6.1 Introduction: Should We Optimize/Minimize the Patient’s Radiation Exposure?

The danger of ionizing radiation is related to the potential long-term risk of carcinogenesis. In Chapters 1 and 2 of this book, Chadwick and Cohen have detailed how this risk is evaluated and considered in the field of low-level radiation in which diagnostic imaging (including CT) is comprised. The linear no threshold (LNT) theory of carcinogenesis is based on the risk of hereditary mutations deriving from cellular effects in germ cells. This theory considers that the cancer risk is linearly proportional to the dose at high doses as well as at low doses, from zero dose up. On the other hand, failure of the LNT theory is based on series of investigations showing that there is substantial evidence that low-level radiation does not have any carcinogenic effect and may even be protective against cancer, a view known as “hormesis”.

Important here is the fact that the Recommendations of the International Commission on Radiological Protection (ICRP), outlined in its Publication 60 (ICRP 1991), implicitly have adopted the LNT concept, because of the precautionary principle. ICRP considers that the risks estimated using the LNT concept are probably conservative. The concept has formed the basis for the development of a radiological protection philosophy including the ALARA (as low as readily achievable) principle. In 1991, the ICRP quantified the radiation risk by adopting a value of 5% for the nominal lifetime excess absolute risk per Sievert (Sv) for fatal cancer for a general population exposed to low-level radiations.

The radiation dose received by patients undergoing diagnostic radiological examinations by CT are generally in the order of 1–24 mSv per examination for adults (UNSCEAR 2000) and 2–6.5 mSv for children (SHRIMPTON et al. 2003). These effective doses can be classified as low even though they are invari-
ably larger than those from conventional diagnostic radiography. Typically, a chest radiographic examination (including two views) delivers between 0.08 and 0.30 mSv whereas a standard dose multidetector-row CT (MDCT) represents a 100 times higher risk, delivering 8 mSv. One fatal cancer should be expected for every 250,000 chest X-rays whereas this risk is 1/2,500 for a chest MDCT scan. Thus, particular attention has to be paid to dose optimization and reduction while using CT.

In this chapter, we will review the many faces of limiting the radiation dose from CT and in particular from MDCT. We will comment on the alternatives to using CT, on the CT parameters managed by the radiology team that have an impact on the radiation dose, and on how to minimize this dose per acquisition, per examination, and per patient. Finally, we will propose dose values suitable for an optimized use of MDCT.

6.2 Guidelines for Appropriate Use of Imaging

CT and in particular MDCT is a fabulous technique with regard to its liability, rapidity, and availability. The spatial resolution provided by MDCT with isotropic voxels makes radiologists and physicians highly confident in the diagnosis yielded by these examinations. As a practical result, the radiologists, the clinicians, and even the patients probably prefer dealing with CT than with other imaging methods or medical tests that could be more difficult to interpret. In addition, new indications of CT have been validated (i.e., ureteric stone disease, virtual colonoscopy, CT angiography including the coronary arteries, etc.). As modern MDCT scanners can now process 60–70 patients a day, as compared to 30–40 patients in the 1990s, the increase in the number of procedures can easily be overcome by modern radiology departments. Most importantly, image-based media now have a central role in our modern societies. CT scans, by showing directly “what is happening inside the patient”, seem easy to read and are thus more attractive than conventional radiography, which often suggests the diagnosis through indirect signs. This evolution has already resulted in a huge increase in CT examinations and subsequently in collective dose.

To overcome some abuse in the use of CT, it should be kept in mind that alternative imaging techniques such as ultrasonography (US) and magnetic resonance imaging (MRI) are also widely available. Substitution of CT with US and MRI is an important factor in collective radiation dose reduction. As an example, a CT scan of the central nervous system (brain and spine) can be replaced by MRI in almost all patients except those with acute trauma. However, this would need a number of MR units approximately as high as that of CT units. There are equal numbers of MR and CT units in some countries, such as Japan, but in others the number of MR units is still three times lower than that of CT. This relative shortfall of MR compared to CT equipment contributes to the excess collective dose.

In order to define diagnostic strategies for clinicians in their consideration of patient radiation protection, guidelines for the prescription of imaging tests have been proposed by the Royal College of Radiology (Royal College of Radiologists 2006). Ideally, such guidelines should be evidence based.

As an example of an evidence-based study, diagnostic strategies including MDCT angiography of pulmonary arteries (CTPA) have been investigated by the group in Geneva (Perrier et al. 2004). These authors have documented the clinical potential of a diagnostic strategy for ruling out pulmonary embolism (PE) based on D-dimer dosage combined with lower-limb US before performing CT pulmonary angiography (CTPA) in outpatients. Such an approach led to a recurrence rate of PE of only 1% (95% confidence interval: 0.5%–2.1%), and CTPA was performed in only 593 out of 965 outpatients (61%). Perrier et al. (2004) concluded thus that a noninvasive diagnostic strategy combining clinical assessment, D-dimer dosage, lower-limb US, and helical CT scanning – necessary in approximately two-thirds of patients only – yields an accurate diagnosis in 99% of outpatients suspected of having PE.

Nowadays, it appears in clinical practice that CTPA is ordered for almost all patients suspected of having a PE. Indeed, in emergency departments of almost all community hospitals, MDCT has now become as available as D-dimer dosage. In addition, the results of CTPA are more rapidly obtained than those of D-dimer dosage and MDCT can deliver very important information on possible alternative