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A novel hook-shaped enhancement on contrast-enhanced sagittal magnetic resonance image in acute Sheehan's syndrome: a case report

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Abstract. We report characteristic magnetic resonance (MR) image findings in a case of Sheehan's syndrome. A 37-year-old woman experienced complications of retained placenta and massive bleeding (3600 g) during delivery of a full-term baby. A pituitary function test demonstrated panhypopituitarism. MR image of the pituitary gland on postpartum day 10 revealed swelling of the anterior lobe. A hook-shaped enhancement was demonstrated on a sagittal image. The pituitary stalk, majority of the marginal zone of the anterior lobe, the anterior lobe just in front of the posterior lobe, and posterior lobe were well enhanced. In contrast, the central portion and the superior margin, just in front of the stalk insertion of the anterior lobe, were not enhanced. Anatomically, blood supply to these unenhanced portions of the anterior lobe was via the hypophyseal long portal vein and trabecular artery, which are tributaries of the superior hypophyseal artery that originate far from the internal carotid artery. Based on clinical history and MR image findings, the patient was diagnosed with Sheehan's syndrome and treated with hydrocortisone and levothyroxine. Follow-up MR image revealed marked atrophy of the anterior lobe. The characteristic hook-shaped enhancement in Sheehan's syndrome well reflected the vulnerability to massive bleeding based on the complex pituitary vasculature, which has not been reported previously. MR image with contrast enhancement is useful in the diagnosis of the acute phase of Sheehan's syndrome and in evaluating infarction of the anterior lobe.

Key words: Sheehan's syndrome, Hook-shaped, MR image, Acute phase

POSTPARTUM pituitary necrosis, Sheehan's syndrome, is caused by pituitary ischemia and its pathophysiology reflects the pituitary blood supply. The vasculature of the hypothalamo-pituitary system is quite complex (Fig. 1) [1-5]. Usually, the anterior lobe of the pituitary gland receives blood from the four vessels: (1) the long portal vein, (2) the short portal vein, (3) the capsular artery, and (4) the trabecular artery. The main blood supply to the anterior lobe is *via* the long portal vein, which collects blood from capillaries in the median eminence and pass down the pituitary stalk into the anterior lobe. The capillaries in the median eminence are supplied with blood by the superior hypophyseal artery which is a branch of the internal carotid artery. Thus, the anterior lobe primarily receives blood, through a long series of vessels, from the internal carotid artery and is vulnerable to hypovolemia resulting from massive hemorrhage in this complicated delivery system. In the acute phase of Sheehan's syndrome, a ring enhancement of the anterior lobe on gadolinium (Gd)-enhanced magnetic resonance (MR) image has been reported in some cases [6-8]. This reflects a situation wherein blood supply to the marginal zone occurs *via* the other three vessels, the short portal vein, the capsular artery, and the trabecular artery, but not the long portal vein.

In this case report on acute Sheehan's syndrome, we demonstrate a novel hook-shaped enhancement that indicates an infarction in the territory of the trabecular artery in addition to that of long portal vein. To the best of our knowledge, this MR finding has not been reported previously.

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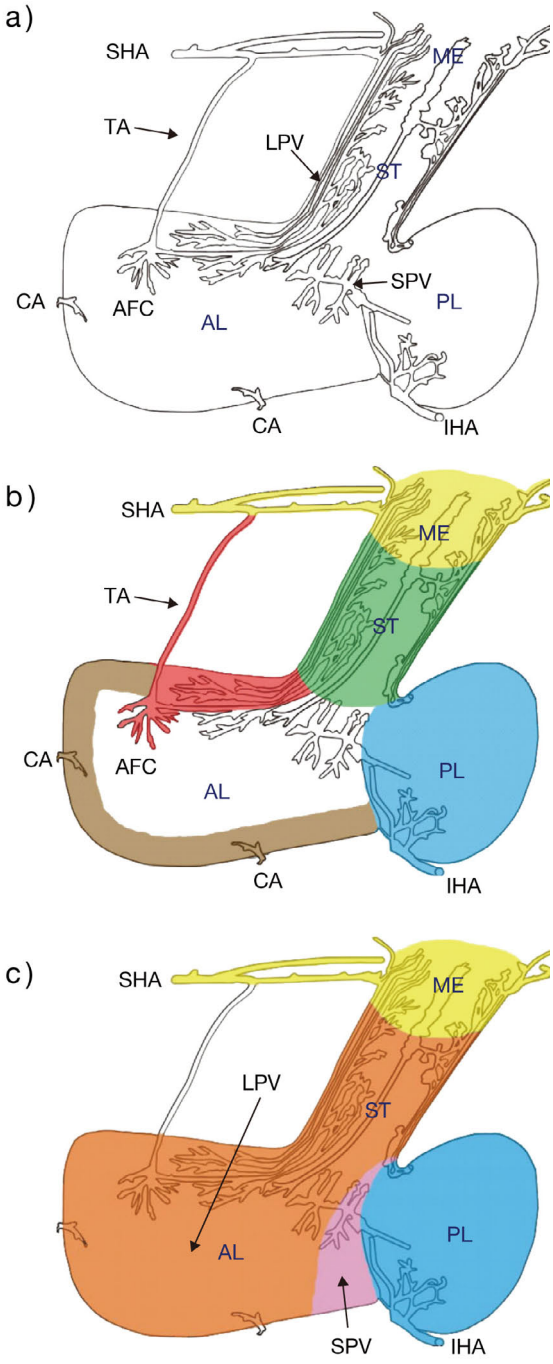

Fig. 1 a) A scheme of the vascularization of the pituitary gland [Adopted from Fig. 4 in Ref. 1 with slight modification] b) Vascular supply of the arteries feeding the pituitary gland c) Vascular supply of the artery-portal system feeding the pituitary gland
AL, anterior lobe of the pituitary gland; PL, posterior lobe of the pituitary gland; ST, stalk; ME, median eminence SHA, superior hypophyseal artery; IHA, inferior hypophyseal artery; LPV, long portal vein; SPV, short portal vein; TA, trabecular artery; AFC, artery of fibrous core; CA, capsular artery. Pituitary stalk is supplied blood by SHA, TA, and IHA.

Case Report

A 37-year-old woman conceived through *in vitro* fertilization and had an uneventful pregnancy. She delivered in a hospital through vaginal delivery at 41 weeks and 6 days of gestation. Although the pregnancy had been uneventful, she experienced complications of retained placenta and massive bleeding (3600 g) during delivery. She was transferred to the emergency room in our hospital by ambulance. On arrival, her blood pressure was 90/48 mmHg and heart rate was 141 beats/min. Laboratory data revealed anemia [hemoglobin 4.0 g/dL, red blood cell count $137 \times 10^4/\mu L$], with a D-dimer level of 85.4 μg/mL and platelet count of $2.1 \times 10^4/\mu L$. These findings indicated hemorrhagic shock and disseminated intravascular coagulation. We transfused 8 units of red cell concentrate, 10 units of platelet concentrate, and 4 units of fresh frozen plasma. The patient also required emergency uterine artery embolization.

The patient experienced problems with lactation and her plasma sodium level was 123 mEq/L and breast engorgement disappeared on postpartum day 4. She underwent endocrinological examination on postpartum day 6, the results of which are shown in Table 1a. The levels of all hormones secreted from the anterior pituitary lobe decreased. The test for anti-pituitary antibody gave a negative result. A combined endocrine stimulation test with CRH (100 μg), TRH (200 μg), GRH (100 μg), and LHRH (100 μg) was performed on postpartum day 12 (Table 1b). The responses for all hormones were low or not significant.

MR image performed on postpartum day 10 revealed swelling of the anterior lobe and the pituitary stalk. The posterior lobe was compressed posteriorly against the dorsum sella by the enlarged anterior lobe (Fig. 2a). The characteristic hook-shaped enhancement was demonstrated on a sagittal T1-weighted image (T1WI) with contrast enhancement (Fig. 2b). The central portion and the superior margin just in front of the stalk insertion of the anterior lobe were not enhanced. In contrast, the pituitary stalk, majority of the marginal zone of the anterior lobe, except the superior portion were enhanced markedly. These findings were quite different from lymphocytic adenohypophysitis, pituitary adenoma, cystic lesion, and other disease entities. We concluded that Sheehan's syndrome had occurred in this patient and the non-enhancement region in the anterior lobe indicated the infarction due to massive hemorrhage during the complicated delivery.

Table 1a Baseline serum hormone levels (day 6)

ACTH	5.3 pg/mL	E2	62 pg/mL
Cortisol	3.0 μg/dL	Prog	<0.2 ng/mL
TSH	0.19 μU/mL	UFC	4.8 mg/day
FT4	0.68 ng/dL	TgAb	<0.3 U/mL
PRL	11.8 ng/mL	TPOAb	<0.3 U/mL
GH	0.16 ng/mL	Pab	negative
LH	<0.1 mIU/mL		
FSH	0.1 mIU/mL		

E2, estradiol; Prog, progesterone; UFC, 24 h urinary-free cortisol; TgAb, anti-thyroglobulin antibody; TPOAb, anti-thyroid peroxidase antibody; Pab, anti-pituitary antibody

Table 1b Results of CRH, TRH, GRH, and LHRH stimulation test (day 12)

(min)	0	30	60	90	120
ACTH (pg/mL)	6.1	18.5	16.2	15.4	12.0
Cortisol (μg/dL)	2.3	3.1	3.3	2.9	2.7
TSH (μU/mL)	0.07	0.10	0.16	0.18	0.16
PRL (ng/mL)	9.1	12.0	13.0	12.8	12.1
GH (ng/mL)	0.16	0.30	0.30	0.24	0.19
LH (mIU/mL)	<0.1	<0.1	<0.1	<0.1	<0.1
FSH (mIU/mL)	0.1	0.2	0.2	0.2	0.3

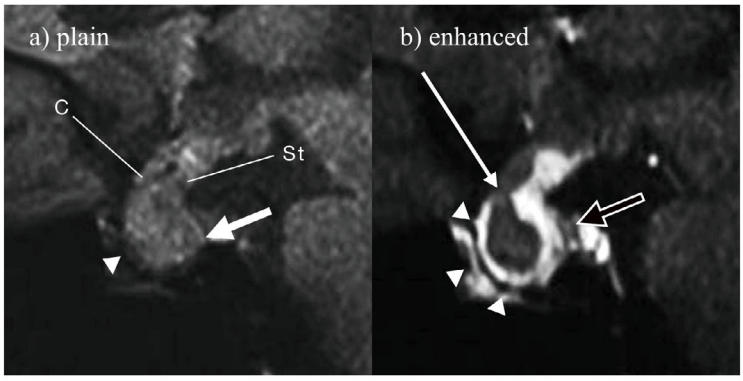

Fig. 2 MR image in acute phase (postpartum day 10)
a) Sagittal T1-weighted image showing slight swelling of the anterior lobe (arrowhead) and the pituitary stalk. The posterior lobe (arrow) was compressed. C, optic chiasm; St, stalk b) Contrast-enhanced images showing characteristic hook-shaped enhancement. The most of the marginal zone of the anterior lobe (arrowhead), just in front of the posterior lobe and the posterior lobe (black arrow), and the pituitary stalk (St) are markedly enhanced. In contrast, the central portion of the anterior lobe and superior margin just in front of the stalk insertion on the gland (white arrow) are not enhanced.

Hydrocortisone 15 mg/day was initiated 10 days after delivery. This improved her general condition and she was discharged from the hospital 16 days after delivery. No symptoms of diabetes insipidus were observed. Changes in hormone levels after discharge are shown in Table 2a. A month after delivery, TSH (0.12 μU/mL) and FT4 (0.50 ng/dL) levels indicated central hypothyroidism, and levothyroxine treatment at 50 μg/day was initiated. Several months after delivery, even after levothyroxine supplementation, TSH levels recovered to as high as 0.48 μU/mL. LH (3.7 mIU/mL) and FSH (8.2 mIU/mL) levels, which had been suppressed at delivery, also improved slightly. However, the other hormones, including FT4, estradiol and progesterone, remained at low levels. The insulin-like growth factor 1 (IGF-1) level remained low even after 19 months, and the growth hormone releasing peptide-2 (GHRP-2) stimulation test revealed a low GH response (peak level 0.38 ng/mL; Table 2b). We

Table 2a Time course of hormone levels after delivery

(month)	1	2	3	4	5	19
ACTH (pg/mL)	7.7	10.1		12.9	9.4	10.2
Cortisol (μg/dL)	2.1	2.2		2.9	1.9	1.9
TSH (μU/mL)	0.12	0.09		0.33	0.48	0.42
FT4 (ng/dL)	0.50	1.15		0.92	1.01	1.21
PRL (ng/mL)			5.3	6.2	6.8	3.9
IGF-1 (ng/mL)				33		24
LH (mIU/mL)		2.1	2.3	3.7	1.3	4.1
FSH (mIU/mL)		5.7	6.2	8.2	3.4	8.9
E2 (pg/mL)		23	13	<10	20	<10
Prog (ng/mL)		<0.2	<0.2	<0.2	<0.2	<0.2

IGF-1, insulin-like growth factor 1 (normal range for her age 98–245 ng/mL); E2, estradiol; Prog, progesterone

Table 2b GHRP-2 stimulation test (19 months)

(min)	0	15	30	45	60
GH (ng/mL)	0.12	0.38	0.34	0.26	0.19

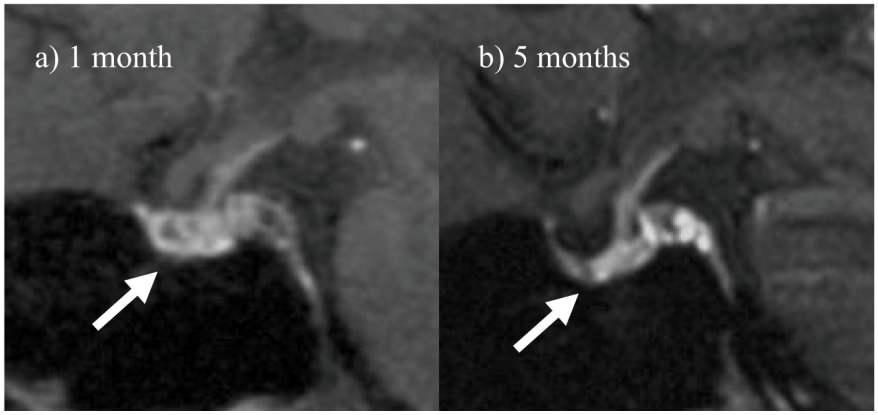

Fig. 3 MR image in chronic phase (contrast-enhanced images)
a) At 1 month after delivery, swelling of the anterior lobe has been reversed (arrow)
b) At 5 months after delivery, marked atrophy of the anterior lobe is observed (arrow)

diagnosed adult GH deficiency and initiated daily 0.2 mg somatotropin supplementation. Impaired anterior lobe function still continues until now. MR image at a month after delivery revealed that the pituitary gland and stalk had returned to an almost normal size. Hook-shaped enhancement had been disappeared (Fig. 3a). A marked atrophy of the pituitary gland, so called empty sella, was demonstrated on MR images at 5 months later (Fig. 3b).

Discussion

Panhypopituitarism after delivery with massive hemorrhage is known as Sheehan's syndrome. This syndrome is thought to be caused by necrosis of the anterior lobe of the pituitary gland due to ischemia [9]. The pattern of hormone deficiency in patients with Sheehan's syndrome is variable. Deficiencies in the following hormone have been reported: ACTH (66%), TSH (42–53%), PRL (67–100%), GH (88%), and gonadotropin (58–76%) [10]. The incidence of diabetes insipidus is very low [11]. Although the hormone levels spontaneously recover in some cases, they usually remain low [12]. In our case, the levels of all hormones secreted from the anterior pituitary lobe decreased. The FT4 level was only slightly decreased (0.68 ng/dL) 6 days after delivery, unlike the TSH level (0.19 μU/mL). This may be explained by the relatively long half-life of thyroxin. A month after delivery, FT4 level decreased to 0.50 ng/dL necessitating daily supplementation with 50 μg levothyroxine. Diabetes insipidus was not observed, even after steroid administration. Panhypopituitarism, except diabetes insipidus, still exists even now.

In our case, the swelling of both the anterior lobe and the stalk were demonstrated on MR image at acute phase. It is known that an adenohypophyseal hypertrophy occurs by pregnancy. In human, the adenohypophysis consists of the pars distalis (the anterior lobe of the pituitary gland) and the pars tuberalis which surrounds the stalk. Probably, adenohypophyseal hypertrophy by pregnancy caused swelling of both the anterior lobe and the stalk on MR images. The novel hook-shaped enhancement on sagittal T1WI, to our knowledge, has not been reported so far. Only ring enhancement of the anterior lobe has been reported in the acute phase of Sheehan's syndrome [6-8]. We speculate that the characteristic hook-shaped enhancement reflects the complex vasculature of the pituitary gland and the stalk (Fig. 1) [1-5]. The anterior lobe of the pituitary gland receives blood from the four vessels: (1) the long portal vein, (2) the short portal vein, (3) the capsular artery, and (4) the trabecular artery. The pituitary stalk is supplied blood by the superior/inferior hypophyseal and the trabecular arteries which anastomose each other. The long portal vein is the main source of blood to the anterior lobe. The superior hypophyseal artery which is the branch of internal carotid artery reaches the median eminence and supplies blood to the capillaries there. The long portal vein collects blood from the capillaries in the median eminence, passes down the pituitary stalk, and feeds the most part of the anterior lobe. There is a long distance from the internal carotid artery to the long portal vein. The short portal vein col-

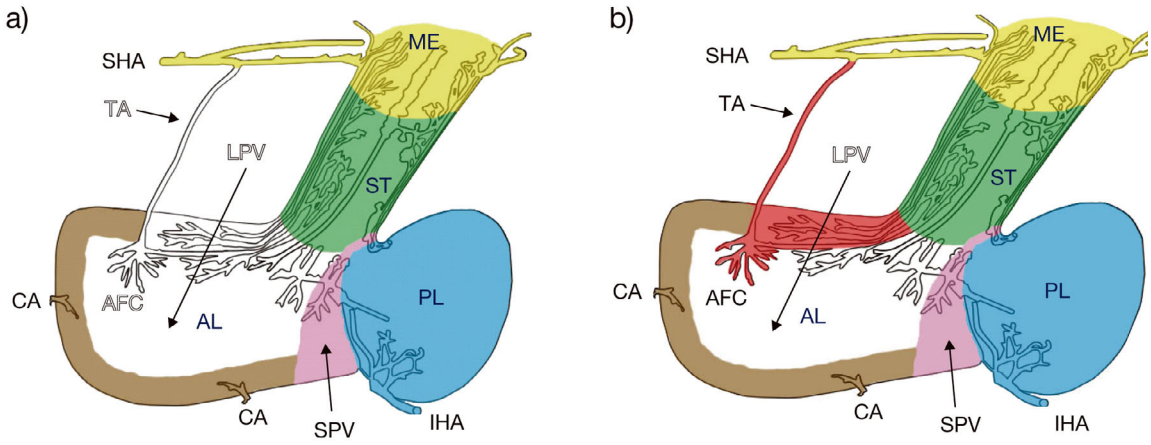

Fig. 4 a) Enhanced area under obstruction of both long portal vein and trabecular artery causes ischemia of superior portion of anterior lobe and shows a hook-shaped image. b) Enhanced area under obstruction of only long portal vein does not evoke ischemia of superior portion of anterior lobe and constructs ring enhanced image.

lects blood from the posterior lobe and distributes in the anterior lobe just in front of the posterior lobe. The posterior lobe is fed by the inferior hypophyseal artery, which is a branch of the internal carotid artery. The capsular artery which is a branch of the internal carotid artery supplies blood directly to most of the anterior lobe margin. The trabecular artery, which is a branch of the superior hypophyseal artery, runs down in front of the pituitary stalk and distributes blood to the superior margin of the anterior lobe. The artery of fibrous core, a branch of trabecular artery, supplies blood to the anterior lobe.

Based on these vasculature patterns, we speculate that the four vessels to the anterior lobe are hemodynamically more vulnerable to hypovolemic shock in the following order: the long portal vein, the trabecular artery, the short portal vein, and the capsular artery. The characteristic hook-shaped enhancement in our case indicates that the infarction occurred in the tributary of both the long portal vein and the trabecular artery in the anterior lobe. Other two vessels, the short portal vein and the capsular artery, were intact (Fig. 4a). On the contrary, the ring enhancement reported in acute Sheehan's syndrome suggests that the infarction occurred in the only long portal vein and the trabecular artery was intact (Fig. 4b). Difference between hook-shaped enhancement and ring enhancement is whether infarction of trabecular artery has occurred or not. Furthermore, in some rare cases, MR image at acute phase shows a heterogeneous enhancement in the anterior lobe [8]. The heterogeneous enhancement might reflect uneven blood supply from the artery of the fibrous core which is the branch of the trabecular artery. Probably, the hook-shaped enhancement pattern demonstrates more severe ischemic changes in the anterior lobe than the ring enhancement one. Panhypopituitarism persisted in our case. The pituitary stalk usually survives after hypovolemia in Sheehan's syndrome that is because there is rich blood supply from the superior/inferior hypophyseal and the trabecular arteries [13].

Lymphocytic adenohypophysitis, an autoimmune disease of the anterior pituitary gland, is often observed after delivery and causes postpartum panhypopituitarism ending up in empty sella, the same as Sheehan's syndrome in chronic phase [14-17]. In acute phase, as we have described previously, lymphocytic adenohypophysitis shows a homogenous enhancement in the anterior lobe in typical MR image [14, 15]. In contrast, only hooked-shaped or ring enhancement are seen in Sheehan's syndrome. These findings will be invaluable in distinguishing between lymphocytic adenohypophysitis and Sheehan's syndrome in acute phase.

In conclusion, a novel hook-shaped enhancement in Sheehan's syndrome reflected the vulnerability to massive bleeding based on the complex pituitary vasculature. MR image with contrast enhancement is useful in the diagnosis of the acute phase of Sheehan's syndrome and in evaluating the infarction area in the anterior lobe of the pituitary gland.

Conflict of Interest

The authors declare that they have no conflict of interest.

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