

THE VALUE OF
MAGNETIC RESONANCE IMAGING
IN SPINAL CORD TUMORS

Essay

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TO
MY WIFE
AND MY
CHILD

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GLOSSARY

Acquisition: Process of measuring and storing image data.

Acquisition time: Period required to collect the image data, excluding the reconstruction time. For multiple layer and volume techniques both the total period and the time per layer are relevant.

Chemical shift: Variation in the nominal Larmor frequency for a particular isotope with the molecular site. The amount of shift is proportional to the magnetic field strength and usually specified in parts per million (ppm) of the resonant frequency relative to a standard.

Coherence: Maintenance of a constant phase relationship between oscillating waves or rotating objects.

Coil: Single or multiple loops of wire (or other electrical conductor, such as tubing, etc.) designed either to produce a magnetic field from current flowing through the wire or to detect a changing magnetic field by voltage induced in the wire.

T₁: Longitudinal relaxation time.

T₂: Transverse relaxation time.

T₂′: Time constant characterizing the true rate of decay of the FID signal which is generally shorter than T₂ largely due to main field inhomogeneities.

Tesla (T): SI unit of magnetic field strength (equivalent to 10,000 gauss in the cgs system).

Zeugmatography: Term for method of image reconstruction using the MR phenomenon with successive rotation of a magnetic gradient and detection of the MR signal following each rotation, i.e. Projection Reconstruction method.

2DF: Two-dimensional Fourier imaging.

3DF (Volume imaging): Three-dimensional Fourier or volume imaging.

Signal-to-noise ratio (SNR or S/N): used to describe the relative contributions to a detected signal of the true signal and random superimposed signals (noise).

Spectrometer: The portions of the NMR apparatus that actually produce the NMR phenomenon and acquire the signals, including the magnet, the probe, the rf circuitry, etc. The spectrometer is controlled by the computer via the interface under the direction of the software.

Spin: The intrinsic angular momentum of an elementary particle, or system of particles such as a nucleus, that is also responsible for the magnetic moment; or, a particle or nucleus possessing such a spin. The spins of nuclei have characteristic fixed values. Pairs of neutrons and protons align to cancel out their spins, so that nuclei with an odd number of neutrons and/or protons will have a net nonzero rotational component characterized by an integer or half integer quantum "nuclear spin number" (I).

Surface coil: Rf coil, used for in-vivo chemical shift spectroscopy and imaging, designed to improve the S/N ratio by limiting the spatial extent of the excitation or detection.

Echo time (TE): period between the 90° pulse and the peak of the echo in either a spin echo sequence or inversion recovery sequence employing the 180° re-phasing pulse. The period between the 90° and 180° pulses is half TE.

Flip angle: Degree of rotation or tripping of the net (macroscopic) magnetization vector with respect to the main magnetic field direction; produced by an RF pulse.

Gate scan: A scan where the measurements are synchronized with a physiological trigger signal. For instance a heart triggered scan or respiration triggered scan.

Gradient coil: Current carrying coils designed to produce a desired gradient magnetic field (so that the magnetic field will be stronger in some location than others).

Gradient pulse: Briefly applied gradient magnetic field.

Magnetic resonance (MR): Absorption or emission of electromagnetic energy by nuclei in a (static) magnetic field after excitation by suitable (RF) radiation: the frequency of resonance is given by the Larmor equation.

NR signal: Electro-magnetic signal, generally in the RF range, produced by the precession of the transverse magnetization of nuclear spins.

Multi-planar imaging (Multi slice): Planar imaging technique in which the recovery period is utilized for making measurements in other layers.

Precession: Gyration of the rotational axis of a spinning body about a directional line of an applied force around which the motion usually describes a cone.

Pulse sequence: Train of RF and gradient pulses used to excite and spatially encode the MR response signal.

Radio frequency (RF) pulse: Electromagnetic radiation below the infrared region. The RF pulses used in MR are commonly in the 1-100 megahertz range and their principal effect on the body is energy deposition in the form of tissue heating, mainly at the surface.

Receiver coil: RF coil, coil or antenna, positioned within the magnet bore to detect the MR signal; sometime also used for excitation.

Repetition time (TR): Period between the beginning of a pulse sequence and the start of the succeeding sequence.

Resonance: Exchange of energy at a particular frequency between two system.

SE: Spin echo.

Sensitivity: Measure of the MR signal strength obtained from a number of nuclei of a particular isotope relative to that from an equal number of ^1H nuclei.

INTRODUCTION

The annual incidence of primary spine neoplasms has been estimated at 2.5 per 100.00 per year (Nittner 1976). In a review of numerous series, Nittner suggested that approximately one fifth of all central nervous system Tumors occur in the spine (Nittner, 1976).

Our current ability to clinically and radiologically diagnose spinal cord tumors with precision during the early stage of their growth enables neurosurgeons to attack these lesions at the stage of minimal symptoms (Stein, 1985).

Magnetic resonance imaging has rapidly become the method of choice for the investigation of both intrinsic and extrinsic spinal cord diseases. The advantages over other modalities are now well established. These include the avoidance of ionizing radiation, lack of planar restriction and above all the wide range of tissue contrast chart can be obtained by the appropriate choice of pulse sequence, providing excellent discrimination between intramedullary, extramedullary intradural and extradural disease processes.

T1-weighted spin-echo (SE) sequences provide good anatomical details and T2-Weighted spin-echo (SE) sequences are very sensitive for demonstrating pathology, which appears as areas of high signal intensity.

However the long repetition times of such sequences necessitates lengthy acquisition times making them more susceptible to motion artifacts, Furthermore T2-weighted SE sequences do not allow clear discrimination between tumor, peritumoral oedema, proteinaceous cystic changes, reactive gliosis and post-radiotherapy changes (Rothwell et al., 1989).

The thrust to develop intravascular contrast agent in MRI was to allow discrimination between magnetically similar tissues and in case of spinal cord to exploit difference, in perfusion and breakdown of the barrier between the blood and neural tissue in a variety of pathologies (Bydder et al., 1985 - Pilon, 1989).

Aim of the Work:

We aim at reviewing the literature concerning the role and value of MRI in the diagnosis of spinal cord tumors and the different points of advantages over other modalities of radiological imaging proving the real spectrum and ability of such imaging technique in delineating the different neoplastic processes concerning the spinal cord.

History of Magnetic Resonance Imaging:

Magnetic Resonance (MR) is a phenomenon that was discovered independently by Purcell and Bloch in 1946.

They received the Nobel prize for physics in 1952 for the discovery and subsequent development of spectroscopic methods based on this phenomenon.

Since that time, MR instrumentation has become increasingly more sophisticated and has proved to be a valuable investigational tool in physical chemistry and biochemistry.

After the discovery of differences in the proton NMR parameters (Relaxation times) of normal and malignant tissues by Damadian (1971), imaging techniques to depict the magnetic behaviour of protons were developed by Lauterbur (1973) and Ernst (1975) among others, disclosing the field of magnetic field imaging (MRI).

Since then image quality has improved steadily while imaging-time has shown a gradual decrease bringing MR imaging within the reach of clinical practice (Koopn, 1985).

ANATOMY OF THE SPINAL CORD

The spinal cord is the least modified portion of the embryonic neural tube and the only part of the adult nervous system in which the primitive segmental arrangement is clearly preserved (Carpenter, 1978).

Gross anatomy:

The spinal cord is elongated, nearly cylindrical part of the CNS which occupies the vertebral canal. Its average length in adults is 45 cm. Its weight is 30 gms. It extends from the level of the upper border of the atlas vertebra to that of the lower border of the first lumbar or upper border of the second lumbar vertebra in adult, but at birth it descends to the level of the third lumbar vertebra.

Above, the spinal cord is continuous with the medulla oblongata, below, it tapers off rapidly into a conical extremity termed the conus medullaris. A delicate non-nervous filament descends from the apex of conus to the back of the first segment of the coccyx named the filum terminal. It is about 20 cm long and consists mainly of fibrous tissue continuous above with that of the pia mater and the spinal central canal is continuous downwards into it for 5 or 6 mms.

The spinal cord is ensheathed in three protective membranes: The dura, arachnoid and pia matters which are continuous with the corresponding membranes inside the skull.

Spinal dura is continuous at the foramen magnum with the inner layer of cranial dura. Between the spinal dura and the periosteum of the vertebra, the epidural space intervenes within this space are the internal vertebral venous plexuses and usually some fat. AT the level of the second sacral vertebra the dural sac is pierced by the filum terminal.

The spinal dura receives sensory innervation from the spinal nerves. Its blood supply is furnished by small branches of the regional spinal arteries.

The spinal arachnoid has an arrangement comparable to that of the intracranial arachnoid. Small arachnoid villi are present and project into the lumina of the segmental veins. Beneath the arachnoid, the subarachnoid space is bridged by arachnoid trabeculae, contains spinal fluid.

The spinal pia is closely adherent to the spinal cord, and dips into anterior and posterior fissures. The spinal cord presents two swellings or enlargements:

- A) The cervical enlargement is more pronounced and corresponds to the attachments of the large nerves of the upper limbs. It extends from the third cervical to the second thoracic segment.
- B) The lumbar enlargement corresponds to the attachments of the nerves of the lower limbs. It begins at the level of the ninth thoracic vertebra and reaches its maximum circumference opposite the last thoracic vertebra, below which it tapers rapidly into the conus medullaris.

Springing from the sides of the spinal cord at intervals along its length are pairs of ventral and dorsal nerve roots. They cross the subarachnoid space, perforate the dura independently, then the dorsal and ventral roots unite in or close to the intervertebral foramen to form the spinal nerves. Below the conus medullaris, the roots form a leash, the cauda equina around the filum terminal.

The spinal segments do not correspond to the segments of the vertebral column due to the disproportionate growth in length of the spinal cord and the vertebral column.

Roughly there is difference of one segment in the cervical region, two at the upper thoracic and three at the lower thoracic. So the last thoracic segment lies apposite the ninth thoracic vertebra. The lumbar segments are apposite T10-to T12. The sacral segments are apposite the L1 vertebra. These relations guide us to know the level of compression in cases of spinal cord injuries or tumors (Last, 1984).

The spinal cord has an anterior median fissure and posterior median septum incompletely dividing it into two symmetrical parts, which are joined across the median plane by a commissural band of neurons tissue.

Internal structure of the spinal cord:

The spinal cord is composed of grey and white nervous matters, in both of which there is a supporting framework of neuroglia. The grey matter is situated centrally and has the form of fluted column which runs through the whole length of the spinal cord.