja.es Festival de Cine Científico Unicaja
http://www.avd.kuleuven.ac.be/iams/Pages/what.html International Association for Media in Science (IAMS)
http://www.mif-sciences.net/ Películas científicas y certámenes médicos
http://www.iwf.de/index_e.html Institut für den Wissenschaftlichen Film (IWF)
http://www.osf.uk.com/index.html Oxford Scientific Films
http://www.precinemahistory.net/index.html Historia del Cine
http://web.inter.nl.net/users/anima/chronoph/marey/index.htm Cine científico: Marey

Teaching resources. Medical audiovisuals in the Internet

http://micf.mic.ki.se/West.html Historia de la medicina
http://www.nlm.nih.gov/hmd/hmd.html Historia de la medicina
http://www.medfindnow.com/history.htm Historia de la medicina
http://www.almaz.com/nobel/ads/ad_rates.html Historia de la medicina
http://www.ptca.org/history.html Historia de la angioplastia y videos
http://webster.aip.org/history/exhibit.htm Historia de la Física
http://www.ob-ultrasound.net/history.html History of Ultrasound in Obstetrics and Gynecology
http://home.earthlink.net/~terrass/radiography/imgproc.html Recursos de imagen médica en internet
http://sig.biostr.washington.edu/projects/da/ Anatomía digital, atlas interactivo
http://noodle.med.yale.edu/intro.html Cardiovascular 3D
http://noodle.med.yale.edu/demos/demos.html Corazón interactivo animaciones
http://www.vh.org/Providers/Lectures/BrandserLectures/Cardiovascular/CardioTOC.html Imagen cardiovascular del Hospital Virtual de la Universidad de Iowa
http://www.med.uiuc.edu/PathAtlasf/titlePage.html#vol2contents Patología cardiovascular
http://www.med.harvard.edu/AANLIB/vana.html Anatomía vascular
http://www.nlm.nih.gov/research/visible/visible_human.html The visible human project
http://www-kismet.iai.fzk.de/ Simulador 3D
http://www.elmedico.net/Images/index.html Imágenes médicas
http://members.nbci.com/sano/index.html Banco de imágenes médicas
http://www.uchsc.edu/sm/pmb/medrounds/HTMLrounds/patienttest.html Sesiones y casos clínicos Universidad de Colorado
http://path.upmc.edu/cases/dxindex.html Casos clínicos.
http://www.journalclub.org/index.html Revisiones y artículos
http://www.diariomedico.com/home.html Noticias médicas, buscadores y enlaces en español.
http://formacion.recol.es/formacion_online/_default.asp Formación "on line" en español
http://www.secardiologia.es/ Sociedad Española de Cardiología
http://www.semn.es/ Sociedad Española de Medicina Nuclear
http://www.searteriosclerosis.org/ Sociedad Española de Arteriosclerosis
http://www.isciii.es/ Cursos, convocatorias y enlaces de medicina y sanidad en España

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