European Journal of Radiology 91 (2017) 15–21

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

3T MR-defecography—A feasibility study in sensorimotor complete spinal cord injured patients with neurogenic bowel dysfunction

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ARTICLE INFO

Article history:
Received 19 August 2016
Received in revised form 31 January 2017
Accepted 21 February 2017

Keywords:
MR-defecography
Spinal cord injury
Paraplegia
Tetraplegia
Neurogenic bowel dysfunction
Obstructed defecation

ABSTRACT

Introduction: To investigate whether MR-defecography can be employed in sensorimotor complete spinal cord injury (SCI) subjects as a potential diagnostic tool to detect defecational disorders associated with neurogenic bowel dysfunction (NBD) using standard parameters for obstructed defecation.
Material and methods: In a prospective single centre clinical trial, we developed MR-defecography in traumatic sensorimotor complete paraplegic SCI patients with upper motoneuron type injury (neurological level of injury T1 to T10) using a conventional 3T scanner. Defecation was successfully induced by eliciting the defecational reflex after rectal filling with ultrasonic gel, application of two lecicarbon suppositories and digital rectal stimulation. Examination was performed with patients in left lateral decubitus position using T2-weighted turbo spin echo sequence in the sagittal plane at rest (TE 89 ms, TR 3220 ms, FOV 300 mm, matrix 512 × 512, ST 4 mm) and ultrafast-T2-weighted-sequence in the sagittal plane with repeating measurements (TE 1.54 ms, TR 3.51 ms, FOV 400 mm, matrix 256 × 256, ST 6 mm). Changes of anorectal angle (ARA), anorectal descent (ARJ) and pelvic floor weakness were documented and measured data was compared to reference values of asymptomatic non-SCI subjects in the literature to assess feasibility.
Results: MR-defecography provides evaluable imaging sequences of the induced evacuation phase in SCI patients. Measurement results for ARA, ARJ, hiatal width (H-line) and hiatal descent (M-line) deviate significantly from reference values in the literature in asymptomatic subjects without SCI. The overall mean values in our study for SCI patients were: ARA (rest) 127.3°, ARA (evacuation) 137.6°, ARJ (rest) 2.4 cm, ARJ (evacuation) 4.0 cm, H-line (rest) 7.6 cm, H-line (evacuation) 8.1 cm, M-line (rest) 2.6 cm, M-line (evacuation) 4.2 cm.
Conclusions: MR-defecography is feasible in sensorimotor complete SCI patients. Individual MR-defecography findings may help to determine specific therapeutical options for respective patients suffering from severe NBD.

Abbreviations: ARA, anorectal angle; ARJ, anorectal junction; ASIA, American Spinal Injury Association; FOV, field of view; LMN, lower motoneuron; MRI, magnetic resonance imaging; NBD, neurogenic bowel dysfunction; NLI, neurological level of injury; PCL, pubococcygeal line; SCI, spinal cord injury; ST, slice thickness; TE, time of echo; TR, time of repetition; UMN, upper motoneuron.

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http://dx.doi.org/10.1016/j.ejrad.2017.02.036
0720-048X/

1. Introduction

Following spinal cord injury, neurogenic bowel dysfunction (NBD) is defined as a colonic dysfunction due to a lack of central control based on an upper motoneuron (UMN) or lower motoneuron (LMN) lesion with reflexive or areflexive bowel, respectively [1]. It constitutes a major physical and psychological problem in individuals with spinal cord injury (SCI) with a high impact on quality of life and restriction of social activities [1–3].

Patients with sensorimotor complete SCI, classified by the American Spinal Injury Association Impairment Scale (AIS) as AIS grade A (AIS-A), lose sensation of rectal filling, anal sensibility and the ability to evacuate their bowels resulting in impaired defecation [4]. The improvement of bowel function is considered amongst the highest priorities in spinal cord injury patients [5].

All patients with complete SCI suffer from bowel-related symptoms and the frequency of gastrointestinal problems increases in individuals who had been spinal cord injured for more than 5 years [3,6]. To prevent such gastrointestinal complications a specific bowel management program during rehabilitation is required to achieve efficient, effective and consistent stool evacuation to avoid chronic overdistension of the colon [6]. Whereas normal individuals have synergistic activity between rectal smooth muscle and pelvic striated muscles, it is hypothesized that SCI patients have dyssynergic pelvic floor movements which contribute to outlet obstruction [7]. This constitutes one of the key factors interfering with regular bowel function. Sphincter electromyography findings indicate involuntary external as well as internal anal sphincter activity supporting the notion that outlet obstruction may be due to persistant external anal sphincter contractions [8], although results of anorectal manometry did not reveal a clear correlation to clinical bowel dysfunction [7]. Overall, the exact pathophysiological process of outlet obstruction involving the pelvic floor and anorectum of SCI patients has yet to be examined.

The primary objective of this study was to evaluate the feasibility to perform MR-defecography in sensorimotor complete SCI patients, who are not able to squeeze or strain actively. MR-defecography provides visualization of all the compartments of the entire pelvis with excellent soft tissue contrast without application of radiation, allowing reproducible and quantifiable assessment of defecation under standardized conditions [9]. First, we established an adopted procedure for MR-defecography examination in patients with SCI using a conventional 3 Tesla (T) scanner. Second, we evaluated standard parameters for obstructed defecation and compared these results to reference values of able-bodied subjects in the literature.

2. Material and methods

This prospective clinical trial was conducted at the Spinal Cord Injury Center, Heidelberg University Hospital, Germany, specialising in comprehensive care of acute and chronic SCI patients. Subjects were recruited from in house and outpatients during 2010–2012 and those that met the inclusion criteria were included in the study. The study (trial number S-274/2008) was approved by an ethics committee at Heidelberg Medical Faculty, Germany. All patients gave informed written consent after explanation of the procedure.

2.1. Patient population, inclusion and exclusion criteria

We enrolled patients with sensorimotor complete traumatic SCI (**A**merican Spinal Injury Association **I**mpairment **S**cale grade A; AIS-A) and a neurological level of injury (NLI) between Th1 and Th10 to yield a homogenous patient population with only UMN lesions [10]. AIS-A is defined as no preserved sensory or motor function in the sacral segments S4-S5 [10]. As a result all patients suffer from neurogenic bowel dysfunction, a dysfunction of the colon (constipation, faecal incontinence and disordered defecation) due to loss of normal sensory and/or motor control or both [11]. To ensure, that our patients had a stable condition in regards to their bowel management, we enrolled patients only 6 months after SCI. Patients with non-traumatic paraplegia, traumatic brain injury, dementia, cauda equina or conus medullaris lesion, polyneuropathy, inflammatory, traumatic or neoplastic bowel disease, pre-existing pelvic floor weakness or gastrointestinal surgical interventions were excluded. Further, we excluded patients who did not meet the inclusion criteria for MRI, e.g. cardiac pacemaker, metal foreign objects and claustrophobia.

2.2. Defecation procedure, image acquisition and analysis

All MRI studies, which were conducted for research purposes only, were performed at a conventional 3T MR scanner (Magnetom Verio, Siemens, Erlangen, Germany). The exam date was scheduled to meet the bowel evacuation rhythm of the patient.

As SCI patients require different kinds of supporting measures for inducing the defecation process (e.g. suppositories, enemas, digital stimulation), application of Lecicarbon (CO_2) suppositories and digital stimulation were determined for this study. The preparation of the patients before and during MR-examination as well as the performed MR-sequences are listed in Table 1. The sequences were separately and independently analysed offline at a PACS-workstation (GE Medical, USA) by a radiologist with 8 years experience in pelvic floor imaging. The analysis was performed upon two images: (1) a sagittal plane at rest after initial rectal filling and (2) a sagittal plane during notable evacuation. As we analysed sensorimotor complete SCI patients, defined images during squeezing (maximal sphincter contraction) or volitional straining could not be performed. Defecation in spinal cord injured patients is recommended in lateral left-sided decubitus if sitting defecation posture is not possible [12,13]. To facilitate the practicality of additional interventions, e.g. digital rectal examination of the patient, second filling and digital rectal stimulation, lateral decubitus was the preferred position during rest and defecation.

Measurement of parameters was completed on the aforementioned sagittal images as follows (Fig. 1a–c):

The pubococcygeal line (PCL), defined as a straight line from the inferior border of the pubic symphysis to the last coccygeal joint, representing the pelvic floor level, was drawn (Fig. 1a) [14,15]. The horizontal line (H-line) represents the anteroposterior hiatal width of the levator plate and is measured from the inferior border of the pubic symphysis to the posterior aspect of the anorectal wall [16–18]. The M-line (M) representing the hiatal descent was measured perpendicular to the PCL to the posterior endpoint of the H-line (Fig. 1a) [16–18]. The anorectal junction (ARJ), defined as the cutting line between the tangent to the posterior wall of the rectum and a line along the central axis of the anal canal was plotted and a perpendicular line to the PCL was drawn to define rectal descent (Fig. 1b) [9]. The anorectal angle (ARA) was defined as the angle between these two aforementioned cutting lines resulting in the ARJ (Fig. 1b) [9]. Furthermore, the maximum rectal diameter before notable evacuation was measured (Fig. 1c).

After acquisition of the data at rest and during induced defecation, the difference of the measured values (Δ) was calculated for all parameters.

To rate the measured findings, established grading systems for pelvic floor weakness, including hiatal widening (H-line), levator plate descent (M-line) and for rectal descent were used (Table 2) [16,19]. Routinely, all images were analysed for the presence of an