MAJOR PAPER

Hypointensity on Postcontrast MR Imaging from Compression of the Sacral Promontory in Enlarged Uterus with Huge Leiomyoma and Adenomyosis

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(Received March 22, 2006; Accepted March 28, 2007)

Purpose: In patients with huge leiomyoma and with adenomyosis of the uterus, a peculiar area of hypointensity was occasionally observed on postcontrast magnetic resonance (MR) imaging in the dorsal portion of the enlarged uterus near the sacral promontory. We describe the imaging characteristics of these MR findings and correlate them with histopathological findings to examine whether the areas represent specific pathological changes.

Methods: Ten patients with huge leiomyomas and two with huge adenomyotic lesions whose imaging revealed the hypointensity were enrolled. All had enlarged uteri that extended beyond the sacral promontory. MR findings of the hypointense areas were evaluated and correlated with histopathological findings in 5 patients with leiomyoma and two with adenomyosis who had hysterectomy.

Results: The ten patients with leiomyoma showed flare-shaped hypointensity arising from the dorsal surface of the uterine body that extended deep into the tumor. The base of the hypointense areas was narrow in 5 patients with intramural leiomyoma and broad in five with subserosal leiomyoma. Two patients with adenomyosis showed nodular-shaped areas of hypointensity in front of the sacral promontory. Precontrast T₁- and T₂-weighted MR images showed no signal abnormalities in the portions corresponding to the hypointensity in any of the 12 patients. Pathological examinations showed no specific findings in the portions corresponding to the hypointensity in the 7 patients who had hysterectomy.

Conclusion: The areas of hypointensity may represent functional changes, such as decreased localized blood flow caused by compression of the sacral promontory.

Keywords: *uterus, leiomyoma, adenomyosis, pseudolesion, MRI*

Introduction

Uterine leiomyomas are common benign tumors composed of bundles of proliferated smooth muscle cells and are seen in women of child-bearing age.¹ They usually show homogeneous decreased signal intensity on T₁- and T₂-weighted MR images from relaxation times of smooth muscle² and homogeneous enhancement on postcontrast T₁-weighted MR images. Leiomyomas may show varying degrees of degeneration, and degenerated leiomyomas tend to demonstrate inhomogeneous

signal intensity on T₂-weighted MR images and inhomogeneous enhancement on postcontrast T₁-weighted images.³

Park and associates⁴ reported 3 patients with huge leiomyoma who showed geographic hypointense areas that mimicked degeneration near the sacral promontory on postcontrast T₁-weighted MR images. Precontrast T₁- and T₂-weighted MR images showed no signal abnormalities at the sites corresponding to hypointensity. They found no pathological changes, such as necrosis or degeneration, in surgical specimens and therefore thought that the hypointensity represented functional changes. We observed similar findings in patients with huge leiomyomas and patients with adenomy-

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osis. To our knowledge, no detailed studies have described this curious finding, and the occurrence of such areas of hypointensity has not been reported in patients with adenomyosis. We describe MR imaging features of these areas and differences between hypointense areas with leiomyoma and with adenomyosis and correlate MR and histopathological findings to examine whether the areas represent specific pathological changes.

Material and Methods

A review of the radiological reports of 1479 pelvic MR imaging studies performed between April 2000 and October 2003 showed ten women (aged 27 to 53 years, mean 40 years) with huge leiomyoma and two with huge adenomyosis lesion whose postcontrast T₁-weighted MR images revealed the area of hypointensity. Diagnosis was confirmed by operation in 5 patients with leiomyoma and two with adenomyosis. MR examinations were performed within 4 months of surgery, and none of the seven received hormonal treatments prior to operation. In the other 5 patients, a well circumscribed mass of homogeneous decreased signal intensity with whorl-like high signal intensity was seen on T₂-weighted images, and leiomyoma was diagnosed on the basis of this typical MR finding. Malignancy was ruled out by follow-up imaging studies for a period of one year or more.

MR imaging was performed with Signa Horizon 1.5T or Signa Twin Speed 1.5T (GE Medical Systems, U.S.A.) using a torso or pelvic phased-array coil. An antiperistaltic drug (Buscopan; Boehringer Ingelheim, Japan) was given intramuscularly to minimize artifacts caused by bowel movement, and a band was fastened tightly on the hypogastrium to diminish artifacts from respiratory movement. T₁-weighted spin-echo MR images (repetition time/echo time, 500/8) and fat-saturated T₂-weighted fast spin-echo MR images (4000/100) were obtained in sagittal and axial planes with 24- to 32-cm field of view, 512 × 224 to 256 image matrix, 8-mm slice thickness, 2-mm gap, and one or 2 numbers of signal excitation. After precontrast imaging, 15 mL of gadopentetate dimeglumine (Magnevist®; Nihon Schering, Japan) were injected intravenously, and T₁-weighted spin-echo MR images, with or without fat saturation, were obtained using the same imaging parameters in axial, sagittal, and coronal planes.

Two radiologists (K.U. and S.M.) well experienced in MR imaging reviewed images in the 12 patients and evaluated the location and size of the leiomyomas and adenomyotic lesions. The number,

shape, and size of the hypointense areas seen on postcontrast T₁-weighted MR images near the sacral promontory in the uterus were studied. The areas were classified as either flare-shaped with narrow base, flare-shaped with broad base, or nodular-shaped. Areas of hypointensity that arose from the dorsal surface of the uterine body and extended deeply and somehow radially were considered flare-shaped. Broad- and narrow-based subtypes were determined by the width of base at the dorsal surface of the uterus. Hypointense areas with relatively well-defined margins with less irregularity than those with flare shape were considered to be nodular in shape. Sagittal MR images were used to measure the areas, and precontrast T₁- and T₂-weighted MR images were studied to find signal abnormalities corresponding to the hypointense areas seen on postcontrast MR images.

MR findings were correlated with histopathological findings in 5 patients with huge leiomyoma and two with adenomyosis who underwent hysterectomy. In one patient with leiomyoma, the portion compressed by the sacral promontory was identified and marked with a stitch during the operation, and specimens obtained from that area underwent microscopic examination. In the other patients, pathological examinations were performed mainly by gross inspection on cut surface.

Results

Leiomyomas (maximum diameter, 70 to 140 mm; mean, 104.1 mm) were located in the subserosa of the dorsal body of the uterus in five of the 10 patients and in the myometrium of the dorsal body of the uterus in the remaining five. Adenomyotic lesions in the 2 patients measured 115 and 120 mm in maximum diameter. MR images of all twelve showed enlarged uterus that extended beyond the sacral promontory as a result of the disease. The dorsal surface of the uterus was depressed by compression of the sacral promontory.

Postcontrast T₁-weighted MR images of the 10 patients with huge leiomyoma showed one or 2 flare-shaped areas of hypointensity in the uterus near the sacral promontory. The areas were flare-shaped with broad base in the 5 patients with subserosal leiomyoma (Fig. 1) and flare-shaped with narrow base in the five with intramural leiomyoma (Fig. 2). In eight of the 10 patients with leiomyoma, a hypointense area was seen in front of the sacral promontory. In the other two, a hypointense area was seen in front of the fifth vertebra, not the promontory, in one and at the level of the fourth/fifth intervertebral space and extended caudally to

Fig. 1. A 46-year-old woman with a huge subserosal leiomyoma. Postcontrast T₁-weighted sagittal magnetic resonance (MR) image with fat saturation (**a**) shows a flare-shaped area of hypointensity in the dorsal portion of a leiomyoma. The area arises from the portion depressed by the sacral promontory and extends into the tumor. Precontrast T₁-weighted sagittal MR image (**b**) and T₂-weighted sagittal MR image (**c**) show no specific signal changes that correspond to the area seen in (**a**). Gross specimen (**d**) shows an indentation (arrows) compressed by the sacral promontory in a subserosal leiomyoma with moderate hyalinization. Microscopic specimen (**e**) obtained from the indented portion seen in (**d**) shows no specific findings, such as degeneration or necrosis.

Fig. 2. A 32-year-old woman with a huge intramural leiomyoma. Postcontrast T₁-weighted sagittal MR image with fat saturation (a) shows flare-shaped hypointensity in a leiomyoma. The base of the area involves normal myometrium between the tumor and sacral promontory, and compared to the base of hypointense areas seen in Fig. 1, it is narrow. T₂-weighted sagittal MR image (b) shows no specific signal changes corresponding to the area seen in (a).

the sacral promontory in the other. Maximum diameters of the areas ranged from 15 to 80 mm, with a mean of 42.5 mm. On precontrast T₁- and T₂-weighted MR images in all 10 patients with leiomyoma, no specific signal changes were noted at the sites corresponding to hypointensity. Post-contrast T₁-weighted MR images in 2 patients with adenomyosis showed nodular-shaped hypointensity (maximum diameter, 25 to 40 mm; mean, 33 mm) in front of the sacral promontory (Fig. 3). Precontrast T₁- and T₂-weighted MR images showed no signal abnormalities in the portions corresponding to these areas.

Histopathological studies in 4 patients showed subserosal tumor to be hyalinized or usual leiomyoma; an intramural tumor in one patient was a cellular leiomyoma, and adenomyosis seen in 2 patients was of a usual type. There was no specific degeneration or necrosis in these lesions at the site corresponding to the hypointensity. The findings of MR imaging and histopathological studies are summarized in Table.

Discussion

The hypointense areas observed in the 12 patients were thought to be identical to the geographic hypointense areas reported by Park and associates,⁴ who also found no signal abnormalities on precontrast T₁- and T₂-weighted MR images that corresponded to the hypointensity. Histopathological examinations of the surgical specimens obtained from the 7 patients showed no specific pathological

changes, such as degeneration or necrosis, at the corresponding sites. Based on these findings, we thought that a localized decrease in blood flow from compression of the sacral promontory caused diminished enhancement, and we agreed with the Park's conclusion. Although we did not perform delayed postcontrast imaging, Park's group found that the hypointense area disappeared on delayed MR images.

A similar phenomenon can be observed in the liver. Yoshimitsu and colleagues reported pseudolesions caused by rib compression.⁵ On dynamic computed tomography (CT), compressed liver parenchyma just beneath the rib showed low attenuation on early-phase images, and the hypoattenuating area disappeared on delayed-phase images. They studied the pseudolesions using CT during arterial portography and during hepatic arteriography and showed that the compression caused by curved ribs could cause transient focal diminishment of portal venous perfusion without altering hepatic arterial perfusion in the liver parenchyma.

Pathologically, vascular density is less, the vascular network sparser, and the diameter of blood vessels is greater in tumor tissues of leiomyomas than in the myometrium.⁶⁻⁸

Adenomyosis is composed of ectopic endometrial glands and stroma that interdigitate with underlying myometrium,⁹ and on angiography and histology, it has been described as having an arterial network that is less dense than that of adjacent myometrium.¹⁰ Therefore, compared with tissues

Fig. 3. A 48-year-old woman with huge adenomyosis. Postcontrast T₁-weighted sagittal MR image (a) shows nodular-shaped hypointensity in the portion compressed by the sacral promontory. Compared with hypointense areas seen in patients with leiomyoma (Figs. 1 and 2), the margin is less irregular and relatively well defined. Precontrast T₁-weighted sagittal MR image (b) and T₂-weighted sagittal image (c) show no specific signal changes that correspond to the area seen in (a).

of the myometrium, tissue of leiomyoma and adenomyosis may have impaired vasculature, and subsequent decrease in blood flow might readily occur. deSousa's group reported that perfusion was retained in the myometrium, but virtually stopped in leiomyoma on dynamic MR imaging performed immediately after bilateral uterine arterial embolization (UAE).¹¹ This result supports the idea mentioned previously.

In patients with leiomyoma, areas of hypointensity showed irregular margins shaped like a flare, especially on the deep side. Blood vessels within leiomyomas orient in the direction of muscle cell bundles that show a whorl-like pattern,^{6,7} so the irregular margin the hypotensity may be creditable to this complicated distribution of blood vessels in tumors. The base widths of the hypointense areas tended to be broader in patients with sub-

serosal leiomyoma than in those with intramural leiomyoma. Subserosal leiomyomas were compressed directly by the sacral promontory or vertebra, and intramural leiomyomas were compressed indirectly through intervening normal myometrium. The base of the area lay in the myometrium of the uterus in patients with intramural leiomyoma and in tumor tissues in patients with subserosal leiomyoma. In patients with intramural leiomyoma, because blood flow of the myometrium between tumor and the promontory was retained despite compression, the base of the hypointense area in the myometrium tended to be narrow.

The hypointense areas seen in the patients with adenomyosis were nodular in shape, not flare-shaped as in the patients with leiomyoma. An exact reason for the difference in shape is unclear. In

Table. Findings of MR imaging and histopathological studies

Case	Age	Lesion Type	Size (mm)	Hypointense area Shape	Size (mm)	Pathology
1	30	Intramural leiomyoma	90 × 60	Flare shape with narrow base	25 × 20	Cellular leiomyoma
2	48		125 × 85		50 × 30	NA
3	32		110 × 80		20 × 45	NA
4	53		70 × 65		15 × 25	NA
5	27		115 × 80		40 × 25	NA
6	38	Subserosal leiomyoma	125 × 75	Flare shape with broad base	35 × 15	NA
7	38		91 × 60		15 × 10	Leiomyoma with hyalinization
8	31		140 × 80		55 × 80	Leiomyoma with hyalinization
9	46		90 × 75		32 × 70	Leiomyoma with hyalinization
10	36		85 × 80		40 × 30	Usual leiomyoma
11	48	Adenomyosis	120 × 60	Nodular shape	40 × 18	Usual adenomyosis
12	53		115 × 90		25 × 15	Usual adenomyosis

Note. NA: not available

adenomyosis, involved myometrium might somehow preserve pre-existing original vasculature and have a different pattern of blood supply from that in tumor tissues of leiomyoma. This difference in vascular structure might reflect the difference in the shape of hypointense areas, but further studies are needed.

The area of hypointensity may mimic necrosis or degeneration and thereby confuse the diagnosis and evaluation of a huge uterine mass. Recently, UAE has been performed widely in patients with leiomyomas and adenomyosis who present with menorrhagia. MR imaging is used in the evaluation of the efficacy of UAE. An embolized lesion is depicted as a non-enhanced area on postcontrast T₁-weighted MR images.¹¹ The hypointense area may mimic embolized tissues and cause overestimation of the effect of UAE.

In conclusion, in the present study, areas of hypointensity may represent functional changes, such as localized decrease in blood flow caused by compression of the sacral promontory. With careful reading of MR images, these areas can be distinguished from true pathological changes, such as degeneration or necrosis. Radiologists should be reminded of this phenomenon to avoid misinterpretation.

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