

# NEURORADIOLOGY

## From Ethics to Nanotechnologies

### Professor Luc PICARD

Head of Diagnostic and Therapeutic Neuroradiology Department  
UNIVERSITY NEUROLOGICAL HOSPITAL - NANCY - France

During the last century, Radiology has been an established discipline defined on the basis of examinations performed largely for diagnostic purposes using initially mainly X-Rays. Gradually, and especially over the past decades, the notion of radiology has considerably shifted, and terminology in its trail, as the concept of radiology, has given way to that of imaging. For some, radiologists have become “Imagists”, a highly questionable term that likens radiologists to the more pejorative “photographer”, which some would have liked to call us a while back. Concurrently, Interventional Radiology has been “invented”! In Neuroradiology, Interventional procedures evolved dramatically and led to a completely new “hyperspecialization”.

Near half a century was necessary to forge with patience and tenacity current Neuroradiology. But has this Neuroradiology reached its adulthood or in other words maturity? The analysis of today’s situation leads us to rather think that **our current Neuroradiology is particularly fragile**: it will not be able to continue to develop itself or merely to survive, should a significant thinking effort be made allowing to determine future paths in which it is advisable to engage. This is what we are trying to demonstrate.

### **TO SUCCEED IN THE FUTURE, WE HAVE TO TAKE UP MANY CHALLENGES:**

Future challenges may be schematically divided into two main categories: conceptual and organizational problems. Ethical problems which are important cannot be dissociated from all the raised questions: consequently these will be discussed step by step.

On the conceptual level, it is necessary to define what a Neuroradiologist should be, his formation, his competence, his exact role in daily practice but also his research activity, a prerequisite for the very survival of any specialty.

On the organisational level, it is advisable to determine how Neuroradiology may be integrated and function within the framework of Neurosciences, which brings us to specify the relations of Neuroradiology with various specialties that deal with the nervous system (neurology - neurosurgery - cognitive neurosciences - neuroreanimation...).

## 1 -HOW TO DEFINE 21st CENTURY'S NEURORADIOLOGIST?

**First the Neuroradiologist has to be and to remain a CLINICIAN** completely responsible for his activity. According to the dictionary, a clinician is a practitioner of clinical medicine, which involves multiple tasks. So what exactly does the word “Clinician” mean? Examining the patient? Questioning and listening to the patient? Mastering symptomatology and pathology? Taking the clinician's place? Keeping up with new diagnostic and therapeutic procedures? Absolutely not! Being a clinician involves being recognized as a legitimate partner with a precious opinion on patient management, not as a mere service provider. In a growing number of countries the technical part of the radiologist's work is now performed by “radiographers”. This reinforces the idea that radiologists should act as practitioners, that is, as human beings who can use their scientific knowledge and accessible technical means for preventive and curative ends or to relieve patients.

In most cases, radiologists have received medical training. But it may prove interesting to analyze the various **motives of a medical student who decides to train as a neuroradiologist**: is it because of purely intellectual interest in a discipline that has some means to accurately diagnose patients and that now uses ultra-sophisticated techniques to develop new therapies? Is it because of a particular interest in a specialty based on techniques that are developing extremely rapidly, forcing the specialist to constantly adapt to new types of investigations? Is it because of the financial benefits entailed? It is a well-known fact that in most countries, radiologists are among the best paid specialists. Or is it because he is afraid of patients? A radiologist who is afraid of patients can easily hide behind his control desk, protected by several screens, from the X-ray tube to the lead apron, from the work station to the very radiographer. Eventually all of this is mainly an idea of deviations one can find when a radiologist has failed as a clinician, which is not an image we happen to defend.

If we want to evolve, we need to weight **current conditions of radiology practice**. Invasive explorations for diagnostic purposes have largely become obsolete. This tendency is particularly well demonstrated in neuroradiology: encephalographies, myelographies have disappeared many years ago; today, most diagnostic angiographies have been replaced by CT scan and MR investigations, where the only type of “aggression” is a usually insignificant intravenous injection. Meanwhile, although invasive diagnostic investigations have practically disappeared, the invasiveness of therapeutic procedures has considerably increased, unquestionably implying greater risk for the patient. And risk is more and more difficult to accept, as a considerable number of procedures are undertaken for preventive purposes on lesions incidentally discovered.

In any case, whether it is for diagnostic purposes or in the course of an interventional procedure, this is where the **radiologist's responsibility** begins. In many countries, and particularly in France, jurisprudence is perfectly clear: **the person who performs the procedure is responsible for the indication of the procedure**. A clinician may suggest an indication for a given patient but in the end, the decision to perform the suggested investigation is the radiologist's. Radiologists often ignore that they are held liable for the indication, especially if they consider themselves as service providers. Liability involves choosing the procedure with the lowest risk, an often difficult decision that may prove impossible to make if technical support is lacking, as is the case for

MRI in “countries under development”. Once the indication problem is solved, radiologists are naturally held liable for the procedure. In interventional neuroradiology, just as in surgery, the problem of the operating person starts at this point, although on a different magnitude in state-owned and private practices.

Among other things, **neuroradiologists are liable for the quality of use equipment**. Since 1993, French jurisprudence has declared that specialists do not have the right to use old or out-of-date equipment that put patients at greater risk than more recent and modern equipment. This applies especially to ionizing radiation and raises the problem of investment and equipment upgrade, which may prove difficult to solve since more often than not decisions belong to ‘hospital administrators more than to medical practitioners’. Neuroradiologists may also be held liable for operating quality of equipment, which is why they must absolutely be implicated in decisions concerning **machine maintenance**. This is important since maintenance costs usually skyrocket during nights and holidays. Some of our colleagues have been charged because a particular equipment was unavailable for an emergency on a Sunday or a holiday. When neuroradiologists are not involved in such important decisions, they absolutely must take preventive measures before local and regional administrative authorities so as not to not be held liable in case of a forensic problem.

Once the procedure has been performed, neuroradiologists are confronted with the **problem of interpretation**. “To interpret means to translate” the meaning of images into words, usually by keeping a written report. It may be interesting at this point to consider the changes in legislation and jurisprudence in our different countries. In France, medical legal responsibility of a radiological investigation is extremely extensive. It includes the written account, which should be clear and easy to understand. But it extends to diagnostic accuracy and reporting speed in case of a potential emergency. A wrong diagnosis is increasingly considered to be a medical error and is consequently punished, especially if the error leads to severe consequences. Failure to detect a severe malformation on a prenatal ultrasonogram may lead to birth of a severely handicapped child, while an accurate diagnosis could have resulted in a medical abortion. Such examples are more and more frequent. Likewise if the requested investigation is insufficient to diagnose the clinical problem, a neuroradiologist must suggest, in his report, an additional procedure if he considers that it may give the solution for the diagnostic problem. In the USA, some judges have pushed the matter even farther and charged neuroradiologists when the report was not provided quickly enough (in case of an emergency), when they had not transmitted it with the most efficient means (fax, e-mail or phone call), or when they had not chosen an interlocutor capable of immediately providing the necessary treatment.

**The postoperative follow up of the patient** is of course also placed under the responsibility of interventional neuroradiologists. The aim is not to take the clinician's or the anesthesiologist's place, but after a difficult procedure, neuroradiologists must follow up their patients, even if they are hospitalized in the intensive care unit.

They should be involved in the decision making process with the rest of the team in case of complications and should, of course, follow up their patient.

At every step of the process, the same problem seems to arise: taking the place of the clinicians. But how could an interventional neuroradiologist assess the results of his therapeutic procedures if he doesn't follow up his patients himself several months or years later? How can he find out whether the treatment was fully efficient?

## **2 - HOW CAN ONE IMAGINE the FUTURE OF NEURORADIOLOGY?**

After having reviewed the main responsibilities of today's Neuroradiologist, it appears interesting to think of the possible, even probable and conceivable evolutions of Neuroradiology in the next decades. To imagine the future is always partly a dream and only some geniuses, such as Leonardo da Vinci or Jules Verne, would be entitled to speak. We will thus restrain ourselves to indicate some trends that appear to us as most probable taking into account what occurred during last decades.

### **2.1 - Emergence of Nanotechnologies and its influences**

From the beginning, various processes used to approach normal and pathological, morphological and functional aspects of the nervous system always evolved in the same direction, that is towards the development of techniques making it possible to explore and consequently "to see" increasingly small structures. The most characteristic example is that of angiography: it is indisputably under the pressure of Neuroradiologists that main companies of radiological material gradually allowed us "to visualize" increasingly small vessels: *Aorta - carotid - anterior cerebral, middle, posterior - ophthalmic artery - thalamoperforating and now very small cerebral and medullary vessels including sulco commissural vessels...* The most recent progress associates "3D angio and flat screen". It is obvious that we shall not stop here: we should be conscious that, shortly, the morphological data of 3D MRI will constitute no more than a "framework" making it possible to locate in three-dimensional space information concerning increasingly small structures and eventually nano structures.

However, it appears that this concept, though interesting, would be extremely reducing, if one limited himself to the matter of size. Indeed, the perspective of conceivable developments due to nanotechnologies is considerably broader. Technological progress of the end of the 20th century enables us to handle atoms one by one: a new vision of the world thus gradually emerges from these experiments. Of course, there is still a long way to go, since the distance, between our current macroscopic world and the world of atoms, remains gigantic. We are still far from building true "nano-systems" whose functions would be comparable to those of integrated current circuits; we hardly start to foresee the physical principles which rule the world of nanotechnologies. Though researchers are already able to manufacture structures of some nanometers, these "objects" remain quite large compared to simple molecules; currently, we are on an intermediate scale described as "mid-scale". However we discover new properties

within this mid-world which constitute for the moment the obligatory crossing point towards the "nanoworld". We must rethink from the start the delicate problems of "communication between these worlds of different size": as an example, the only fact of recording information from nanostructures and transmit it to a world of higher size may engender serious disturbances in the nano-system than we should study; this reminds the very nature of autopsies whose inescapable consequence is the total destruction of the studied "human body".

Nevertheless, chemists became "molecular engineers": they gradually get the ability to assemble elements which rotate or glide on one another. These elements constitute the first parts of molecular engines and consequently of "nanomachines"; some of these machines will consist of only one molecule. If the nanostructures that are currently designed in the laboratories are primarily intended to be used as electronic components, other applications and particularly medical applications may be imagined: building of new types of molecular markers which could be compared to specific contrast materials (?), specific vectors of drugs, building of nanorobots able to be injected into circulation, to locate or even treat pathological targets...

*Of course, any progress implicitly entails the probable "creation" of new hazards. The famous and very actual "principle of precaution" obliges us to try to foresee these new potential risks. In a recent report of the British Academy of Science, Ann Dowling estimates that we do not know the behaviour of free nanoparticles and therefore it is advisable to temporarily withhold projects centred on the release of these products into the environment*

## **2.2 - Modifications of disease concepts and therapeutic approaches:**

As Pierre LASJAUNIAS wrote in 1992 to Giuseppe SCOTTI who had asked him to write "something on Interventional Neuroradiology in the year 2100": "*Anatomy of forms got substituted by biology of structures and anatomy of diseases by biology of the disorders. Specificity of targets and their mechanical attack got transformed into recognition specificity. We passed from inert embols, specifically conveyed, to bio-recognition delivered by main circulatory systems. Blood supremacy in tissue function saw its role dampened. The main carrier is water, not the lymphatic system or cerebrospinal fluid, but the interstitial water which, like the basal membrane, proves to be a continuous system inside the body. Control of its physiology, its access and the diffusion of specific products is now known. The bond between central nervous system affections and disorders of interstitial liquids, of inflammatory, infectious, of immunological origin or not, are now established; as for Interventional Neuroradiology, it acts in these new spaces to repair the symptomatic breaches at their borders "*. The concept of disease got substituted or augmented by the concept of weakness of the host. It is already known that tumour development corresponds to failure of repression combined to influence of a triggering factor. On the same time, a

vascular malformation reveals a local functional deficit in architectural genes " *New therapeutic objectives result from this analysis: to associate reinforcement of function of the host who harbours disease and repair of already established morphological disorders*"

These new concepts lie perfectly within the scope of the new technical possibilities that developments of nanotechnologies will offer us. The dream will thus quickly become reality: It is thus advisable to get prepared if one wants to be able to adapt. Adaptation will obviously require technical skills and especially significant preliminary thinking, an essential condition for the control of new ethical problems that will gradually appear.

### **2.3 - Development of neurocognitive Sciences**

No one can deny the fact that Functional Imaging is progressing faster and faster thanks to late developments in neuroradiologic techniques. However, on the same time, curiously, a number of "neuroradiology experts" seem to ignore these advances and act as if they were not related to the subject. Of course, there is no intention to judge this attitude and very often, this apparent disinterest reflects a lack of human and material resources in our teams. However, progress is not to be expected if we don't show direct interest in this imaging technique and its consequences on patient management. Also, our attention is certainly drawn by skids like "Neurotheology". Activation of some circuits during prayer or meditation is not a proof of "spirituality circuits" no more that God is from the beginning registered somewhere in circuit in our brain! On the other hand, we should be conscious that our techniques will tremendously widen with evolution of Neuropharmacology. For example, it would seem that in the near future we should be able to erase painful memories, selectively, especially when these memories are recent. In this way, we become directly implicated to an immense area of development with difficult ethical issues we must be prepared to deal with.

### **2.4 - Multiplication and complexity of ethical problems generated by the extraordinary power of the means that doctors will have**

Liability problems are intricately linked to those generated by the respect of what we now have the habit of calling **medical ethics**. "To each his own God" is no longer a sacrilegious saying. From our God we infer our life rules, slowly building, block by block, our own personal moral standards. Some of us live according to their moral standards while trying to impose them on the rest. Others abide by their self-imposed rules and think their example will suffice. Others still impose their standards while disregarding them themselves. It is usually in this last category that fanatics close to fascism can be found. Fascism is not necessarily religious or political; it can also be intellectual, and no less dangerous. In view of this and of the many contradictory opinions in the world, **a Medical Doctor must focus on seeking the Truth**. Truth, however, is never unmovable or intangible: with the fantastic development of new technologies, a

temporal parameter has to be added to it. Some attitudes, if not altogether “righteous”, probably prove to be the best or the least harmful at a given time. “Instantaneous truth” differs from one person to the next. Often fleeting, it depends on the speed at which knowledge diffuses and the proofs given thereof. The case of AIDS is highly demonstrative in the matter. When did scientists discover that heated blood products should be used? Who, by the way, can pinpoint the instant? This example clearly shows the medical and legal implications of ethics. Our society is constantly looking for landmarks that might help it protect its children and its citizens.

### **3 – PRACTICAL AND ETHICAL CONSEQUENCES OF FUTURE PROGRESSSES IN NEURORADIOLOGY**

Ethics, with its extremely profound and often very personal basis, has multiple implications in everyday professional life. For the sake of clarity, it seems interesting to systemize these questions, by studying a **neuroradiologist's career**, from his initial training to his continuing education, not overlooking problems that he may encounter in the course of his practice.

#### ***3.1 - Training and Ethics***

It seems obvious that in order to practice neuroradiology properly, sound initial training is necessary. Today, finding this type of training is difficult because of the lack of official standards and true references in the world. The training that a diagnostic and/or interventional neuroradiologist acquire is currently submitted to the aura of such or such a school of thought, or to the influence of a renowned team...and its length is highly variable. The quality of the ensuing practice, however, depends on the efficiency but mainly on the rigor of this initial training. It is interesting to note that each doctor determines his own training-path, really, according to his own consciousness, and that its length may vary from a few days...to several years!

It is the duty of Universities, National and International Societies, and World Federations to define training standards that can serve as references to those who wish to undertake such a practice. That is the price to pay if we want to avoid experimentation by “self-made men” whose victims are the first patients of the newly self-proclaimed specialist. Thus we should immediately work to settle international rules for training in neuroradiology that may be used as references for training programs on the national level. For years, the World Federation of Interventional and Therapeutic Neuroradiology (WFITN) has published its proposals for Interventional Neuroradiology; basically, a training in Neurosciences that could be a joint base for all specialties involved in the nervous system. This 2 years joint base would associate a formation in neurology, neurosurgery, neuropathology, neurobiology and neuroreanimation... none being exclusive. This training would be combined to one year of radiology, 2 years of Diagnostic Neuroradiology and 2 years of Interventional Neuroradiology for those who choose this orientation. The World Federation of

Neuroradiological Societies (WFNRS) works in the same direction and one should hope for the publication of precise rules for the years to come.

On the other hand, teams agreeing to train young colleagues should have the adequate means to ensure maximum training quality and efficiency. Because of the current situation, the team must also assume responsibility for assessing the training received. This should then be vouched for not only by a training certificate confirmed by a log book, but by a true diploma.

The most elementary ethics imposes total dissociation between training structures and commercial companies. Even though companies have to look after their possible medico-legal responsibility, training can not and should not focus on equipment or devices. Acquiring a technique can constitute no more than a tool in the course of training. Training must necessarily remain clinical and scientific.

### **3. 2 - Ethics and Continuing Education**

Until now, continuing education was entirely left up to the individual doctor in most countries. It depended solely upon the 'good-will' of the specialist, upon his motivations, and, ultimately, upon his conscientiousness. But as we well know, medicine is becoming more and more effective, and consequently more and more iatrogenic: an incompetent doctor holds weapons in his hands or in his brain which are becoming more and more dangerous. In order to ensure the quality of medical care and more particularly to protect the patient, we will soon find Society increasingly imposing continuing education, because the rapidly developing new technologies require it. Maintaining and developing one's knowledge are part of the ethical rules that Society must impose, since it does not spontaneously strike all practitioners as 'normal and essential'.

During its last meeting in Seattle, the ASNR organized a lengthy session devoted to « practical » problems actually encountered with evolution of Neuroradiology in USA. In this context, the President, Patricia A. Hudgins exposed the actual situation our American colleagues are facing today and called « Maintenance of Competence (MOC) » : « *Quality of care is the degree to which health care services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge .Health care quality problems may be classified into 3 categories : underuse, overuse and misuse. The American Board of Medical Specialties has mandated each specialty board (24 in US) develop specialty specific MOC program. Board certification will no longer be time-unlimited. Prior to 2002, radiologists fulfilled Radiology Board Requirements one time, and never had to re-certify (renew medical licenses). Now to participate in MOC will be mandatory for radiologists certified in 2002 or after and strongly encouraged for neuroradiologists certified prior to 2002. But local regulating bodies and third party payers will likely require formal MOC, even for those certified prior to 2002...Finally it is important to know that all is organized under the responsibility of American Board of Radiology.* »

### ***3. 3 - Ethics and Daily Medical Practice***

As for all the medical specialties, competency is one of the bases of ethics in neuroradiology. The relationships between the various partners, however, modulate the quality of their practice. In France, article 36 in the Deontology Code requires of doctors that they use every necessary means to achieve a precise diagnosis. Because of this, we as doctors must endeavor to use every material and human means necessary, but also, from time to time, to request other opinions when the problem is particularly complex. The old and common practice of requesting the opinion from a more competent specialist is bound to develop more and more over the next few years because of the advances made in teleradiology which, in turn, poses its own specific problems. But when an opinion is solicited and given, who will be held liable for erroneous advice and the unfortunate consequences thereof? Although the problem has yet to be solved, the thinking process has begun.

Once the diagnosis has been settled upon, **indication of the treatment** must be discussed. Again, numerous ethical problems arise at this stage. The choice of an indication must be considered in light of the different therapeutic possibilities really existing at the time of the treatment, and not only in view of the one technique that the consulted interventional neuroradiologist has mastered. This ethical choice can lead a medical practitioner to entrust his patient to other teams, which naturally implies some sort of personal renouncement.

More often than not, however, the choice of an indication does not belong to one therapist alone, i.e. the interventional neuroradiologist. It is usually the choice of a team. It should also be the patient's choice, guided by the therapeutic team, naturally. In order for his freedom of choice to be effective, before any treatment, the patient should carefully and precisely be given the information necessary to obtain his enlightened consent. The **quality of the information** he is given is fundamental. Experience shows that information fluctuates and is not always honest, perhaps unconsciously so. We must explain to the patient what motivated the indication according to what we know or what we think we know about the natural history of the disease, as compared to the actual therapeutic risks. What are the risks? Are they the risks of the best team in the world, or those of the interventional neuroradiologists facing the patient? What should one do in the case of a beginning specialist? Should we be aware of all the problems linked to the "learning curve".

The discussion with the patient should, preferably, take place in the presence of members of the family and/or a witness. Presenting the patient with a written document may be discussed. In any case, it is preferable to have the patient sign a document attesting that he has been informed, that he has understood what was explained and that he agrees to undergo the suggested treatment. This voucher of an enlightened consent is only valid if the information provided was 'loyal', clear, accurate and above all if it could be understood by the patient. This last point is crucial: the therapist must make sure that the message has been correctly received by the patient and his family. As an answer to this problem, some teams have

developed 'test-programs' on the computer, enabling them to test the information received by the patient after the discussion. But must we really go that far?

### ***3.4 - Ethics and Treatment***

Once the indication has been given and accepted, the treatment must take place under the conditions that were agreed upon. Personalization of the operator can be questioned here, particularly in University Hospitals, as the interventional neuroradiologist is surrounded by training colleagues there more than anywhere else. In France, apart from the state owned sector where civil responsibility is mostly administrative, the contact established at the time of the visit is equivalent to a contract: the consulted doctor should be the one to actually perform the medical act. Should it not be so, he must inform the patient who, in turn, theoretically has the right to freedom of choice.

Discovery of new elements, unknown beforehand, during the procedure, may cause difficult problems. Should one stop everything in order to discuss procedures with the patient, or continue as best as possible? Similarly, the patient should be informed of what was actually done during the operation. He has the right to know that 'nothing could be done'. Experience shows that postoperative information is sometimes edited in order that the patient might not be disappointed! Carefulness is the rule, for a lie is most certainly the worst solution. It must however be noted that most treatments take place in a large, multidisciplinary context, and that liability problems among the different teams involved go beyond the realm of ethics.

### ***3.5 - Ethics and Equipment***

The intertwining of ethical problems and liability is once again found when discussing equipment and maintenance. We live in a time of extraordinarily rapid technical development, imposing heavier and more frequent investments than ever. But Society is sometimes unable to deal with such investments. Choices must then be made, rendered more difficult by the fact that the operator is not often the decision-maker.

Thus the question: what are the limits to working with out dated equipment that does not ensure the patient as much security as more modern equipment? We must determine the criteria of our choice in order to discuss this question: when does working within a scope of insufficient quality become unethical? A more sensitive point, and more debatable, is the use of the biplane technique. I have always worked with biplane angiography equipment, and in my opinion it undeniably adds elements which in turn increase patient safety. Embolizing the nidus of an arterio-venous malformation while using the biplane technique greatly facilitates understanding of the embolus' progress, and can help avoid complications, even if the operator's neuro-anatomical knowledge is excellent. I am not trying to say that embolizing with the monoplane technique is unethical, but merely using this example to illustrate the difficulty in

setting limits. The same problems can be discussed for using 3D angio to treat an intracranial aneurysm or when we compare the information obtained with an “old” or an up to date MRI.

In the same realm lie the problems of maintenance and use of **system failure prevention techniques**. Regular maintenance costs, but it can also prevent unexpected breakdowns which, if they occur in the course of a glue injection, for example, can cause major complications. Ensuring maintenance, around the clock, costs even more, but what happens if equipment breaks down during the week-end? Further still, preventing an electrical failure can be done by installing high power undulators associated with condensers capable of preventing the X-ray generator to stop if a power failure should occur. All this equipment can prove very costly, adding up to several millions Euros per operating room. Where should the limit be drawn between what is ethical and what isn't? The same is true of smaller equipment concerning its intrinsic qualities as well as the conditions of its use or re-use. Re-using a ‘tired’ coil in the course of embolization is perfectly understandable from an economical point of view, but can lead to serious complications should it rupture. Where are the limits? The conception of disposable equipment varies widely from one country to the next. In what we consider rich countries, it is no longer ethical to use catheterisation equipment twice. In poorer countries, however, there is sometimes no other solution for those who want to continue working.

### **3.6 - Ethics of Research and Experimentation**

It is interesting to note that in many countries, animals were the first to be protected against abusive medical experimentation. Only few years ago, have the French legislators looked into protecting human beings. The first law concerning the protection of people lending themselves to biomedical research was promulgated on December 20th, 1988. Called the HURIET Law, it was modified by another on January 23rd, 1990, and added to on September 22nd, 1990 by a decree.

*This law specifies that “no biomedical research can be carried out on a human being:*

*if it is not based upon the latest state of scientific knowledge and on sufficient pre-clinical experimentation.*

*if predictable risks brought about to the people lending themselves to or to the interest of research are out of proportion with the expected benefits to these people*

*if it does not aim to extend knowledge of the human being and the means to better his condition.*

*Research without direct therapeutic finality is however acceptable if the following three conditions are respected: that it represent no serious and predictable risk to the person's health*

*that it be useful to people presenting the same characteristics of age, disease, or handicap*

*that it cannot be carried out otherwise.*

*Prior to carrying out biomedical research on a person, free, enlightened and purposely obtained consent must be given by him to the investigator or the medical practitioner representing the investigator, after that he has given him knowledge of :*

*the goal, methodology and length of research*

*the constraints and predictable risks, including the case in which research is stopped before its term*

*the opinion of the ethical committee responsible for the area”.*

*The person whose consent is solicited must have the right to refuse to take part in the program or to withdraw at any moment, without any consequence for him. The information which was communicated must be summarized in a written document, and given to the person whose consent is solicited. In each area, the Minister in charge of Health registers one or several Advisory Committees for the Protection of People according to the need, in the field of biomedical research. Before beginning research on human beings, investigators are under the obligation of submitting their project to an Advisory Committee for the Protection of People in the biomedical field in the area of their exercise. Obviously such a law is constraining. Because of it, research agencies have to take out insurance policies covering the patients in case of an incident or an accident. Nevertheless it can be viewed as a brick in the edifice of progress.*

*This in turn explains why many countries are instituting similar ethical structures. As an illustration of this, a European Council report dated 1993 could read that “except for Austria, Ireland, Island and Liechtenstein who announced they had none, the great majority of the European Community members and observing countries have a national ethical structure...”. Two tendencies are actually predominant as far as the constitution of these national ethical structures. While some countries have opted for a permanent, independent specific National Committee, others have chosen the multiplicity of national instances and their creation ‘ad hoc’ or according to specialization. All of these committees are fairly recent, the earliest having been created in 1983 and the latest in 1991; others are being considered but have not been established as of today.*

Submitting research and experimentation projects to an Ethical Committee exterior to the research team no doubt constitutes progress in itself: it forces scientists to define extremely precise objectives and protocols. It also forces them to respect the Human Being. This might appear obvious to some but has unfortunately not always been the case; dramatic experiences undergone during the last decades in the midst of conflicts or totalitarian states can testify to this.

Nevertheless, ethical problems can arise even within this type of structure. Randomization is currently recognized as being one of the only methods capable of solving certain difficult problems. Our current experience with aneurysms enables us to appreciate just how difficult such a concept can prove to be. I am not the only one to show reluctance toward a certain form of randomization in the treatment of aneurysms, destined to compare the advantages of endovascular treatment over surgical treatment: in many teams it

appeared very rapidly that endovascular treatment had reduced mortality and morbidity of basilar aneurysms. Is it still necessary to prove it?

### ***3.7 - Ethics and Science***

Anytime scientific work is carried out, results must be published, whether it be actual experimentation, clinical studies or other types of work. But the temptation to cheat is great in a world of competition. Most humans like to show themselves to their advantage, and consequently, to present interesting results, especially so if they are in competition with rival teams. If we overlook the cases of what can be considered mere personality traits, the situation can be much more delicate than it may seem: in certain totalitarian countries, scientists do not have the right to make mistakes, for fear of losing their position. It is then difficult to resist temptation to “improve” their results.

Apart from questioning its honesty, such a behavior has tremendous ethical implications. To withhold or to hide failures of a technique from publication inevitably leads other teams to attempt the very same technique and to cause a new series of complications for other patients. Unfortunately, rigging results has become easier than ever for anyone who may attempt it. As most of our results are images, what can be easier than purchasing some of that fabulous new software on the market to embellish the real images? The knowledge of such risks makes us responsible for preventing them by controlling the information in order to guarantee the truth of our scientific publications.

### ***3.8 - Ethics and Humanism***

**The financial problem** cannot be eluded. As for every profession, neuroradiology has a price. For many years, neuroradiology remained an ultramodern technique reserved to the more fortunate classes in society. But what about the poorer classes?

At the same time, conceptions change and new ideas emerge. The patient naturally has **the right to discretion and medical secrets** must be kept. But that is proving to be more and more difficult with computers and the extended networks which link them all together. How can information be protected from insurance companies seeking to modulate their premiums according to a calculated risk?

Dealing with **image property** is a more recent development. Until recently, image property rights applied only to an individual's face, the part of his body enabling others to recognize him. Claims are currently being made to extend the notion to any type of image of any part of the body, whether it be an MRI image of the brain or another kind of test.

These new questions have caused ethical committees to form in an attempt to establish a **'Patient Rights Charter'** setting limits to medical activities. It is essential that we as Medical Doctors be aware of the weight of our responsibility in order to practice our Art with the respect due to Human Beings depicted in the “Human Rights Declaration”

#### **4 – CONCLUSIONS**

These few thoughts shed light on the multiplicity and complexity of problems a neuroradiologist will encounter in the future. Though challenges are difficult, let us not forget they're particularly exciting. Because of its key role in the function of the human being, the brain has a unique and irreplaceable place. Though we know how to transplant a heart, we are far from being able to transplant a brain. So let us be conscious of the immense chance we have and do not let Neuroradiology sleep on its glory. Neuroradiology will be able to flourish only if it is animated by true Neuroscience specialists whom only the broadness of sight will ensure its survival.