UNIVERSITI TEKNOLOGI MARA

LOWER LIMB MUSCLES ASSESSMENT IN INCOMPLETE SPINAL CORD INJURY PATIENTS BY USING MAGNETIC RESONANCE (MR) SPECTROSCOPY

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ABSTRACT

In Malaysia, spinal cord injury cases become epidemiological patterns among residents. Spinal cord injury is a signal disturbance moved by a bunch of nerves up and down between the human body and brain. This research study aimed to non-invasively evaluate choline (CHO), creatine (Cr), and intramyocellular lipid (IMCL) metabolites in vastus lateralis, semitendinosus, and gluteus maximus muscles for incomplete spinal cord injury ASIA-AIS B, C, and D patients by using ^{1}H-MRS, to compare the CHO, Cr, and IMCL metabolites among vastus lateralis, semitendinosus and gluteal maximus muscles, to measure the metabolites value changes before and after high-intensity FES cycling exercise among incomplete spinal cord injury ASIA-AIS D patients, and to propose a metabolite as a potential indicator for assessing muscle activity in incomplete spinal cord injury ASIA-AIS B, C, and D patients. These metabolites were measured from the three critical muscles in 17 incomplete spinal cord injury ASIA-AIS B, C, and D patients. All subjects underwent 3 Tesla MRI (repetition time/echo time; TR/TE of 3500ms/100ms, field-of-view; FOV of 20cm, slice thickness of 6mm) and ^{1}H-MRS (TR/TE of 2000ms/31ms, voxel size of 20mm x 20mm x 35mm) scans, then two incomplete spinal cord injury ASIA-AIS D subjects had functional electrical stimulation (FES) cycling sessions and followed by post-MRI and ^{1}H-MRS. The acquisition and analysis of CHO, Cr, and IMCL metabolite values for this research study could be performed on all 17 subjects without any exception. CHO metabolite in the semitendinosus and gluteus maximus muscles showed a statistically significant difference ($p = 0.01$) for strong legs. A significant difference was also detected for IMCL metabolite in the semitendinosus muscle ($p = 0.01$). Meanwhile, significant differences were detected for CHO and Cr metabolites in the vastus lateralis muscle ($p = 0.02$) for weak legs. For FES cycling exercise findings, only the IMCL value of semitendinosus showed a statistically significant difference between pre- and post-FES exercise ($p = 0.01$) in strong legs. In the meantime, only the Cr value of vastus lateralis showed a significant difference between pre- and post-FES exercise ($p = 0.01$) in weak legs. In conclusion, this study showed that ^{1}H-MRS at 3T could non-invasively provide metabolic information regarding human skeletal muscles in incomplete spinal cord injury patients. Additionally, ^{1}H-MRS detects metabolite changes before and after electrical stimulation on muscles. The result indicated that Cr metabolite could become a potential indicator to evaluate spinal cord injury patients' muscle activity.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Spinal cord injury is a signal disturbance moved by a bunch of nerves up and down between the human body and the brain. This injury starts with a blast that causes the vertebrae to dislocate or fracture. Nevertheless, most injuries cause destruction when vertebrae pieces rip into cord tissue or the nerve parts that carry signals are pressed by the damaged vertebrae bone and not because of the spinal cord cut.

In Malaysia, spinal cord injury cases become epidemiological patterns among residents. The primary regular cause of traumatic spinal cord injury is motor vehicle accidents, contributing to more than 50% of cases. Meanwhile, degenerative problems and tumours give about 64% of non-traumatic spinal cord injury cases (Ibrahim et al., 2013). Spinal cord injuries are commonly associated with physical, emotional, and socioeconomic burdens to patients and their families. The patient will experience sensory abnormalities, motor loss, bladder, and bowel deformities that demand prolonged treatment and rehabilitation. These situations contribute significantly to high expenses regarding healthcare utilisation.

The classifications of spinal cord injury are based on International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI), which introduces the American Spinal Cord Injury Association Impairment Scale (ASIA-AIS) (Ibrahim et al., 2013). ASIA-AIS issues the ISNCSCI, which determines spinal cord injury severity grade. ASIA-AIS's functions are to standardise detailed documentation of spinal cord injuries, conduct forward radiographic procedures and treatment, and determine whether the injury is incomplete (Roberts, Leonard, & Cepela, 2017). Furthermore, ASIA-AIS also helps to provide the answer for a tricky question such as "will the patient ever walk again?". Besides, ASIA-AIS may help predict recovery of autonomic functions such as the bladder, bowel, respiratory, and reproductive functions (Middendorp et al., 2011).

ASIA-AIS can be categorised as the spinal cord injury ASIA-AIS A, B, C, D, or E depending on the severity level of injury. ASIA-AIS A indicates a complete spinal cord injury lesion with loss of motor and sensory functions in the sacral segments of