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Original Research Article

Usefulness of clinical magnetic resonance scanners for imaging experimental changes in laboratory rodents' central nervous system

Dorota Mystkowska[a,*], *Anna Tutas*[a], *Katarzyna Jezierska-Woźniak*[a], *Anita Mikołajczyk*[a], *Barbara Bobek-Billewicz*[b], *Marek Jurkowski*[b]

[a]*Department of Neurology and Neurosurgery, Faculty of Medical Sciences, University of Warmia and Mazury in Olsztyn, Poland*
[b]*Department of Nuclear Medicine and Endocrine Oncology, The Maria Skłodowska-Curie Memorial Cancer Center, Institute of Oncology, Gliwice Branch, Poland*

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ABSTRACT

Introduction: Magnetic resonance imaging (MRI) is a noninvasive technique applied in medical diagnosis and for studying animal models of human diseases. MRI offers longitudinal *in vivo* studies without the need to sacrifice animals, thus making data easier to compare. The number of required animals can be limited.

Aim: The aim of this article was to present the potential role of clinical MRI scanners in the management of central nervous system visualization and injury in rodents on the basis of the current literature.

Materials and methods: Clinical small bore scanners with field strength from 0.1 T to 3 T are used for imaging the nervous system of rodents *in vivo*.

Results and discussion: The employment of clinical scanners equipped with dedicated human coils, for small objects imaging, results in the reduction of image quality. It is caused by a small signal-to-noise ratio (SNR). The way to increase the SNR is to use clinical scanners for imaging particular parts of the human body, e.g. head, or dedicated coils for imaging small parts of the human body, e.g., thumb or wrist, or to use dedicated small animal coils to image multiple animals in the larger bore of the clinical scanner at the same time. For some neurobiological experiments clinical scanners seem to be sufficient. Although clinical MRI scanners are widespread, not many laboratories use them for small animal research.

Conclusions: Clinical scanners with surface coils dedicated to small human organs, or with dedicated small animal coils, are useful for imaging experimental changes in the central nervous system of laboratory rodents.

*Correspondence to: Stem Cells Laboratory, Faculty of Medical Sciences, University of Warmia and Mazury, Warszawska 30, 10-082 Olsztyn, Poland. Tel.: +4889 524 53 38; fax: +4889 524 53 18.
E-mail address: dorota.mystkowska@uwm.edu.pl (D. Mystkowska).

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1. Introduction

Magnetic resonance imaging (MRI) is a method based on magnetization of hydrogen atomic nuclei which begin to rotate in the magnetic field. Hydrogen nuclei are excited with a radio frequency, caused by a special transmitting coil. The signal generated by rotating nuclei is detected by the receiving coil, and processed by special computer systems. This method was used for the first time for clinical research at the beginning of the 1970s. Presently, it is widely applied for imaging entire body structures.

The application of MRI into diagnostic procedures was a breakthrough in the assessment of central nervous system (CNS) structures.[22] MRI allows for evaluating anatomical conditions before elective surgeries. In the case of brain tumors, it allows for localizing the tumor and its malignancy. MRI makes it possible to asses radicality of resection, shows post surgical lesions and the differentiation or recurrence of the neoplastic process.[1,12] Advanced MRI techniques allow for the analysis of tumor or necrotic tissue properties, and provide more accurate information on its nature.[2] MRI is the only method that allows a direct visualization of the spinal cord, and with the help of a high contrast resolution it facilitates detecting early stage lesions. This method allows one to assess the totality of vertebrae and intraspinal structures, as well as damage in paraspinal soft tissues.[16]

In medical diagnosis, MRI scanners with field strengths of up to 3 T are used. The quality of obtained images is enhanced by an increase in magnetic field strength. It enables the imaging of smaller structures.

MRI provides an opportunity to monitor lesions *in vivo* in experimental therapies, with the use of animal models, such as rats and mice, in order to transpose results for the planning of clinical examinations. This method contributes to reducing both costs and the number of animals needed.

Using clinical MRI scanners is connected with the problem of small object volume. It is important to increase the signal-to-noise ratio (SNR). The way to increase the SNR is to use small clinical (for imaging thumb or wrist) or dedicated animal coils, or clinical scanners designed for imaging parts of the body, e.g., head scanners.[6] To enhance the signal, contrast agents with magnetic properties are applied. Furthermore, a larger bore of the clinical scanner offers the possibility to image multiple animals at the same time, when using a larger standard coil (e.g., human head coil, birdcage coil).[3,6]

2. Aim

The aim of this paper is to present the role of clinical MRI in the management of the CNS anatomy and injury in rodents on the basis of the current literature.

3. Materials and methods

Clinical small bore scanners with field strength from 0.1 T to 3 T are used for imaging the nervous system of rodents *in vivo*.

4. Results

4.1. *Scanners with a magnetic field strength of 0.1 T*

A low magnetic field strength (0.1 T) Bouhnik SAS scanner (Vélizy-Villacoublay, France) is the weakest reported scanner. The experiment was conducted on 4 male Wistar rats, weighing 250–400 g. Rats were anesthetized with isoflurane (1.5–2.0% pushed by air). Cerebral tumor growth was induced by injecting the C6 glioma cell line. Two weeks after the cells implantation, the imaging was carried out. T1-weighted images demonstrated a deviation of brain ventricles to the left, due to the development of the tumor. T2-weighted images visualized the inflammatory reaction and necrosis in the brain's right hemisphere.[4] The authors estimated the tumor size to be 505 mm^3.

4.2. *Scanners with a magnetic field strength of 1.5 T*

There are many reports concerning the use of clinical MRI scanners with the field strength of 1.5 T for the purpose of small animal imaging.[5,11,13,14,15,17,18,19,20] A clinical Magnetom Symphony scanner (Siemens Medical Solutions, Erlangen, Germany) with standard, commercially available coils (Head Array Coil, Double Loop Array Coil, Loop Flex Coil, Siemens Medical Solutions, Erlangen, Germany) was used in the experiments performed on male RH-RNU and Wistar rats, weighing 250–300 g. RH-RNU rats were anesthetized with an intraperitoneal injection of ketamine (100 mg/kg) and xylazine (10 mg/kg) in sterile saline. The Wistar rats were anesthetized with chloralhydrate (300 mg/kg) injected intraperitoneally. Rat model of bacterial meningitis was used to prove the usefulness of a clinical MRI scanner for small animal imaging. The imaging was performed before and after the administration of the contrast agent Magnevist (0.3 mmol/kg) into the femoral vein, with T1- and T2-weighted images. The authors demonstrated that the resolution achieved in clinical MRI scanners is sufficient for imaging small animals, and allows one to visualize pathological lesions. Imaging parameters are presented in Table 1.[14]

A clinical MRI scanner operating at the field strength of 1.5 T was used to monitor tumor growth in female nude mice as well.[6] In this experiment clinical scanners: Magnetom Symphony, Sonata or Avanto (Siemens, Erlangen, Germany) with standard small loop RF-coil (Siemens, Erlangen, Germany) were used for imaging purposes. Mice were anesthetized with an intraperitoneal administration of ketamine (100 mg/kg) and xylazine (5 mg/kg). Tumor growth was induced by the injection of the U-87 MG glioma cells into the right caudate nucleus. One week after the cells implantation, groups of 5 animals were exposed to radiotherapy with different doses of radiation: 5×1 Gy, 5×2 Gy and 5×3 Gy, with 24 h intervals. Three weeks after the tumor cells injection, MRI was performed on the control group (without radiotherapy) and on all 3 groups treated with radiation therapy, before and after the administration of the contrast agent Magnevist (0.4 mL intraperitoneally). This experiment finally managed to establish a correlation between the dose of radiotherapy and tumor size. Tumor growth was apparently suppressed in mice that were treated with higher