ORIGINAL ARTICLE

The sensitivity of ultrasound screening examination in detecting heterotopic ossification following spinal cord injury

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Study design: Retrospective chart review.

Objective: To analyze the role of sonography in detecting heterotopic ossification (HO) following spinal cord injury (SCI).

Setting: Department of Spinal Cord Injury and Department of General and Trauma Surgery, BG University Hospital Bergmannsheil Bochum, Ruhr University Bochum, Germany.

Methods: Between January 2003 and December 2013, 217 patients with HO of the hips met the inclusion criteria and were included in the final analyses. The diagnosis of HO was carried out in all cases using our hospital protocol. Primary outcome measure was to calculate the sensitivity of ultrasound screening examination in detecting HO following SCI.

Results: The diagnosis of HO was confirmed in 217 patients after a mean interval of 64.8 days (range from 8 to 295; s.d. = 40.4) via computerized tomography or magnetic resonance imaging scan. In 193 out of 217 patients, suspicious HO signs were noted in the ultrasound screening examination (sensitivity = 88.9%).

Conclusions: The use of ultrasound for screening for HO in SCI patients is reliable and has a high sensitivity.

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INTRODUCTION

Heterotopic ossification (HO) is a common occurrence in patients with acute spinal cord injury (SCI).^{1–4} Despite its high incidence, the exact pathophysiology is still unknown. However, several risk factors for HO development have been reported.^{2–4} A complete spinal cord lesion, tetraplegia, the presence of a tracheostomy, associated thoracic trauma and pneumonia have all been reported as risk factors by Citak *et al.*³ in a large case–control study. Aside from the identification of these risk factors, there are only a limited number of reliable diagnostic methods for the early detection of HO—for example, three-phase bone scan.^{5,6} However, this diagnostic tool has high costs and is associated with radiation exposure, and is not available in smaller hospitals.

The development of a reliable screening test is of particular importance, given that early treatment in the acute phase of HO is crucial to avoid joint stiffness and that there are no specific clinical signs or symptoms for HO. Unspecific symptoms for HO are swelling, erythema, pain or restriction of joint mobility. To date, specific laboratory screening parameters for HO are missing.^{2,5–10} Previous studies reported on the correlation of elevated alkaline phosphatase (AP) or bone alkaline phosphatase (BAP) with HO development.^{6,10} However, a recent large patient cohort study did not find the use of laboratory parameters such as AP, BAP or CRP to be reliable for the early detection of HO.¹¹

Ultrasound (US) examination is an inexpensive and readily available imaging tool that could be used for early detection of HO following

SCI.^{12–14} The goal of this study was to determine the diagnostic performance of US examination as a screening tool for HO, using CT or MRI examinations to confirm the diagnosis.

MATERIALS AND METHODS

All patients treated for HO about the hip joint following SCI between January 2003 and December 2013, and who underwent routine US screening, were included in this study. Patients with associated pelvic trauma were excluded. From 268 patients who were treated for HO following SCI during the study period, 23 patients were excluded because of the lack of routine US examination; two patients were excluded because of inadequate documentation of their US; and 26 patients were excluded for having associated pelvic trauma. A total of 217 patients met the criteria and were included in the final analysis.

The diagnosis of HO was performed using our standardized hospital protocol. According to this protocol, every acute spinal cord-injured patient receives biweekly US examinations performed by experienced radiologists. All US examinations were performed in the B-mode technique, with special focus on muscle or muscle performance around the hip joint. A suspected US finding was defined besides an edema as the so-called zone phenomenon (Figure 1). In case of suspicion of HO, computerized tomography (CT) or magnetic resonance imaging (MRI) was performed to confirm the HO diagnosis (Figure 2).

The primary outcome measure was to calculate the sensitivity of US screening examination in detecting HO following SCI. Secondary outcome measures were collected based on the patient medical records: age, gender, time interval of SCI and HO development (in days), date of suspected US finding and date of performed CT/MRI. Descriptive statistics are presented in the form of a number of occurrences and percentage, or mean, s.d. and range. All data

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Figure 1 Demonstrates the suspicion for HO in the US screening examination. The edema is marked with an arrow. A full color version of this figure is available at the *Spinal Cord* journal online.

were processed using the software (Graph Pad Prism version 5.0d, La Jolla, CA, USA).

RESULTS

Of the 217 patients included in the study, 185 were males and 32 were females, with a mean age of 46.5 years (range, 18–81 years; s.d. = 18.3 years). There were 106 tetraplegic and 111 paraplegic patients, whereas 186 patients had a complete lesion (AIS A).

In 193 patients (sensitivity = 88.9%), suspicious HO signs were noted in the US screening examination after a mean interval of 62.4 days (range from 8 to 290; s.d. = 39.8) after SCI development. The diagnosis of HO was confirmed in 217 patients after a mean interval of 64.8 days (range from 8 to 295; s.d. = 40.4) via CT or MRI scan. In 24 patients, US examination showed no signs of HO, but CT or MRI scans performed later did reveal HO around the hip. In those cases, CT or MRI control was performed because of a decrease in joint mobility and elevated CK, CRP and/or BAP.

DISCUSSION

The diagnosis of HO in its early stage is challenging for every physician. The main reason is that there are no specific clinical signs for HO. Another reason is the fact that there is no specific laboratory screening parameter for HO in patients with SCI.^{2,5–10} Citak *et al.*¹⁵ studied the combination of elevated CK, fever and CRP as a marker in patients with severe HO. However, the combination of those parameters was found only in ~9% of cases. More recently, Citak *et al.*¹¹ demonstrated that previously reported laboratory markers such as elevated AP or BAP are not reliable markers for the early detection of HO.

Hence, only imaging techniques can be currently used for the diagnosis of HO.^{16,12} In contrast to the well-developed, mature-appearing bone that can be identified on plain radiographs during the late stages of HO, no radiographic findings are seen in the early stage.² Argyropoulou *et al.*¹⁶ showed MRI to be more effective than radiography at demonstrating early HO. The use of three-phase bone scan is particularly useful for the diagnosis of HO in the early stage.¹ However, this method is expensive, is associated with radiation exposure, and has a lack of easy availability and might produce false-negative results, especially in patients with associated pelvic trauma.¹⁷ In 1995, Snoecx *et al.*¹⁴ used ultrasonographic findings to indicate a possible traumatic origin of HO around the hip in four paraplegic patients. Pistarini *et al.*^{12,13} demonstrated in a larger cohort

Figure 2 Presents the validation of HO in MRI. The arrow shows the area with HO. A full color version of this figure is available at the *Spinal Cord* journal online.

of 59 patients that sonographic assessment for the diagnosis of HO is superior to bone 99mTc scintigraphy and the assessment of serum AP.

In our study, we found that US screening examination had a high sensitivity for detecting HO (88.9%). The usefulness of US in detecting HO has been already presented in previous studies. However, as reported, the majority of published studies include small numbers of patients. Aside from the standardized screening protocol, the main strength of the current study is the large patient cohort included, which, to the best of our knowledge, is the largest study sample of patients with HO after SCI to date.

The main limitation of the study is the lack of a comparison group of SCI patients without HO, which would have allowed for the calculation of specificity of US screening. Another limitation is the retrospective design of the study. Future prospective cohort studies could be designed to confirm the current findings and fully explore the diagnostic performance of US screening.

In conclusion, the use of US for screening for HO in SCI patients is reliable and has a high sensitivity.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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