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Research article

Serial magnetic resonance imaging evaluations of irradiated superior cervical sympathetic ganglia: Not every retropharyngeal enlarging mass is a sign of malignancy

Se Jin Cho[a], Jeong Hyun Lee[a,*], Ji Eun Park[a], Young Jun Choi[a], Jin Hee Kim[a], Hwa Jung Kim[b], Jung Hwan Baek[a]

[a] Department of Radiology and Research Institute of Radiology, University of Ulsan College of Medicine, Asan Medical Center, Republic of Korea
[b] Clinical Epidemiology and Biostatistics, University of Ulsan College of Medicine, Asan Medical Center, Republic of Korea

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ABSTRACT

Introduction: To describe serial changes in irradiated superior cervical sympathetic ganglia (SCSGs) on MRI (magnetic resonance imaging) evaluation in patients with head and neck squamous cell carcinoma (HNSCC) and to find the features differentiating them from the metastatic retropharyngeal lymph nodes.

Materials and methods: This retrospective study evaluated 52 consecutive patients with definitive radiotherapy with/without chemotherapy for pathologically confirmed HNSCC and pre- and postradiation MRI follow-up evaluations. MR images of SCSGs were analyzed including enhancement pattern, margin, and the presence of intraganglionic hypointensity.

Results: MRI evaluations were performed in 36 men and 16 women with HNSCC with an average age of 58 years, range 23–80 years before irradiation (n = 52), and at 6 (n = 21) and 13–18 (n = 52) months follow-up. Mean total radiation dose was 6351 ± 483 cGy (range, 5640–7000 cGy). Intraganglionic hypointensity, homogeneous enhancement pattern, and well-defined margins were observed in 96%, 97%, and 97% of ganglia on the last follow-up, which showed no difference between pretreatment and 6-month follow-up ($P > 0.05$). Mixed linear model analysis revealed significant increases in diameter and normalized T2SI of SCSGs after irradiation ($P < 0.05$).

Conclusions: Despite of the increase in diameter and normalized T2SI of SCSGs, preservation of intraganglionic hypointensity, well-defined margins and homogeneous enhancement might be helpful for radiologists to identify SCSGs during the follow-up of HNSCC patients.

1. Introduction

In a healthy person, the superior cervical sympathetic ganglion (SCSG) is the largest and most cranial of the three cervical sympathetic ganglia in the head and neck [1,2]. Anatomical evaluations of the SCSG are generally conducted when performing ganglion blocks for pain relief or to avoid iatrogenic injuries during spine surgery [2,3]. Recent cases of an enlarged SCSG mimicking a metastatic retropharyngeal lymph node after radiation therapy for nasopharyngeal carcinoma have been reported, and were confirmed only after surgical dissection [4,5]. One report suggested that irradiation caused the changes in anatomical morphology and signal intensity consistent with edema, fatty degeneration, and fibrosis on magnetic resonance imaging (MRI) [5]. However, they had neither evaluated the normal imaging appearance nor performed serial imaging after irradiation of the SCSGs.

We recently published a prospective MRI study of SCSGs in 53 patients without either head and neck squamous cell carcinoma (HNSCC) or a history of irradiation [6]. In 73% of those patients, a fusiform SCSG was located medial to the internal carotid artery (ICA), lateral to the longus capitis muscle, and between the C2 and C4 vertebrae. Anatomical variations included a position anterior to the longus capitis muscle in 18%, lateral to ICA in 7%, and posterior to ICA in 3% of patients. The SCSGs were characteristically homogeneous with high signal intensity on T2-weighted imaging (T2WI) and intermediate

Abbreviations: CE FS T1WI, contrast-enhanced fat-suppressed T1-weighted images; FS, fat-suppressed; HNSCC, head and neck squamous cell carcinoma; MRI, magnetic resonance imaging; SCSG(s), superior cervical sympathetic ganglion (ganglia); ICA, internal carotid artery; TIWI, T1-weighted image; T2SI, T2 signal intensity; T2WI, T2-weighted image

* Corresponding author at: Department of Radiology and Research Institute of Radiology, University of Ulsan College of Medicine, Asan Medical Center, 88 Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Republic of Korea.
E-mail addresses: jeonghlee@amc.seoul.kr, michellejhlee@gmail.com (J.H. Lee).

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signal intensity on T1-weighted imaging (T1WI). Intraganglionic hypointensity was typically seen in 90% of SCSGs on contrast-enhanced fat-suppressed T1-weighted imaging (CE FS T1WI). Except the central hypointensity, SCSGs demonstrate homogeneous with marked enhancement on CE FS T1WI. [6].

Based on the previous results, we evaluated the serial changes in SCSGs on MRI after head and neck irradiation in patients with HNSCC. The aim was to describe the characteristic MRI appearance of irradiated SCSGs to allow potential discrimination from a metastatic retropharyngeal lymph node. The hypothesis was that the characteristic MRI appearance of nonirradiated SCSGs might be preserved even if their size were enlarged following irradiation.

2. Material and methods

2.1. Patients and MRI evaluation

This retrospective study was approved by the Institutional Review Board of our hospital. Between January 2006 and December 2013, 175 patients underwent definitive radiation with/without chemotherapy for pathologically conformed HNSCC. All patients were evaluated by MRI prior to treatment. Of these, 123 patients were excluded for lack of follow-up MRI (n = 108) or inadequate image quality (n = 15). The remaining 52 patients were included. Pretreatment demographic data including age, sex, primary tumor location, total dose of irradiation, and TNM staging were retrieved from their medical records.

All MRI evaluations were performed with a 3-T MR unit (Achieva, Philips Medical Systems, Best, the Netherlands; Skyra, Siemens Healthcare Systems, Erlangen, Germany) using a 16- or 64-element phased-array neurovascular coil. The MRI protocol for HNSCC included axial and coronal T1WIs, coronal fat-suppressed (FS) T2WI, axial T2WI, and axial and coronal CE FS T1WI with a 3 or 4 mm slice thickness and no gaps. Axial T2WIs were obtained with a repetition time of 4100 ms, echo time of 100 ms, two excitations, 271 phase-encoding steps, echo train length of 16, flip angle of 90°, field-of-view of 230 mm × 190 mm, acquisition matrix of 272 × 271, reconstruction matrix of 512 × 512, section thickness of 3 mm, and section spacing of 3 mm. Axial T1WIs were obtained with a repetition time of 600 ms, echo time of 8.8 ms, two excitations, 232 phase-encoding steps, echo train length of 5, flip angle of 90°, field-of-view of 230 mm × 190 mm, acquisition matrix of 236 × 232, reconstruction matrix of 512 × 512, section thickness of 3 mm, and section spacing of 3 mm. Spectral presaturation with an inversion recovery pulse was used in all FS sequences. Gadoterate meglumine (0.1 mmol/kg body weight; Dotarem; Guerbet, Paris, France) was injected intravenously and CE FS T1WIs were acquired after 3–8 min.

2.2. Analysis of pretreatment and follow-up MRI

All patients had received a pretreatment MRI. Follow-up MRI was given at 6 months and 13–18 months after irradiation. MRI was evaluated by two radiologists with 18 (J.H.L.) and 3 (S.J.C.) years of experience in head and neck imaging. SCSGs were identified by consensus following results of our previously published report [6]. Qualitative analysis of the contrast enhancement pattern on CE FS T1WI (homogeneous vs. heterogeneous), the margin (well-defined vs. ill-defined), and presence of intraganglionic hypointensity on either T2WI or CE FS T1WI was then performed independently by the two radiologists. The results of the independent analysis were used to evaluate the interreader agreement. One radiologist (C.S.J) performed the same analysis after a 3-week interval to evaluate the intrareader agreement. At the same time, the radiologist measured the maximum and minimum axial diameters of the SCSGs and the T2 signal intensity (T2SI) using circular region-of-interest on picture archiving and communication systems. The T2SI of each SCSG was normalized for comparison by the signal intensity of the posterior cervical fat on the same image (normalized T2SI = T2SI of SCSG/T2SI of the posterior cervical fat). SCSGs were stratified by location to ipsilateral versus contralateral groups.

2.3. Statistical analysis

Continuous variables were expressed as means ± standard deviation and categorical variables as numbers and percentages. Differences in the normalized T2SI, enhancement pattern, margin, and axial diameter of the SCSG on serial MRI were tested for significance using a repeated measures of ANOVA. Inter- and intrareader agreement was determined for qualitative imaging findings using kappa statistics. Statistical analysis was performed using the Statistical Package for the Social Sciences (Version 18 for Windows; IBM, Armonk, NY, USA). *P*-values < 0.05 were considered statistically significant.

3. Results

A total of 125 MRI evaluations in 52 patients, 36 men and 16 women with an average age of 58 years (range 23–80 years), had pretreatment (n = 52), 6 month (n = 21), and 13–18 month (n = 52) post-irradiation follow-up evaluations. Twenty-seven patients (52%) had primary tumors in the oropharynx, eighteen in the oral cavity (35%), six in the nasopharynx (12%), and one in the larynx (1%). The mean total radiation dose was 6351 ± 483 cGy (range, 5640–7000 cGy). All patients had pretreatment and 13–18-month follow-up MRI evaluations. Twenty-one (40.1%) MR examinations from 21 patients were included in the 6-month follow-up group (Table 1).

On pretreatment MRI, intraganglionic hypointensity was present in 95 (91%) of 104 SCSGs on either T2WI or CE FS T1WI; 103 SCSGs (99%) had a homogeneous enhancement pattern except intraganglionic hypointensity on CE FS T1WI. The margins of all SCSGs were well-defined. Three MRI characteristics, intraganglionic hypointensity, homogeneous enhancement on CE FS T1WI, and well-defined margins were preserved throughout follow-up and were not significantly different at pretreatment and follow-up evaluations (Table 2). The inter-reader agreement for the presence of intraganglionic hypointensity was moderate (κ = 0.451; 95% confidence interval: 0.347–0.544; standard error = 0.119). The number of disagreement cases was 15 out of 250 SCSGs for the presence of intraganglionic hypointensity (Table 3). The analysis results obtained for homogeneous enhancement pattern and well-defined margin by the two readers were perfectly matched. The intrareader agreement was nearly perfect for the presence of

Table 1
Patient demographics, tumor characteristics, total radiation dose, and number of MRI evaluations.

Patient demographics	
Total number	52
Male: Female	36 (70): 16 (30)
Age, mean (SD), y	58 (10.3)
Tumor characteristics	
Right: Left	24 (46): 28 (54)
Location	
Oropharynx	27 (52)
Oral cavity	18 (35)
Nasopharynx	6 (12)
Larynx	1 (1)
TNM stage	
Stage I	5 (10)
Stage II	2 (4)
Stage III	8 (15)
Stage IV	37 (71)
Total radiation dose, mean (SD), cGy	6351 (483)
Number of MRI examinations	
Pretreatment	52 (100)
6 M F/U	21 (40)
13–18 M F/U	52 (100)

Data are numbers (%) except for age and total radiation dose. F/U, follow-up; M, month.