11.1 Introduction

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MRI is understood as a dedicated method for the evaluation of local disease. Despite its ability to image the whole body with high resolution and superior soft-tissue contrast, and consequently to detect systemic spread of diseases with high sensitivity, it is rarely applied for more than one body part within a single examination. The limited awareness of the clinical potential of whole-body MRI (WB-MRI) can be explained by the long examination times and patient discomfort associated with the test and, to a greater degree, by its relatively high cost, which is generally not adequately reimbursed by health insurance. Consequently, the cost-effectiveness of WB-MRI is considered questionable by most radiologists. Mainly because of practical considerations such as availability, time, and cost, CT is most often used as the standard whole-body imaging modality.

The medical and economic potential of whole-body imaging is, however, of considerable importance, particularly because systemic illnesses such as cardiovascular diseases, cancer, and diabetes are responsible worldwide for substantial morbidity and mortality, not only in high-income but also in low- and middle-income countries (Epping-Jordan et al. 2005). Treatment and disability account for substantial healthcare costs, and may further increase with population aging, and changing social and environmental factors. Preconditions for assessing prognosis and planning individually optimized treatment strategies are early detection and accurate staging of disease. Treatment decisions in chronic and incurable diseases must consider individual disease characteristics and identify patients who are candidates for aggressive medical or surgical interventions, particularly with respect to quality of life and life expectancy. In this context, whole-body imaging provides important components of the decision-making process, including not only disease-specific information, but also accompanying findings (e.g., staging of lung cancer and detection of an unexpected paraneoplastic thrombosis of pelvic veins). Moreover, because treatment strategies are frequently dependent on the response to earlier treatments, tools for monitoring the success of systemic treatments are also urgently needed. Whole-body imaging may ensure that patients receive the most appropriate treatment.
11.2 Examination Techniques

11.2.1 Hardware

The field of view (FOV) of a single MRI examination is limited by the length of the magnet and the gradient coil system. As a consequence, state-of-the-art MRI of multiple body parts can be performed only with a step-by-step approach, and subsequent MRI examinations of different body parts are needed, with repeated repositioning of the patient and the surface coils. This approach is infeasible in clinical routine, because it is time-consuming and understandably cumbersome for patients as well as technicians. Furthermore, optimal intravenous contrast medium application is not possible because of the loss of time required for patient repositioning and repeated receiver and transmitter adjustments. Recently, however, technical advances in surface coil and integrated parallel imaging technology (iPAT) have enabled MR imaging of multiple body parts during a single examination.

Three different WB-MRI techniques have been developed to subsequently extend the volume coverage from partial to multiple anatomic regions, without the need for patient repositioning. As relatively long examinations times are major obstacles to routine application, MRI systems with 1.5 T and high-performance gradients have been used for to achieve fast data acquisition with sufficient signal-to-noise ratio (SNR). Patients are typically placed in the supine position with their arms lying beside their bodies. Whether the patient is positioned head or feet first depends on the particular technique used.

1 The radiofrequency (RF) signal is transmitted and received by the body coil. Whole-body coverage is generally achieved by acquiring coronal slabs of turbo STIR sequences at several (usually five) stations (Walker et al. 2000). The advantages of this method over the surface coil methods described below include the effortless performance of the examination and the greater comfort of the patient. The clinical impact for examining systemic diseases of the musculoskeletal system has been shown, e.g., for evaluating bone marrow metastases, for staging of multiple myeloma, or for examining polymyositis (Walker and Eustace 2001; Daldrup-Link et al. 2001; Goo et al. 2005). A drawback of this method as compared with the performance of a series of dedicated state-of-the-art MRI studies, however, is the comparatively moderate spatial resolution, which allows a limited diagnostic accuracy, particularly concerning the brain or moving organs such as the liver and lungs.

2 The RF signal is transmitted by the body coil and received anteriorly by one body phased-array surface coil and posteriorly by two spine coil elements embedded in the patient table (Ruehm et al. 2001). During the examination, the receiving coils remain stationary in the isocenter of the magnet while the patient is gliding through the body phased-array surface coil on a rolling table platform, which is mounted on the original patient table on seven pairs of roller bearings (AngioSURF, MR-Innovation, Essen, Germany). The signal gain relative to the previously described technique enables an increase in the spatial and/or temporal resolution and contrast-enhanced whole-body–3D MR angiography (MRA) of the whole body is feasible within one single examination. Five contiguous 3D FLASH sequences from the level of the neck to the feet can be recorded within 72 s and repeated twice before and after intravenous contrast administration. One single 3D data set can be acquired within 12 s through partial k-space coverage, while an additional 3 s are needed for moving the table to the next imaging location. The method was initially described for evaluating atherosclerosis, but shortly after also successfully applied for tumor staging (Lauenstein et al. 2002). Promising results have been found for tumor staging in comparison to PET/CT or MSCT (Antoch et al. 2003). It has also been applied for screening purposes, whereby an additional MR sequence for virtual colonoscopy has been integrated for early detection of colon polyps (Goyen et al. 2003).

3 Recently, a novel WB-MRI technology was introduced, employing multiple phased-array surface coils in combination with multiple receiver channels and accelerated image acquisition by integrated parallel imaging technology (iPAT) (Schlemmer et al. 2005). The 1.5-T MR system enables the connection of up to 76 coil elements and signal acquisition, with up to 32 independent receiving channels for synchronous signal recording. For whole-body imaging a set of five to six phased-array surface coils with multiple individual coil elements are used independent of the body size: one head coil (12 coil elements), one neck coil (4 coil elements), two to three body phased-array coils for thorax, abdomen and pelvis (6 coil elements each), one peripheral angio coil for lower extremities (16 coil elements), and a set of spine coils with 24 elements imbedded in the patient table. The combination of an automatic moveable table, 500-mm FOV per imaging station, a high-performance gradient system (maximum amplitude: 45 mT/m), and parallel imaging technology in all three spatial directions enables high-resolution WB-MRI in a state-of-the-art technique, with a maximal FOV length of 205 cm within a total examination time of approximately 1 h.

11.2.2 Sequence Protocols

WB-MRI is not built on a unique examination protocol. The development of novel hardware technology and fast imaging techniques in combination with iPAT enables standard MRI sequence protocols to be used in whole-