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Contents lists available at ScienceDirect
Journal of Acute Disease
journal homepage: www.jadweb.org

Original article http://dx.doi.org/10.1016/j.joad.2016.04.004

Compared study of routine magnetic resonance imaging and diffusion tensor tractography on the predictive value of diagnosis and prognosis in acute cervical spinal cord injury

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ARTICLE INFO

Article history:
Received 12 Mar 2016
Received in revised form 8 Apr 2016
Accepted 18 Apr 2016
Available online 13 Jun 2016

Keywords:
Acute cervical spinal cord injury
Magnetic resonance imaging
Diffusion tensor imaging
Diffusion tensor tractography
American Spinal Injury Association

ABSTRACT

Objective: To compare and analyze the predictive value of two kinds of classification methods, routine magnetic resonance imaging (MRI) and diffusion tensor tractography (DTT), on the diagnosis and prognosis in different degrees of acute cervical spinal cord injury (ACSCI).

Methods: A total of 35 patients with ACSCI treated with surgery in our department from January 2013 to December 2014 were included and all patients had received MRI examination and diffusion tensor imaging examination before surgery. The motor score, sensory score and abbreviated injury scale (AIS) of American Spinal Injury Association were used to evaluate the neurological function of patients before and one year after surgery, respectively. Routine MRI was divided into 3 grades according to the compression and signals of spinal cords and DTT was also divided into 3 grades according to continuous levels of fibre bundle. The correlations between routine MRI grades and DTT grades and the neurological function of ACSCI before surgery and after surgery were analyzed, respectively.

Results: There were no correlations between MRI grading and the motor score, sensory score and AIS of patients with ACSCI before surgery and after surgery. DTT grading showed no relations with the motor score, sensory score before surgery but were related to AIS before surgery. DTT grading was all related to the motor score, sensory score and AIS after surgery.

Conclusions: The noninvasion of DTT showed spinal nerve fibers has a higher predictive value on the diagnosis and prognosis of ACSCI than routine MRI.

1. Introduction

The pathogeny of acute cervical spinal cord injury (ACSCI) includes acute compression injuries, such as cervical fracture and dislocation, acute cervical internal disc herniation and hyperextension injury or whiplash injury of cervical vertebra; penetrating wound and incised wound of sharp instruments, and acute ischemic injury of spinal cord mostly caused by the injury of the anterior or posterior spinal artery or the radicular artery. All kinds of traumas are the commonly causes leading to acute compression injuries of cervical spinal cord[1,2]. The diagnosis of ACSCI is mainly according to histories of traumas and relevant imaging examinations, including computed tomography (CT) and magnetic resonance imaging (MRI)[3]. CT can confirm clearly the presence of fracture, dislocation, hyperplastic osteophyte and ossification of posterior longitudinal ligament and so on. MRI has a better development effect on soft tissues and delivers great image of the degree of spinal cord compression and change of signal. The commonly occurrence of T2 weighted image with increased signal intensity (ISI) of

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Foundation Project: Supported by Emerging Frontier Technology Joint Research Program of Shanghai Shen-Kang Hospital Development Center (Grant No. SHDC12015103).
Peer review under responsibility of Hainan Medical College. The journal implements double-blind peer review practiced by specially invited international editorial board members.

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spinal cord reflects the acute changes of nonspecific edema of spinal cord, inflammatory response and ischemia, while T1 weighted image with low signal intensity (LSI) of spinal cord presents rarely[4,5]. However, morphological imaging of routine MRI can only show the anatomic form and pressure degree of spinal cord but cannot accurately evaluate the state of the neurological function of spinal cord[6,7].

Diffusion tensor imaging (DTI) is a new technology of diffusion MRI, which quantifies diffusion movement from multiple directions by using the theory of the presence of anisotropy in diffusion of water molecule in tissues to reflect the change of fine structure and function of living tissues. The assessment parameters of DTI include apparent diffusion coefficient and fractional anisotropy (FA). The diffusion direction and speed of water molecules can be used to conduct diffusion tensor tractography (DTT) to rebuild the form and course of white matter fibers in the spinal cord, which is currently the only noninvasive method to show the nerve fiber bundle of living organisms[8].

DTI has been applied in the evaluation of diagnosis and prognosis of many spinal cord lesions. Some related researches showed that the damage degree of fibre bundle of DTT is consistent with the damage degree of nerve injury in patients and the integrity of fibre bundle is positively correlated with the prognosis of patients[9,10]. Although some literatures reported that DTT could be used in acute spinal cord injury, the number of cases that are studied in these studies are insufficient and the comparison between DTT and routine MRI in the application value of ACSCI has not been reported yet[11–14]. In this research, we compare and study the function evaluation and predictive value of prognosis of routine MRI grades and DTT grades on ACSCI by enlarging the sample size so as to verify the clinical application value of DTT more accurately.

2. Materials and methods

2.1. General data

A total of 42 cases patients with traumatic ACSCI treated with surgery in our department from January 2013 to December 2014 were included and the patients with congenital cervical vertebral malformation, intraspinal tumor, cervical vertebra infection or history of cervical spine surgery were excluded. All patients received MRI and DTI examinations before surgery and signed the informed consent before examinations. The motor score, sensory score and abbreviated injury scale (AIS) of American Spinal Injury Association (ASIA) were used to evaluate the neurological function of patients before and one year after surgery, respectively.

2.2. MRI and DTI

2.2.1. Scanning process

Imaging was performed using a GE HDxt Twinspeed 3.0T dual gradient superconductor MR (Signa HDxt, GE Healthcare, Waukesha, WI, USA) and a NV-full 8-channel array coil (GE Healthcare, Waukesha, WI, USA), at a gradient strength of 40 mT/m and a switching rate of 150 mT/ms^{-1}. Sagittal and axial T_1W_I and T_2W_I scans were performed routinely. The sagittal flair-T_1W_I having the repetition time/echo time (TR/TE) of 3 200.0 ms/116.8 ms, section thickness of 3.0 mm, interlamellar spacing of 1.0 mm, field of view (FOV) of 24 × 24 mm, image matrix of 320 × 224 and number of signals averaged (NEX) of 2, the sagittal FRFSE-T_2W_I sequence having the TR/TE of 2 698.0 ms/25.8 ms, section thickness of 3.0 mm; interlamellar spacing of 1.0 mm, FOV of 240 × 240 mm, image matrix of 320 × 224 and NEX of 2, and an axial FRFSE-T_2W_I sequence having the TR/TE of 3 200.0/121.0 ms; section thickness of 4.0 mm, interlamellar spacing of 0.5 mm, bandwidth of 41.7 kHZ; FOV of 180 × 180 mm, image matrix of 288 × 224 and NEX of 4 were acquired. DTI examination was alike with the scanning positions of routine transverse view. A single-shot spin-echo echo-planar imaging sequence with b values of 1 000 s/mm^2 and gradient directions of 15 was conducted and repeated 2 times; The TR/TE was 8 000.0/87.6 ms; section thickness was 4.0 mm; interlamellar spacing was 0.0 mm; bandwidth was 250 kHZ; FOV was 180 × 180 mm; image matrix was 130 × 128 and NEX of 2. The total DTI scan time was 5 min.

2.2.2. Image processing and DTT reestablishment

We used the GE Functool 9.4 software (GE Healthcare, Waukesha, WI, USA) to post-process the DTI data. The Correct program (included in the GE functool software) was used to correct the original data in order to reduce motion artifacts and images distortion. The transversal sections of the spinal cord at the b0 of all diffusion weighted imaging images were selected as the regions of interest for tractography using the minimal FA value of 0.2 and the maximal apparent diffusion coefficient value of 0.01.

2.2.3. Routine MRI grading and DTT grading

MRI grading and DTT grading were performed by two intermediate and senior radiologists respectively who were blinded to the clinical data during image processing and grading independently. The inconsistent grading of the final result summaries was confirmed by the two radiologists.

Patients were divided into three grades according to the severity of spinal cord compression, form and signal changes of the sagittal in routine MRI. Grade 1 had no static compression on spinal cord (no abnormal signals on sagittal T_1W_I and T_2W_I); Grade 2 had compression on spinal cord (ISI on sagittal T_2W_I but normal signal on sagittal T_1W_I); and Grade 3 had obvious compression on spinal cord (ISI on sagittal T_2W_I and LSI on sagittal T_1W_I) (Figure 1). DTT images were also divided into three grades according to the severity of the spinal cord compression and continuous degree of the fiber bundle. Grade 1 had a mixed signal in lesion area but had a complete and continuous fibre bundle; Grade 2 had abnormal signal and disordered fiber bundle in local lesion of spinal cord; and Grade 3 of DTT showed interrupted fiber bundle (Figure 2).

2.3. Statistical analysis

Data were expressed as mean ± SD and were statistically analyzed by using SPSS 18.0 software (IBM, Armonk, NY, USA). Correlations between the MRI and DTT grading and the motor scores, sensory scores and impairment scale of ASIA were analyzed by using the Spearman's rank correlation coefficient. $P < 0.05$ was considered as statistical significant.