Since its introduction in the 1970s, CT has played an increasingly important role in the imaging diagnosis of a variety of disorders. This is especially true in the field of neuroradiology, where CT made direct visualization of neurological anatomy possible for the first time, thereby revolutionizing diagnostic imaging. However, it is well known that the CT-induced radiation dose is considered high compared with other (X-ray based) imaging techniques. For a CT examination of the same region, various authors have reported different dose values. This difference is due to variations in applied scan protocols, and the different choice of units of measurements in which they expressed the dose. This hindered comparison between studies and makes the correlation of CT with other radiological procedures difficult. In routine practice, about 30%–40% of all CT studies are studies of the head or brain, with a mean effective dose ranging from 1 mSv to 5 mSv (Van Unnik et al. 1997).

Although magnetic resonance imaging (MRI) was expected to reduce the overall frequency of CT (especially in neuroimaging), this has not been the case (Rehani and Berry 2000). Indeed, the advent of helical and multidetector helical CT (MDCT) with rapid acquisitions times and new diagnostic fields (e.g. CT angiography, perfusion CT) has led to a further increase in CT examinations: over the last 10 years CT has more than doubled its contribution and is now responsible for 47% of the collective dose from medical X-rays in the UK (Hart and Wall 2004). This evolution has spurred a growing interest in CT dose optimization and reduction in recent years.

MRI has superseded CT for examining the head, neck and spine, many parts of the musculoskeletal system and it offers an alternative to CT in the abdomen and pelvis. Nevertheless, the higher cost and the lesser availability of MRI remain a problem. Therefore, CT remains the method of choice for evaluation of post-traumatic injuries of the head, spine, thorax, abdomen and pelvis, for detection and characterization of parenchymal lung disease and for staging of almost all solid malignancies, including lymphomas. In the evaluation of cerebrovascular pathology, recent developments with diffusion and perfusion techniques have given MRI a higher sensitivity and specificity, although CT still plays a major role in this area.
in the evaluation of these disorders, due to its high sensitivity in the detection of intracranial haemorrhage, faster image acquisition, wider availability, lower cost, ease of use and fewer contraindications (Rehani and Berry 2000).

In CT, the effect of changing dose (e.g. by changing tube current or mAs settings) on image quality is sometimes difficult to assess, as CT is a digital technique in which image acquisition and display are not related, i.e. the “uncoupling effect”. Thus, unlike conventional plain-film radiography, excessive exposure will not result in overexposure of images and degradation of image quality. As a result, significant variations have been observed between individual scanners in the typical patient doses for common CT examinations (Van Unnik et al. 1997; Clark et al. 2000). Multiple studies concentrating on dose reduction showed that low-dose CT is possible in high-contrast imaging, e.g. imaging of the lungs, without loss of diagnostic information (Zwirewich et al. 1991). It remains however unclear if dose reduction is also possible in areas with low contrast differences, such as the intracranial brain structures.

This is nevertheless an important issue, since patients who are examined or treated for complex or chronic brain disease (e.g. malformation, tumours, trauma and cerebrovascular disease) often undergo multiple CT studies over time. This also applies, for instance, to children with hydrocephalus with malfunctioning ventricular shunts. Although initial CT studies are oriented towards identification of subtle changes of intracranial structures, the main purpose of those control studies is to identify complications and gross morphological changes. As this often involves structures with high contrast or large structures (e.g. follow-up of haemorrhage or ventricular size), a reduction of “standard” scan parameters to lower dose settings seems possible in these CT studies (Cohnen et al. 2000).

9.1.2 Typical Dose Values in Head CT

Two large-scale surveys regarding the use of brain CT were undertaken in the late 1980s and early 1990s in the USA (McCrohan et al. 1987; Conway et al. 1992). These involved more than 250 CT scanners of different models. The average radiation dose in a standard CT brain examination in adults was hereby investigated at that time. Results showed that for brain CT examinations, the tube voltage (kV) was consistent at 120–140 kV for a given manufacturer and model. Slice thickness, slice spacing (increment) and total scan length and therefore the number of slices were also quite consistent and constant. However, tube current (mAs) was one of the most variable parameters between different CT systems and even for systems of the same manufacturer and model. For most systems, the minimum and maximum mAs values used for CT brain examinations differed by a factor of 3–4. This resulted in a dose variation of a factor of 2 or more for a typical (“standard”) head examination for a given model of CT scanner. In these earlier surveys, the multi-scan average dose (MSAD) was used as the dose descriptor. For most of the systems, the MSAD at the midpoint on the central axis of a standard dosimetry phantom varied between 22 and 68 mGy, but doses as high as 140 mGy were noted. Furthermore, the registered dose sometimes varied by a factor of 2 or more between identical CT units. The MSAD can be compared with the later introduced and now more commonly used CT dose index (CTDI), since both are based on the integral of a single-section dose profile, whereby CTDI may differ from MSAD with a variation of 10% up to 25%, depending on the used slice thickness and spacing. Both measurement units give a simple estimate of the dose delivered during the entire CT procedure to the region of the central section (Conway et al. 1992). The authors of these two large surveys concluded that these wide dose ranges indicated that dose has the potential to be reduced by careful selection of standard CT techniques.

Overall, variations in dose can result from differences in the user’s choice of technique (desired image quality) or from actual differences in scanner performances (caused by differences in collimation, filtration or scan geometry). “Users of CT systems should be aware of radiation dose delivered with CT, dose ranges associated with different systems and doses delivered by their particular unit. This requires that dose performances of CT systems should be assessed by means of a protocol that allows comparison of data collected for identical and/or different units. To use CT appropriately, a facility should consider dose as well as image quality in selecting optimal techniques for typical modes of operation” (McCrohan et al. 1987; Conway et al. 1992).

In 1990, The International Commission on Radiological Protection introduced the dosimetric quantity “effective dose” that provides a direct relationship to the radiation hazard (ICRP 1991, report