Neuroradiology (2001) 43: 237–241

J.M. Mellado
X. Merino
A. Ramos
E. Salvadó
A. Saurí

Agenesis of the internal carotid artery with a trans-sellar anastomosis: CT and MRI findings in late-onset congenital hypopituitarism

Received: 1 March 2000
Accepted: 19 August 2000

J.M. Mellado (✉) · X. Merino · A. Ramos · E. Salvadó · A. Saurí
Institut de Diagnòstic per la Imatge,
Centre de Ressonància
Magnètica de Tarragona,
Hospital Joan XXIII,
Carrer Doctor Mallafrè Guasch, 4,
43007 Tarragona, Spain
e-mail: JMMellado@teleline.es
Tel.: + 34-977-250690
Fax: + 34-977-250691

Abstract A 29-year-old woman with a history of hypothyroidism since early childhood developed hypopituitarism. CT and MRI revealed anterior pituitary hypoplasia, an ectopic posterior lobe, a Chiari I malformation and agenesis of the right internal carotid artery with a trans-sellar anastomosis. This constellation of findings constitutes a previously unreported association in congenital hypopituitarism of late onset. The usefulness of imaging modalities and the pathogenic implications are also discussed.

Key words Artery, internal carotid, agenesis · Anastomosis, trans-sellar · Pituitary, hypoplasia · Pituitary, ectopic · Chiari malformation · Magnetic resonance imaging · Magnetic resonance angiography

Introduction

Congenital hypopituitarism is a rare disorder of uncertain pathogenesis, often detected clinically because of early growth failure secondary to growth-hormone deficiency (GHD) or complex endocrine manifestations secondary to multiple pituitary hormone deficiency (MPHD) [1]. Delay in diagnosis is not rare, owing to the sometimes insidious or slowly progressive nature of the symptoms [2]. Late onset has been described [3]. MRI has proved useful in the study of congenital hypopituitarism and can add prognostic information and further understanding of pathogenesis [4, 5, 6, 7, 8, 9, 10, 11].

Agenesis of one internal carotid artery (ICA) with a trans-sellar anastomosis from the other has been described on conventional and MR angiography (MRA) [10, 12, 13, 14, 15]. Association of congenital hypopituitarism with ICA agenesis [5, 9, 10, 11,] appears to be extremely uncommon, and trans-sellar anastomosis has rarely been reported [10] in this clinical setting.

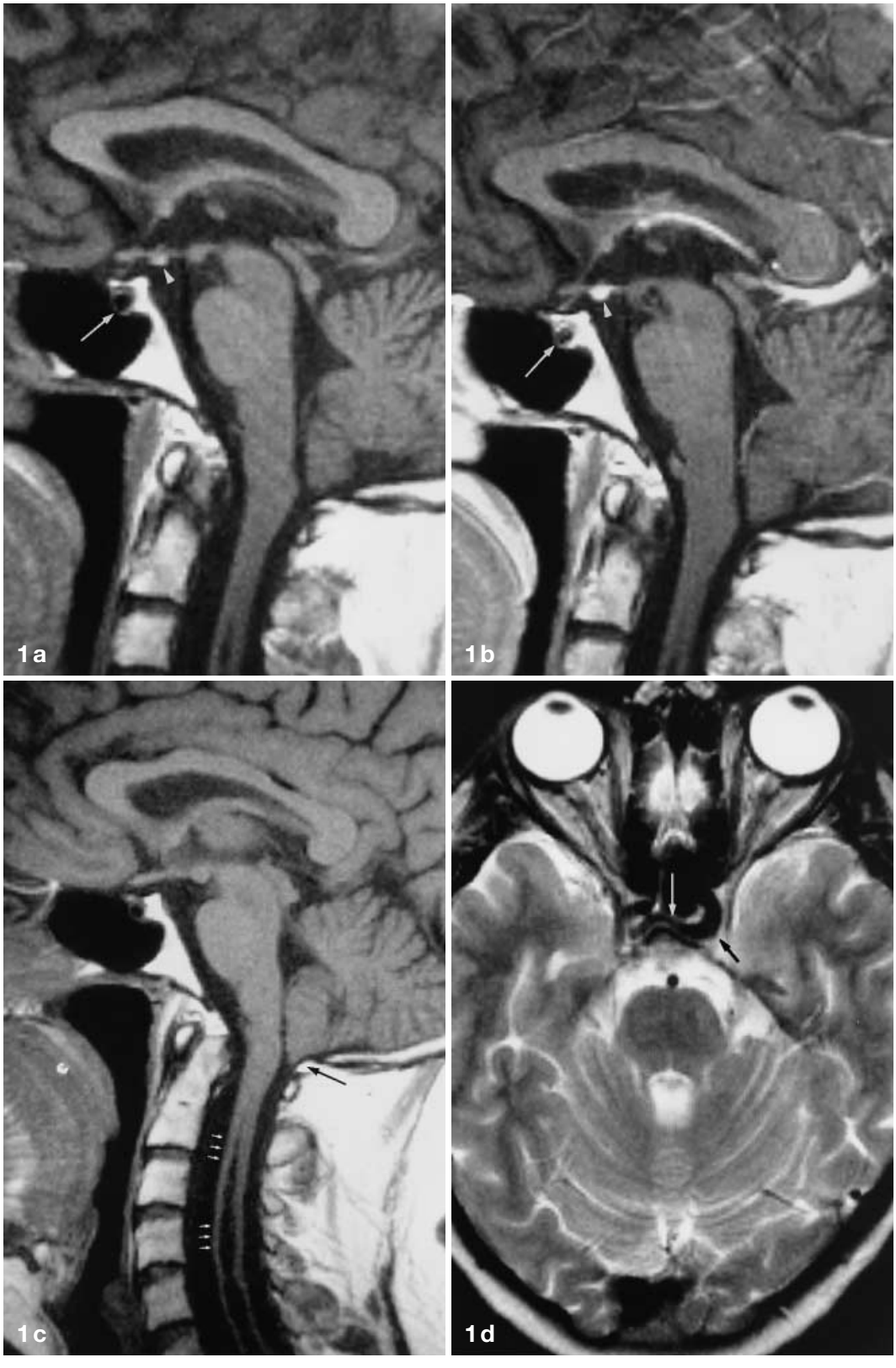
We present a 29-year-old woman with congenital hypopituitarism of late onset. MRI findings included pituitary hypoplasia, with an ectopic posterior lobe, a Chiari I malformation and agenesis of the right ICA with a trans-sellar anastomosis from the left.

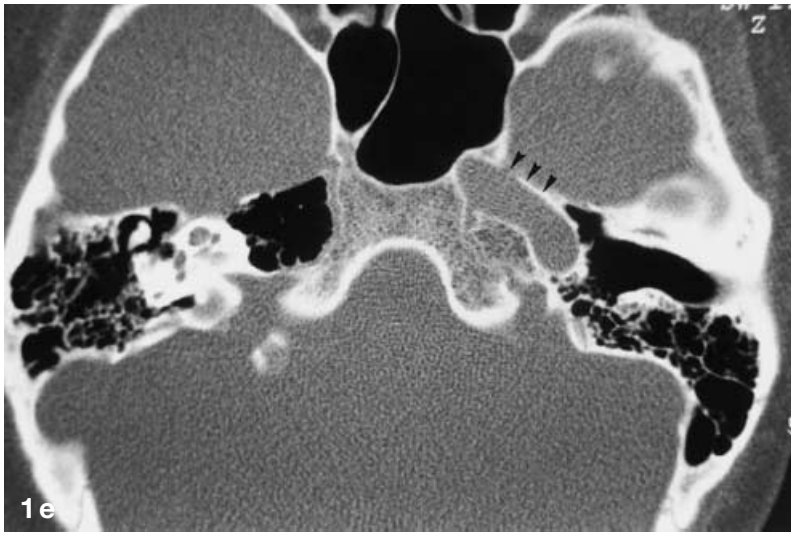
Case report

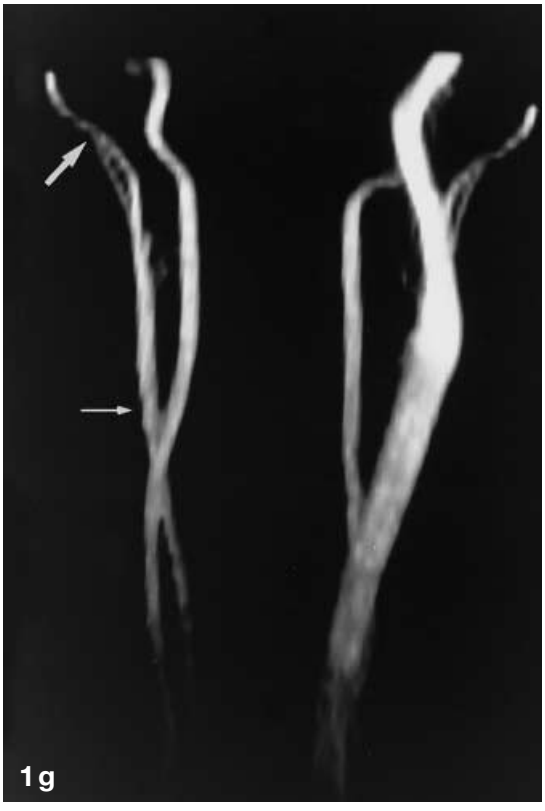
A 29-year-old woman with a vague history of hypothyroidism since early childhood had been treated with L-thyroxin for many years. She presented with fatigue, postural hypotension, hair loss, dry, pale skin, loss of libido and attenuated secondary sexual characteristics. She was 149 cm tall and weighed 46 kg. She reported a late menarche, and amenorrhoea for the past 3 years, after a long period of infrequent and highly irregular menstrual cycles. No history of breech presentation or perinatal asphyxia was given, and there was no clinical evidence of diabetes insipidus.

Laboratory tests revealed normal levels of prolactin (PRL), low thyroid-stimulating (TSH), follicle-stimulating (FSH) and luteinising (LH) hormones, and a poor response of corticotrophin (ACTH) and growth hormone (GH) to insulin-induced hypoglycaemia.

MRI findings included a normal or mildly enlarged sella turcica, a hypoplastic, band-like pituitary gland, and a thin but intact mildly-enhancing infundibulum (Fig. 1 a, b). There was no normally located posterior lobe, but a nodule 2 mm in diameter was seen at the medi-


1a
1b
1c
1d





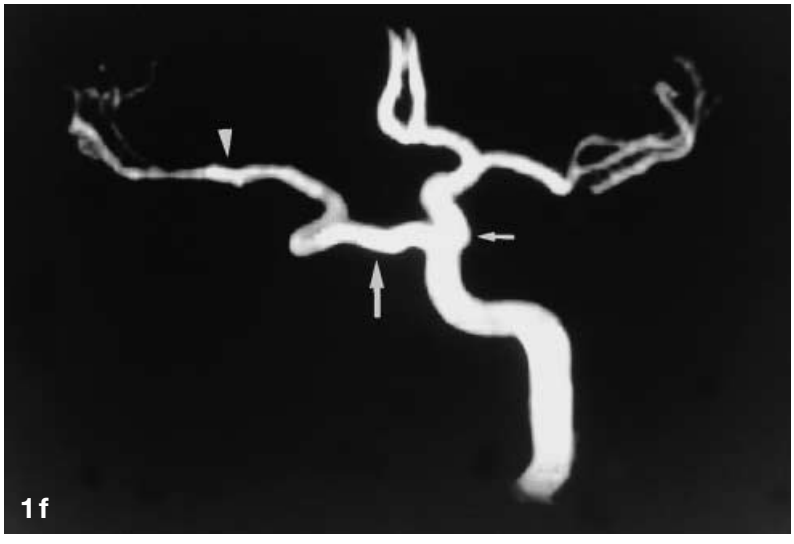


Fig. 1 a Sagittal T1-weighted image shows a hypoplastic band-like pituitary gland and a normal or mildly enlarged sella turcica. The infundibulum is thin but complete, and appears to be displaced anteriorly. The posterior lobe is not clearly identified in its normal position. An ectopic posterior lobe is seen at the median eminence, giving very mildly high signal (*white arrowhead*). An anomalous vessel coursing along the floor of the sella turcica is also seen end-on as a signal void (*arrow*). **b** After intravenous contrast medium there is intense enhancement of the ectopic posterior pituitary lobe, which appears larger (*arrowhead*). The infundibulum also showed mild enhancement, becoming more conspicuous. The anomalous vessel is again seen (*arrow*). **c** Sagittal T1-weighted image of craniocervical region shows mildly low peg-shaped cerebellar tonsils (*long black arrow*) with loss of adjacent subarachnoid space and cervical syringomyelia (*small white arrows*). **d** Axial T2-weighted image through sella turcica shows no signal void corresponding to the right internal carotid artery (ICA). The left cavernous ICA is enlarged (*black arrow*) and a tortuous anomalous vessel traverses the sella (*white arrow*). **e** High-resolution CT of the skull base shows no right carotid canal and an enlarged left canal (*arrowheads*). **f** Coronal maximum intensity projection (MIP) of 3D MRA of the circle of Willis (showing only the anterior circulation) confirms the absence of the right cavernous ICA. The transsellar anastomosis (large arrow) originating from the left (*small arrow*) leads to a normally developed right middle cerebral artery (*arrowhead*). Both anterior cerebral arteries originate from the left ICA; the right A1 is not seen. **g** Coronal MIP of MRA of supra-aortic vessels shows a narrow right common (*thin arrow*) and normal external (*thick arrow*) carotid arteries and not ICA. The left carotid arteries are of mildly enlarged calibre

an eminence, which gave mildly high signal on T1-weighted images (Fig. 1 a) and early spread of enhancement on a dynamic study (Fig. 1 b) and was interpreted as an ectopic posterior lobe.

Peg-shaped cerebellar tonsils in moderately low position (4 mm below the foramen magnum), with narrowed adjacent subarachnoid space and anterior angulation of the lower brain stem were also found (Fig. 1 c). Spinal MRI study revealed cervical syringomyelia extending into the upper thoracic region. These appearances suggested a Chiari I malformation with syringomyelia.

On axial T2-weighted images there was no signal void corresponding to the petrous and cavernous segments of the right ICA (Fig. 1 d). An abnormal tortuous vessel traversing the lower part of the sella turcica was seen on sagittal (Fig. 1a–c) and axial (Fig. 1 d) images. High-resolution CT (Fig. 1 e) showed complete absence of the right petrous carotid canal and an enlarged one on the left. 3D-time-of-flight (TOF) MRA of the circle of Willis (Fig. 1 f) confirmed the absence of the right ICA and showed the abnormal vessel originating from the cavernous segment of an enlarged left internal carotid artery, reaching the right supraclinoid area and followed by a normal right middle cerebral artery (MCA). Both anterior cerebral arteries (ACA) originated from the left ICA, and the right A1 segment could not be seen. The left posterior communicating artery and intracranial vertebrobasilar circulation were also normal. 2D-TOF MRA of the neck (Fig. 1 e) showed a narrow right common carotid artery (CCA) followed by a single vessel with the course and branching pattern of a normal external carotid artery (ECA). The left CCA and ICA were of increased calibre. These findings were interpreted as agenesis of the cervical, petrous and cavernous portions of right ICA with a trans-sellar anastomosis from the left cavernous ICA.

Discussion

Congenital hypopituitarism can present with one or more of the following on MRI: a normal, hypoplastic or absent anterior pituitary gland; normal, thin, interrupted or absent infundibulum; and normal, absent or ectopic posterior pituitary (EPP) lobe [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]. Other midline malformations can be present, including hypoplasia of the optic nerve or corpus callosum, absence of the septum pellucidum, an anomalous skull base and a Chiari I malformation [4, 5, 6, 7, 8, 9, 10, 11]. Medial deviation [4, 6] or agenesis [5, 9, 10, 11] of the ICA can be present, along with different phenotypical abnormalities [1].

In this case, a hypoplastic anterior pituitary gland, an EPP and a Chiari I malformation were found in the clinical setting of slowly -developing, probably congenital hypopituitarism. Our patient presented with MPHD after years of hormone therapy for hypothyroidism. Hypothyroidism is uncommon as the initial presentation of congenital hypopituitarism, although partial deficits of other pituitary hormones may have gone undetected initially. Progression of hormone deficiencies and clinical manifestations could not be documented, as the patient was referred from a distant institution. However, insidious cumulative MPHD is well known in congenital hypopituitarism [1], and delayed diagnosis or late onset has been described [1, 2, 3].

While the sella turcica is commonly shallow in congenital hypopituitarism [1], we found a normal or mildly enlarged sella. We speculated that a progressively-enlarging trans-sellar anastomosis from left ICA may have eroded or remodelled the floor of the sella, as previously reported [13].

A normally enhancing infundibulum can be associated with EPP, but is usually found with isolated GHD [7]. In our case, the initial isolated hypothyroidism seems to illustrate the prognostic value of a normally enhancing infundibulum. Subsequent development of anterior panhypopituitarism with MPHD might be part of the natural history of the disorder, or related to associated anomalies.

Both a normal posterior pituitary lobe and EPP lobe commonly exhibit remarkable T1 shortening [4, 5, 6, 7, 8, 9, 10, 11], although its functional and prognostic significance remains unclear [16]. The mild T1 shortening in our patient could be related to recent development of EPP. This would correlate with progression of the clinical syndrome. Lack of previous MRI studies did not allow us to demonstrate the presumably recent origin of the EPP. Differential diagnosis would include hamartoma of the tuber cinereum, although the clinical setting and contrast enhancement did not favour this [17].

ICA agenesis commonly remains asymptomatic, although subarachnoid haemorrhage has been reported, presumably due to the frequent association with intracranial aneurysms [12]. The lack of clinical manifestations is due to the presence of collateral pathways, enlargement of normal vessels (posterior communicating, basilar and pharyngeal arteries), development of an arterial network at the base of the skull or persistence of primitive vessels such as a trans-sellar anastomosis from the contralateral ICA [9, 10, 11, 12, 13, 14, 15]. Our patient showed such an anastomosis and no aneurysms were seen.

This case illustrates the utility of CT, MRI and MRA for diagnosis of ICA agenesis [18, 19]. Absence of the carotid canal on CT is diagnostic of ICA agenesis, while a narrow canal can suggest ICA hypoplasia [18]. MRI showed no signal void in the petrous and cavernous segment of the ICA and showed the abnormalities related to congenital hypopituitarism. Optimal display of ICA agenesis and trans-sellar anastomosis was obtained with MRA. We did not perform conventional angiography or Doppler sonography, although it is claimed that they may play a useful role in selected patients [18, 19].

In this case MRI findings were thought to represent developmental abnormalities. As the skull base, carotid arteries and the hypothalamic-pituitary axis originate or consolidate around the 4–8th weeks, unique or closely sequential embryonic insults may have disturbed their normal development [6, 9, 10, 11, 20, 21]. The Chiari I malformation is thought to represent a mesodermal insufficiency occurring after the closure of the neural folds, which gives rise to an underdeveloped occipital

bone and a small posterior cranial fossa [22]. It has been pointed out that migration of cells derived from the cephalic neural crest at the beginning of the 4th week may play a critical role in development of the rostral aspect of skull base and sella turcica [20]. The smooth-muscle cells and connective tissue forming the walls of the aortic arches, which give rise to the carotid arteries, are also of cephalic neural crest origin [21]. Migration of cephalic neural crest cells may influence normal differentiation of diencephalon and appropriate induction of the hypothalamic-pituitary axis [11]. Their abnormal migration or altered interaction may be a common pathogenetic mechanism for most of the abnormalities in our case. However, the relationship between abnormal migration of neural crest cells and development of a Chiari I malformation is not clear, and a simple loose association cannot be excluded.

Beyond an embryonic disturbance, the slow progression of the pituitary deficit in our patient seems to suggest additional pathogenetic mechanisms. We speculate that progressive enlargement of the trans-sellar anastomosis may have contributed to aggravate pituitary atrophy, while remodelling the sella turcica. Alternatively, ICA agenesis itself, or the trans-sellar anastomosis derived from primitive circulation, most likely capsular or inferior hypophyseal arteries [12, 13, 14, 15], may have caused vascular insufficiency in the pituitary and the hypothalamic-hypophyseal portal system [5, 9, 10]. This could have given rise to pituitary hypoplasia and an attenuated infundibulum. A certain degree of collateral pathways or vascular deprivation may be necessary to precipitate pituitary dysfunction, which might explain the extreme infrequency of this association [9].

References

1. Reiter EO (1998) Normal and aberrant growth. In: Wilson JD (ed) Williams textbook of endocrinology, 9th edn. Saunders, Philadelphia, pp 1427–1507
2. Crowne EC, Shalet SM (1991) Adult panhypopituitarism presenting as idiopathic growth hormone deficiency in childhood. Acta Pediatric Scand 80: 255–258
3. Navarro P, Halperin I, Rodríguez C, González JM, Vidal J, Vilardell E (1994) Congenital panhypopituitarism of late onset. J Endocrinol Invest 17: 347–350
4. Fujita K, Matsuo N, Mori O, Koda N, Mukai E, Okabe Y, Shirakawa N, Tamai S, Itagane Y, Hibi I (1992) The association of hypopituitarism with small pituitary, invisible pituitary stalk, type I Arnold-Chiari malformation, and syringomyelia in seven patients born in breech position: a further proof of birth injury theory on the pathogenesis of idiopathic hypopituitarism. Eur J Pediatr 151: 266–270
5. Triulzi F, Scotti G, di Natale B, Pellini C, Lukezic M, Scognamiglio M, Chiumello G (1994) Evidence of a congenital midline brain anomaly in pituitary dwarfs: a magnetic resonance imaging study in 101 patients. Pediatrics 93: 409–416
6. Hamilton J, Blaser S, Daneman D (1998) MR imaging in idiopathic growth hormone deficiency. AJNR 19: 1609–1615
7. Chen S, Leger J, Garel C, Hassan M, Czernichow P (1999) Growth hormone deficiency with ectopic neurohypophysis: anatomical variations and relationship between the visibility of the pituitary stalk asserted by magnetic resonance imaging and anterior pituitary function. J Clin Endocrinol Metab 84: 2408–2413
8. Cameron FJ, Khadilkar VV, Stanhope R (1999) Pituitary dysfunction, morbidity and mortality with congenital midline malformation of the cerebrum. Eur J Pediatr 158: 97–102
9. Shulman DI, Martínez CR (1996) Association of ectopic posterior pituitary and anterior pituitary hypoplasia with absence of the left internal carotid artery. J Pediatr Endocrinol Metab 9: 539–442
10. Kjellin IB, Kaiserman KB, Curran JG, Geffner ME (1999) Aplasia of right internal carotid artery and hypopituitarism. Pediatr Radiol 29: 586–588
11. Blustajn J, Netchine I, Frédy D, Bakouche P, Piekarski JD, Meder JF (1999) Dysgenesis of the internal carotid artery associated with transsphenoidal encephalocele: a neural crest syndrome? AJNR 20: 1154–1157
12. Tracy PT (1987) Unusual intercarotid anastomosis associated with anterior communicating artery aneurysm. Case report. J Neurosurg 67: 765–767
13. Kishore PR, Kaufman AB, Melichar FA (1979) Intrasellar anastomosis simulating pituitary microadenoma. Radiology 132: 381–383
14. Quint DJ, Boulos RS, Spera TD (1989) Congenital absence of the cervical and petrous internal carotid artery with intercavernous anastomosis. AJNR 10: 435–439
15. Midkiff RB, Boykin MW, McFarland DR, Bauman JA (1995) Agenesis of the internal carotid artery with intercavernous anastomosis. AJNR 16: 1356–1359
16. Miki Y, Asato R, Okumura R, Hua F, Konishi J (1992) Contrast enhanced area of posterior pituitary gland in early dynamic MRI exceeds hyperintense area on T1-Weighted images. J Comput Assist Tomogr 16: 845–848
17. Robben SG, Oostdijk W, Drop SL, Tanghe HL, Vielvoye GJ, Meradji M (1995) Idiopathic isosexual central precocious puberty: magnetic resonance findings in 30 patients. Br J Radiol 68: 34–38
18. Quint DJ, Silbergleit R, Young WC (1992) Absence of the carotid canals at skull base CT. Radiology 182: 477–481
19. Sliwka U, Schmidt P, Reul J, Noth J (1998) Agenesis of the internal carotid artery: color Doppler, CT, and MR angiography findings. J Clin Ultrasound 26: 213–216
20. Ricciardelli E (1995) Embryology and anatomy of the cranial base. Clin Plast Surg 22: 361–372
21. Noden DM (1991) Cell movements and control of patterned tissue assembly during craniofacial development. J Craniofac Genet Dev Biol 11: 192–213
22. Sarnat HB (1991) Embryology and dysgenesis of the posterior fossa. In: Batzdorf U (ed) Syringomyelia: current concepts in diagnosis and treatment. Williams & Wilkins, Baltimore, pp 3–34