High Signal Intensity of the Infundibular Stalk on Fluid-Attenuated Inversion Recovery MR

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PURPOSE: To determine the MR imaging characteristics of the pituitary stalk with a fluid-attenuated inversion recovery (FLAIR) technique. **METHODS:** We retrospectively studied the prevalence of a high-signal infundibular stalk on FLAIR MR images of the brain in 133 patients and compared this finding with the patients' ages. To understand the cause of the high signal intensity of the pituitary stalk on FLAIR images, we calculated the T1, T2, and proton-density values in regions of gray matter, white matter, and the pituitary stalk in nine cases. **RESULTS:** FLAIR images showed the pituitary stalk as having high signal intensity in 97 (73%) of 133 cases; however, in 11 of 16 patients less than 10 years old, the infundibular stalk was not of high signal intensity. In patients with a high-signal pituitary stalk on FLAIR images, the T2 value of the pituitary stalk was longer than that of gray or white matter. **CONCLUSION:** High signal intensity of the infundibular stalk was frequently seen on FLAIR MR images of the brain at all ages. A prolonged T2 value of the pituitary stalk caused the high signal intensity, presumably reflecting the fluid component of the pituitary stalk.

Index terms: Magnetic resonance, technique; Pituitary gland, magnetic resonance

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The purpose of this study was to evaluate the signal intensity of the pituitary stalk on fluid-attenuated inversion recovery (FLAIR) magnetic resonance (MR) images. This technique yields T2-weighted images with suppressed water signal by virtue of its long inversion time (1). The pituitary stalk has long been believed to have the same signal intensity as gray or white matter on T2-weighted images. Use of the FLAIR technique reveals that the pituitary stalk has different signal intensity from gray or white matter.

Materials and Methods

MR imaging of the brain was performed in 133 patients with clinically suspected brain diseases over a period of 1 year beginning in July 1993. The patients included 68 male and 65 female subjects ranging in age from 10 months to 83 years (mean, 41 years). MR findings were normal in 53 patients; in the remaining patients, diagnoses included cerebrovascular diseases in 33, brain tumor in 20, cerebral trauma in nine, demyelinated disease in seven, nonpressure hydrocephalus in four, diabetes insipidus in one, and various other diseases in six. For all patients, axial FLAIR T1- and T2-weighted images were obtained.

In 100 patients, a 0.5-T MR unit was used; in the remaining 33 patients, imaging was performed with a 1.5-T MR unit. On the 0.5-T MR unit, parameters for the FLAIR technique included 6000/100/1 (repetition time/echo time/excitations), inversion time of 2000, 128 × 256 matrix with a 20-cm field of view, and 8-mm-thick sections with a 2-mm intersection gap. T1- and T2-weighted images were obtained by means of the following parameters: 500/25/3 for T1-weighted images and 2000/90/2 for T2-weighted images.

On the 1.5-T MR unit, parameters for the FLAIR images obtained with a fast spin-echo technique were 8000/120/1, inversion time of 2000, 192 × 256 matrix with a 20-cm field of view, and 6-mm thickness with a 1-mm intersection gap. T1- and T2-weighted images were obtained with parameters of 400/15/2 and 4000/120/2, respectively. The T2-weighted images were also acquired with the use of a fast spin-echo technique.

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TABLE 1: Signal intensity of the pituitary stalk on FLAIR MR images

	No. of patients imaged at intermediate field strength (no. of patients imaged at high field strength)							
Age, y	0–10	11–20	21–30	31–40	41–50	51–60	60+	**Total**
Male								
High signal	1 (2)	5 (2)	0 (1)	5 (4)	3 (3)	5 (2)	11 (3)	**30 (17)**
Isointense signal	4 (1)	1 (0)	3 (1)	3 (0)	3 (1)	0 (0)	4 (0)	**18 (3)**
Female								
High signal	1 (1)	8 (3)	1 (1)	1 (1)	5 (1)	16 (2)	8 (1)	**40 (10)**
Isointense signal	5 (1)	0 (1)	1 (0)	0 (0)	0 (0)	2 (0)	4 (1)	**12 (3)**

Note.—FLAIR indicates fluid-attenuated inversion recovery.

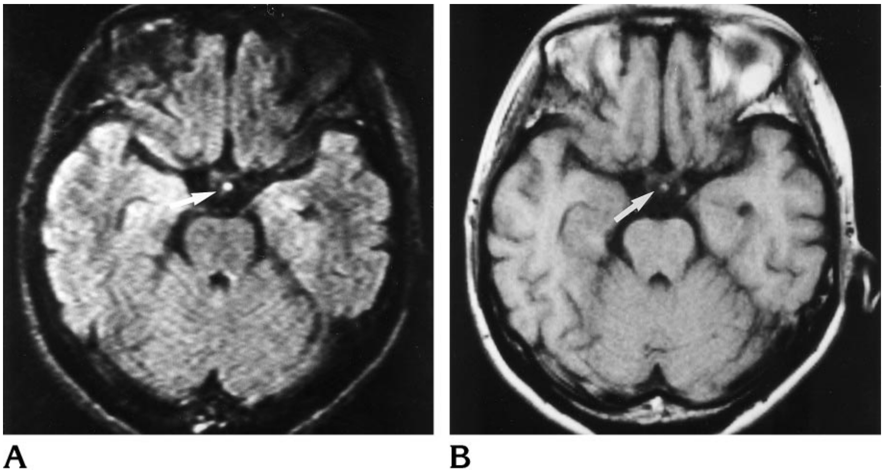


Fig 1. A 47-year-old woman.

A, Axial FLAIR MR image of the brain (obtained on a 0.5-T unit) at the level of the suprasellar cistern shows the infundibular stalk as having high signal intensity (*arrow*) relative to white matter.

B, T1-weighted image at the same level as *A* shows the stalk (*arrow*) has an isointense signal with temporal lobe white matter.

To determine the cause of the high signal intensity of the pituitary stalk, we calculated the proton-density, T1, and T2 values in the pituitary stalk and in the gray and white matter of the temporal lobe in nine cases. These calculations were all made on studies obtained on the 0.5-T MR unit. In seven of these nine cases, the pituitary stalk was of high signal intensity on FLAIR images; it was isointense with gray and white matter in the other two cases. The signal intensity on MR images is expressed by the following equation:

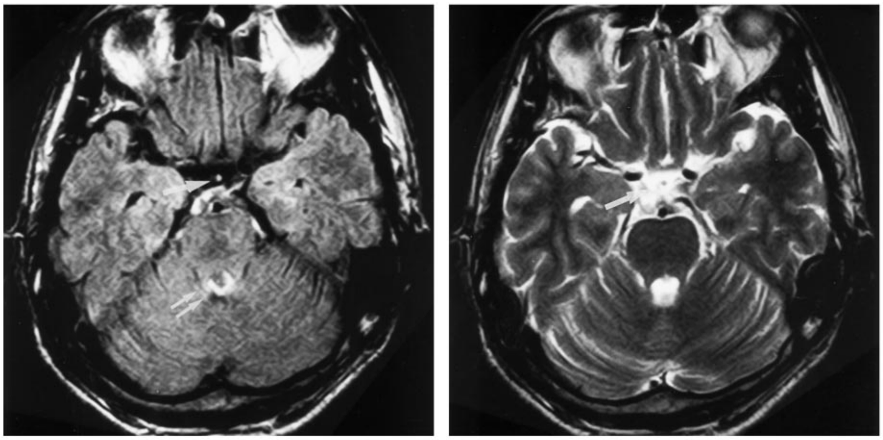
$$\text{Signal intensity} = K \cdot f(v) \cdot D\{1-\exp(-TR/T1)\} \cdot \exp(-TE/T2)\},$$

where K is the nondimensional coefficient of the equation, f(v) is the function by flow component, and D is the proton density. To solve this problem and derive T1, T2, and proton-density values, the three imaging sequences (T1-, T2-, and proton density–weighted) were obtained. The T1- and proton density–weighted sequences had the same echo time (600/30 and 2500/30, respectively). The T2- and proton density–weighted sequences had the same repetition time (2500/120 and 2500/30, respectively). The three equations allowed us to obtain T1, T2, and proton-density values. These calculations were all done interactively by the scanner software, producing three maps whose signal intensities in regions of interest directly indicated T1, T2, and proton-density values. These regions of interest were 3 mm in diameter (about 15 pixels) in the pituitary stalk and gray matter, and 10 mm in diameter (about 100 pixels) in the white matter at the level of the suprasellar cistern in the temporal lobe.

Results

FLAIR images revealed the infundibular stalk as being of high signal intensity in 97 (73%) of 133 cases (Table 1 and Figs 1A, 2A, 3A, and 4), whereas spin-echo T2-weighted images did not show the pituitary stalk as having high signal intensity in any case (Fig 2B). On the 0.5-T system, FLAIR images showed the pituitary stalk as having high signal intensity in 70 (70%) of 100 cases (Figs 1A and 4). On the 1.5-T system, FLAIR images showed it as having high signal intensity in 27 (82%) of 33 cases (Figs 2A and 3A).

On FLAIR images obtained by the fast spin-echo technique on a 1.5-T unit, regions of high signal intensity were frequently seen in the prepontine cistern (Fig 2A). Conversely, the signal from cerebrospinal fluid (CSF) in a large part of the suprasellar cistern was completely attenuated.

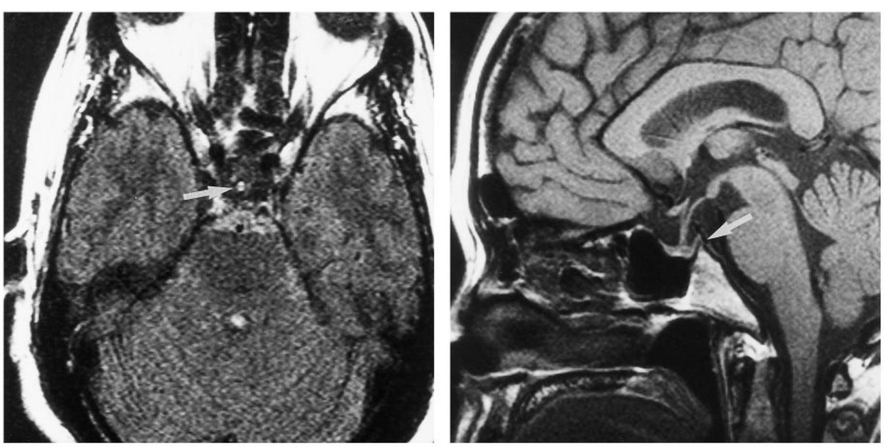


A B

Fig 2. A 40 year-old man.

A, Axial FLAIR fast spin-echo MR image of the brain (obtained on a 1.5-T unit) at the level of the suprasellar cistern shows the infundibular stalk as being of high signal intensity (*single arrow*) relative to white matter. The signal intensity of CSF in the prepontine cistern and the fourth ventricle (*double arrows*) is thought to be artificially high because of this fast spin-echo technique.

B, A 1.5-T MR spin-echo T2-weighted image at the same level as *A* shows the infundibular stalk (*arrow*) as having a signal that is isointense with white matter.

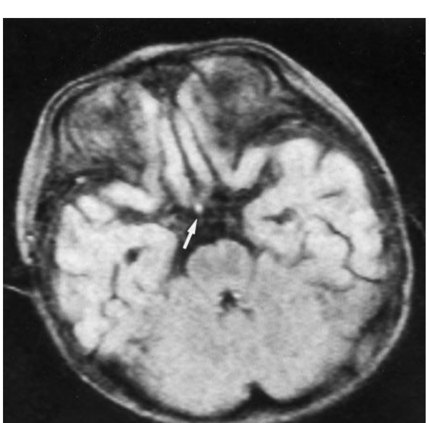


A B

Fig 3. A 25-year-old woman with diabetes insipidus.

A, Axial FLAIR MR image of the brain (obtained on a 1.5-T unit) shows the infundibular stalk as having high signal intensity (*arrow*) relative to white matter. The horizontal line through the middle of the stalk may be an artifact.

B, Sagittal T1-weighted MR image shows the absence of bright signal of the posterior pituitary (*arrow*), which is the result of diabetes insipidus.



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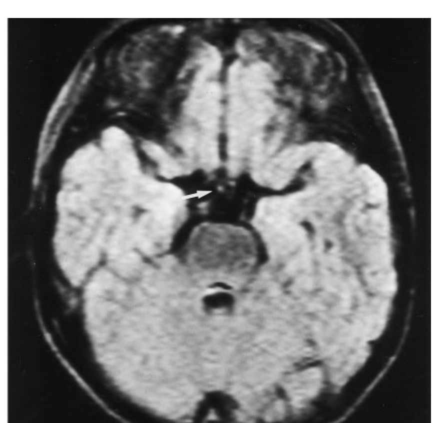

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Fig 4. A 10-month-old infant. FLAIR MR image (obtained on a 0.5-T unit) shows the pituitary stalk as having high signal intensity relative to white matter.

Fig 5. A 5-year-old girl. Axial MR image of the brain (obtained on a 0.5-T unit) at the level of the suprasellar cistern does not show the infundibular stalk as being of high signal intensity (*arrow*), presumably because of the volume-averaging artifacts caused by the relatively large pixel sizes at 0.5 T MR.

TABLE 2: T1, T2, and proton-density values of the pituitary stalk, gray matter, and white matters on 0.5-T MR images

Age, y/Sex	T1 Values, ms*	T2 Values, ms*	Proton-Density Values, ms*
Patients with High-Signal Pituitary Stalk on FLAIR Images			
39/M	1586, 1047, 487	87, 77, 59	1842, 2022, 1570
67/M	1957, 1389, 583	113, 66, 51	2454, 2469, 1890
40/M	2259, 1098, 428	73, 65, 54	2421, 2064, 1337
49/M	1477, 1051, 623	82, 73, 57	2161, 2060, 1814
30/M	2064, 954, 430	105, 81, 52	1693, 1963, 1353
80/F	1246, 1306, 571	91, 76, 50	1735, 1762, 1462
8/M	2608, 1090, 507	112, 90, 58	2387, 1992, 1636
Patients with Isointense Signal of Pituitary Stalk on FLAIR Images			
68/M	1651, 1282, 506	75, 89, 53	2110, 1710, 1628
4/M	1432, 2036, 567	129, 101, 61	1791, 2472, 1867

Note.—FLAIR indicates fluid-attenuated inversion recovery.
*Values are of stalk, gray matter, white matter.

In terms of age distribution, the pituitary stalk did not display high signal intensity in 11 (69%) of 16 patients under 10 years of age (Fig 5). On the other hand, the stalk showed high signal intensity in 86 (73.5%) of 117 patients over 10 years of age; however, even in a 10-month-old, FLAIR images showed the stalk as having high signal intensity (Fig 4).

In one patient with diabetes insipidus, the pituitary stalk was of high signal intensity on FLAIR images (Fig 3A and B). In patients without diabetes insipidus, the pituitary stalk was of intermediate signal intensity on T1-weighted images (Fig 1B).

The calculated values of T1, T2, and proton density are listed in Table 2. In all seven patients in whom the pituitary stalk had high signal intensity on FLAIR images, the stalk had longer T2 values than those of gray and white matter, although the proton-density values of the pituitary stalk, white matter, and gray matter were approximately equal. In six of these seven patients, the pituitary stalk had longer T1 values than those of gray and white matter.

In one of the two patients in whom the pituitary stalk had an isointense signal on FLAIR images, the stalk had a longer T2 value and a much lower proton-density value than those of gray and white matter (Fig 5). In the one remaining patient, the pituitary stalk had a shorter T2 value.

Discussion

We have noted the pituitary stalk to be of high signal intensity on axial FLAIR MR images of the brain (Figs 1A, 2A, 3A, and 4; and Table 1). This finding was unexpected, because we assumed that the pituitary stalk would have the same signal intensity as gray or white matter on T2-weighted images.

FLAIR sequences performed with an inversion recovery technique can produce T2-weighted images in which signal from CSF is suppressed through the use of a longer inversion time (1). Brain tissue with long T2 values is seen as high signal on FLAIR images, and the signal intensity on FLAIR images is directly proportional to proton-density values.

Although there have been many publications describing the signal intensity of the pituitary gland (2–11), we know of only three studies that have dealt with the signal intensity of the infundibular stalk (2–4). Fujisawa et al (5) reported that both the pituitary stalk and the posterior pituitary had similar high signal intensity on T1-weighted images. On the other hand, Simmons et al (2) concluded that the stalk is typically hypointense relative to the neurohypophysis on T1-weighted images; our findings support this observation (Fig 1B).

It has been difficult to evaluate the stalk accurately on T2-weighted images because it is masked by bright signal from CSF in the suprasellar cistern (Fig 2B). FLAIR images can overcome this problem by attenuating the water signal. Although the reason is still unknown, the pituitary stalk often had a high signal intensity on FLAIR images (Figs 1A, 2A, 3A, and 4; and Table 1). This observation pertained to images obtained on both the 0.5-T and 1.5-T MR units; however, on the 1.5-T images, high signal intensities of the CSF were often seen at the margin of the suprasellar cistern, presumably caused by high-flow artifacts of CSF on FLAIR images obtained with the fast spin-echo technique (Fig 2A), although, theoretically, the CSF signal should be nulled by the FLAIR technique. Thus, a high-signal-intensity pituitary stalk might be masked by high-signal-intensity CSF in the infundibular recess of the third ventricle. In our case, however, T1- and T2-weighted images confirmed the high-signal structure on FLAIR images as the stalk (Fig 2B). In some patients, the pituitary stalk was seen as having an isointense signal on FLAIR images (Fig 5). Most of these patients were under 10 years of age, and the images were all obtained on a 0.5-T MR unit (Table 1). We believe that this effect could be related to the smallness of the pituitary stalk and to partial volume averaging by the relatively large matrix size used with the 0.5-T system.

It is well known that the posterior lobe of the pituitary gland is ordinarily seen as a high-signal-intensity structure on T1-weighted images (5–11). Some conditions, such as diabetes insipidus and Langerhans cell histiocytosis, cause absence of the bright spot of the posterior pituitary on T1-weighted images (3–5). In one of our patients with diabetes insipidus, the pituitary stalk showed high signal intensity on FLAIR images (Fig 3A and B), suggesting that the bright signal of the stalk on FLAIR images is caused by a process different from the process that causes high signal intensity of the posterior pituitary on T1-weighted images. We are not aware of any specific diseases that decrease the bright signal of the pituitary stalk on FLAIR images.

In our calculations (Table 2), the T2 values of the pituitary stalk were greater than those of gray or white matter in all seven patients in whom the pituitary stalk was of high signal intensity on FLAIR images. In one (68-year-old) patient in whom the stalk had an isointense signal, the T2 value of the stalk was between that of gray and white matter (Table 2). In the one remaining patient in whom the stalk had an isointense signal, the long T2 effect was thought to be masked by a low proton-density value (Table 2). Therefore, our results indicate that the high signal intensity of the stalk is caused predominantly by the prolongation of T2 values. It is still unknown why T2 values of the pituitary stalk are prolonged; however, because the pituitary stalk connects the hypothalamus and the pituitary gland, and because it contains the pituitary portal veins and hypothalamic hormones, we hypothesize that these components may cause the prolongation of T2 relaxation time of the stalk on FLAIR images.

In conclusion, our study showed that the pituitary stalk was frequently seen as a high-signal-intensity structure on FLAIR MR images. This high signal intensity is present at all ages, and is produced primarily by prolonged T2 of the pituitary stalk. We postulate that this prolonged T2 value is caused by the fluid-rich components of the pituitary stalk.

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