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Angiographic Characteristics of Central Neurocytoma Suggest the Origin of Tumor

The authors retrospectively analyzed the angiographic findings performed in 17 cases with central neurocytoma to document the angiographic characteristics and suggested the origin of tumor based on the angiographic findings. Their medical records and radiological investigations were reviewed and cerebral angiographies were thoroughly examined in arterial, capillary, and venous phases. In ten cases, marked or moderate tumor staining was found whereas the staining was either scanty or absent in seven cases. In the ten cases showing marked or moderate tumor staining, the feeding vessels were originated from the ipsilateral carotid and/or vertebro-basilar system. In the venous phase, the ipsilateral thalamostriate vein, tortuous and enlarged, was elevated, and the internal cerebral vein was depressed. Thus, the venous angle of the ipsilateral side was widened at an irregular contour. Based on the characteristic displacement and the increased size of the associated venous system, it is suggested that the central neurocytoma might originate from a neuronal cell mass of the subependymal zone located on the floor of the lateral ventricle around the foramen of Monro rather than from the septum pellucidum.

Key Words : *Angiography; Central Neurocytoma; Central Nervous System Neoplasms*

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INTRODUCTION

The central neurocytoma is a well-differentiated neuronal neoplasm, recognized by Hassoun and the colleagues in 1982 on the basis of ultrastructural features, which included synaptic structures, clear and dense-cored vesicles, and parallel microtubule arrays (1). The histological appearances of the central neurocytoma mimic those of oligodendroglioma, and retrospective studies have demonstrated that most of the tumors previously diagnosed as intraventricular oligodendrogliomas were central neurocytomas (2-6). During the ensuing decade, many reports concerning clinical examinations, laboratory studies, and clinical follow-ups have confirmed the neuronal nature of and overall excellent prognosis for this unique tumor (5, 7, 8).

In some cases of central neurocytomas, however, cerebral angiography demonstrated marked to moderate vascularity, which sometimes makes complete resection difficult or provokes spontaneous bleeding (5, 7, 9). There have been few reports about the findings of angiography pertaining to this tumor, although the angiographic findings of intraventricular tumors such as meningioma or choroid plexus papilloma are well known (10).

Besides, there are two theories about the histogenesis of central neurocytoma. In the first description of the tumor by Hassoun et al. (1), it was suggested that central neurocytoma may originate from some of the small gray nuclei of the septum pellucidum, as this appeared to be the attachment site of the tumor. Another hypothesis is that central neurocytomas originate postnatally from the remnants of the subependymal germinal plate of the lateral ventricles, and bipotential progenitor cells in the periventricular matrix persistently present throughout the life of an adult in the mammalian brain (11). However, more studies are needed for clarification on the origin of the tumor in central neurocytoma.

The authors analyzed retrospectively the findings of cerebral angiographies from 17 patients with central neurocytoma to define the characteristics of angiographic findings and to suggest the clues concerning the origin of tumor based on the venous change in the review of angiography.

MATERIALS AND METHODS

Between January 1982 and September 1999, 17 of the 26 patients who were diagnosed as central neurocytoma underwent the cerebral angiography. The final diagnosis of central neurocytoma was confirmed with the result from immunohistochemical stainings and electron microscopic examination as previously reported (5, 7, 8). Medical records and radiological investigations were reviewed, and angiographic findings were thoroughly examined in three different stages: arterial, capillary, and venous phase. In the arterial phase, the examination was not only focused on the origin of feeding arteries but also on the presence of arteriovenous shunting and early draining veins. In the capillary and venous phases, the degree of tumor-

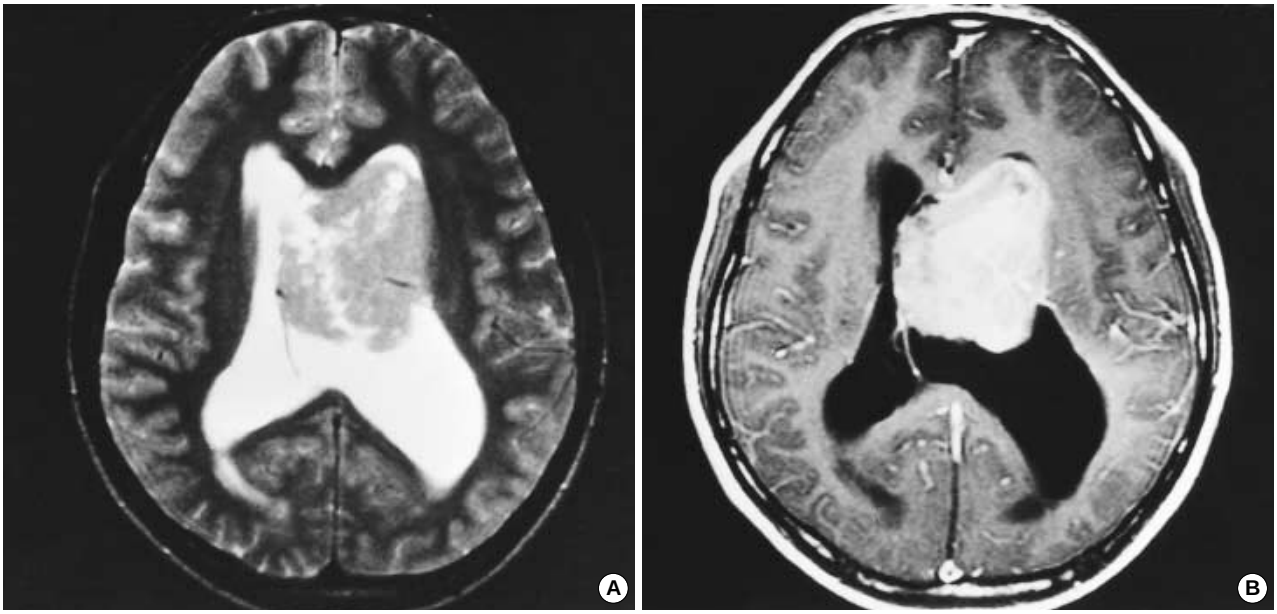

Fig. 1. A T2-weighted (A) and gadolinium-enhanced T1-weighted (B) MR images in the patient of case 14 demonstrate a 5 cm-sized intraventricular mass located in the left lateral ventricle. Asymmetrical enlargement of the lateral ventricle in the left side is found, where the main portion of the tumor is located. The septum pellucidum is well preserved but displaced to the contralateral ventricle delineating the medial contour of the tumor.

Table 1. Summary of angiographic findings in 17 patients with central neurocytoma

No.	Age (yr)/ sex	Size (cm)	Tumor staining	Feeder from AC	Feeder from PC	Draining veins	Thalamostriate vein		Internal cerebral vein		Venous angle	
							Ipsi	Contra	Ipsi	Contra	Ipsi	Contra
1	23/m	4	Marked	Ach, LLS	Pch	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
2	24/m	4	Moderate	Ach, LLS	Pch	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
3	44/f	3	Nil	-	-	-	Elevated	Stretched	Down	Down	WI	WS
4	30/m	4	Moderate	Ach, LLS	Pch	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
5	32/m	7.5	Marked	Ach, LLS	Pch, PPC	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
6	31/f	5	Nil	-	-	ND	Enlarged	Stretched	Down	Down	WI	WS
7	32/m	6	Marked	MLS, LLS, APC	Pch	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
8	36/m	6.5	Marked	Ach, APC	PPC	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
9	34/m	5.5	Moderate	MLS, LLS, Ach, APC	Pch, PPC	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
10	38/m	6	Scanty	Ach, MLS, LLS	-	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
11	20/f	4	Moderate	MLS, LLS, APC	Pch, PPC	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
12	28/m	5	Scanty	MLS, LLS, APC	Pch, PPC	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
13	32/f	6.5	Moderate	MLS, LLS, Ach	Pch	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
14	29/f	4	Scanty	MLS, LLS, Ach	-	ND	Enlarged	Stretched	Down	Down	WI	WS
15	28/m	7.5	Marked	MLS, LLS, Ach, APC	Pch, PPC	ICV-VG	Enlarged	Stretched	Down	Down	WI	WS
16	28/m	5	Scanty	MLS, LLS, Ach, APC	Pch, PPC	ND	Enlarged	Stretched	Down	Down	WI	WS
17	26/m	2.5	Nil	-	-	-	Elevated	NC	NC	NC	W(S)	NC

No.: number, m: male, f: female, -: absent, AC: anterior circulation, PC: posterior circulation, Ach: anterior choroidal artery, LLS: lateral lenticulostriate artery, MLS: medial lenticulostriate artery, APC: anterior pericallosal artery, Pch: posterior choroidal artery (medial & lateral), PPC: posterior pericallosal artery, Ipsi: ipsilateral, Contra: contralateral, NC: no change, ND: not definite, Down: downward displacement, ICV-VG: internal cerebral vein-vein of Galen, WI: widened irregularly, WS: widened smoothly, W(S): suspiciously widened.

staining was evaluated using a four-tiered grading system: nil (not visible), scanty (less prominent than choroidal flushing), moderate (more prominent than choroidal flushing), and marked staining (more prominent than the surrounding draining veins). In the venous phase, the draining veins and their displacement were carefully examined.

RESULTS

The ages of patients at the time of diagnosis ranged from 20 to 44 (median age: 30) and the male-to-female ratio was 12:5. The size of the tumor ranged from 2.5 to 7.5 cm in its longest dimension. All patients showed asymmetrical enlargement of

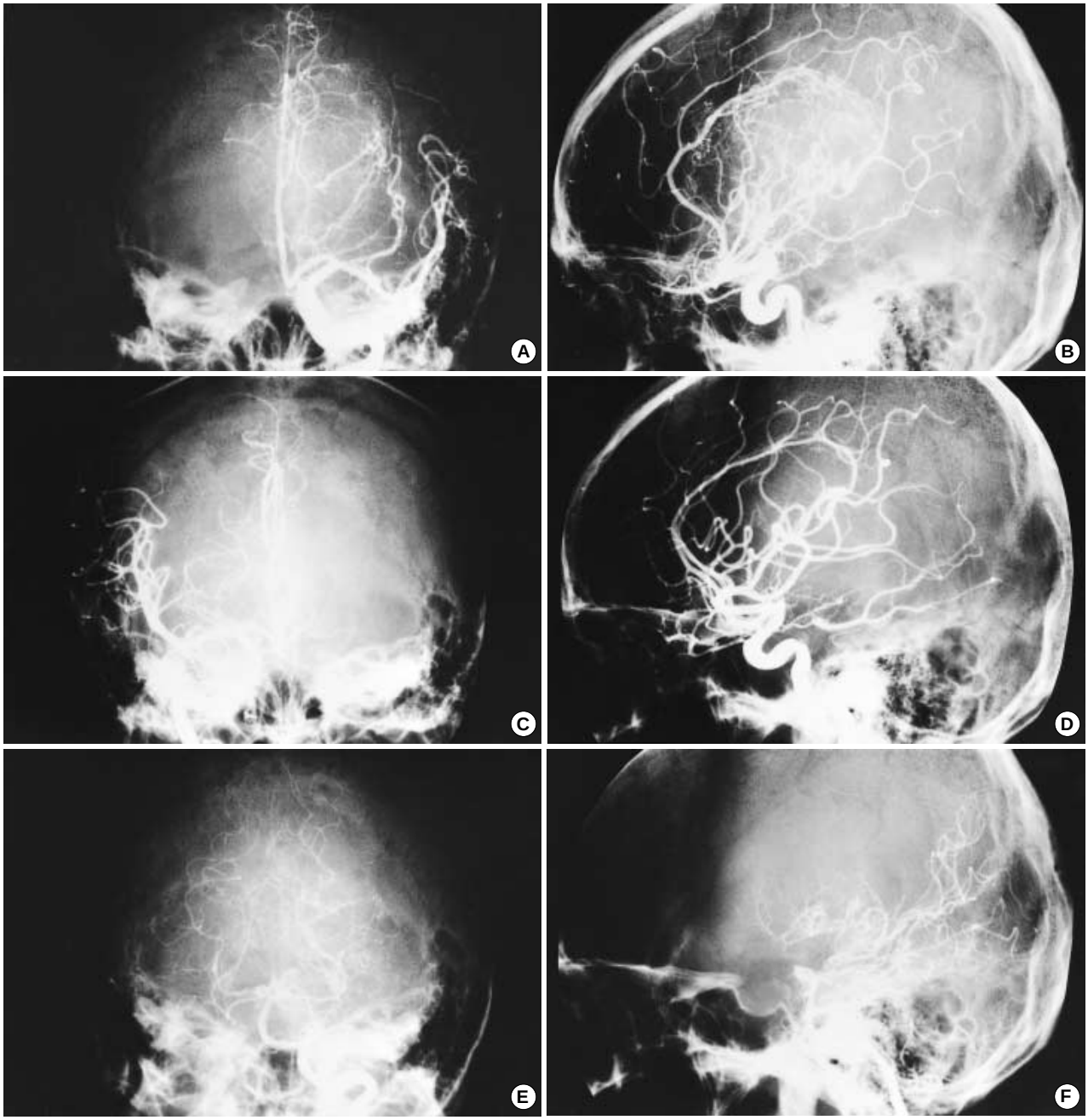

Fig. 2. The anteroposterior (A) and lateral (B) view of the left internal carotid angiogram demonstrates the increased bowing of the pericallosal artery and widening of the carotid fork. The feeding vessels to the tumor originated from the anterior choroidal artery, the lenticulostriate arteries, and the anterior pericallosal arteries in the patient of case 14. In contrast, the anteroposterior (C) and lateral (D) view of the right internal carotid angiogram do not show any feeding vessels to the tumor. The anteroposterior (E) and lateral (F) view of the vertebro-basilar angiogram reveal that the feeding vessels to the tumor from the posterior circulation originate mainly from the medial and lateral posterior choroidal arteries. In the lateral view of the vertebro-basilar angiogram, a characteristic downward displacement of the posterior choroidal artery is noticed.

the lateral ventricles where the main portion of the tumor was located in the larger ventricle with the septum pellucidum, delineating the medial contour of the tumor, displaced but found to be preserved as magnetic resonance (MR) images illustrated (Fig. 1). The angiographic findings from the 17 patients are summarized in Table 1.

Arterial & Capillary Phases

The bowing of the pericallosal arteries in both sides was fo-

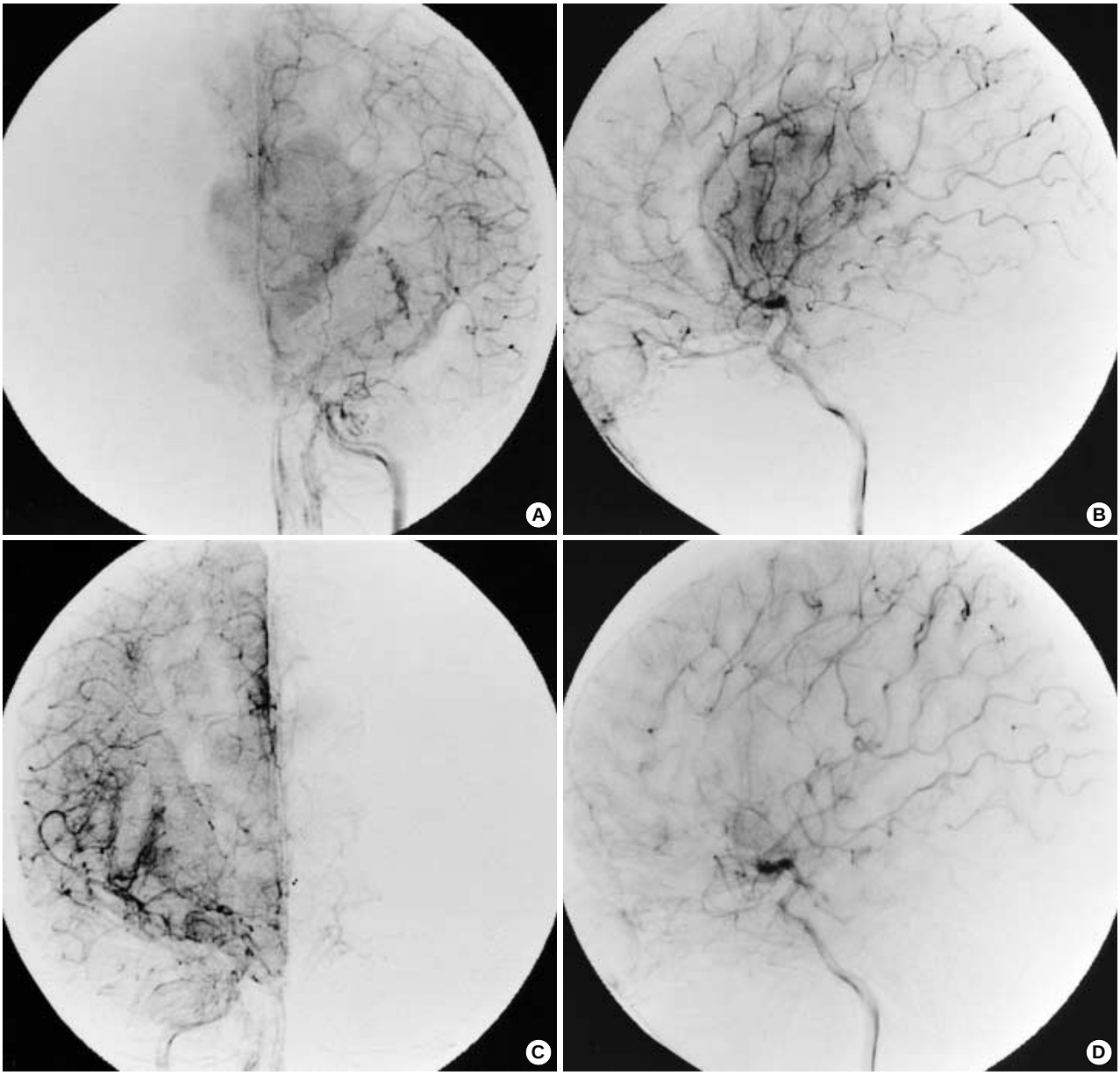

Fig. 3. Moderate vascular staining is demonstrated in the capillary phase of the antero-posterior (A) and lateral (B) views of the left internal carotid angiogram in the patient of case 14. The vascular staining is homogeneous in nature and delineated the mass. However, there is no vascular staining in the capillary phase of the antero-posterior (C) and lateral (D) views of the contralateral carotid angiography.

und to be increased as seen in the lateral projection, and the carotid fork was widened bilaterally as seen in the anteroposterior (AP) projection. In AP projection, the medial and lateral lenticulostriate arteries of the ipsilateral side were markedly shifted in an inferior-lateral direction whereas those of the contralateral side were shifted laterally. The posterior medial and posterior lateral choroidal arteries taking their courses above the thalamus via the velum interpositum and the floor of the lateral ventricle were compressed by the mass of the tumor. The feeding vessels to the tumor from the anterior circulation originated from the anterior choroidal artery, the lenticulostriate arteries, and branches of the anterior pericallosal artery. The feeding vessels were visualized exclusively from the ipsilateral angiogram. The feeding vessels to the tumor from the posterior circulation originated mainly from posterior medial and posterior lateral choroidal arteries, while some feeding vessels came from the posterior pericallosal arteries (Fig. 2). There was no evidence of arterio-venous shunting or early draining vein even in the cases of marked tumor-staining.

Marked and moderate tumor-stainings became evident in each of the five patients, respectively. The signs of the tumor-staining began to show in the late arterial or capillary phase

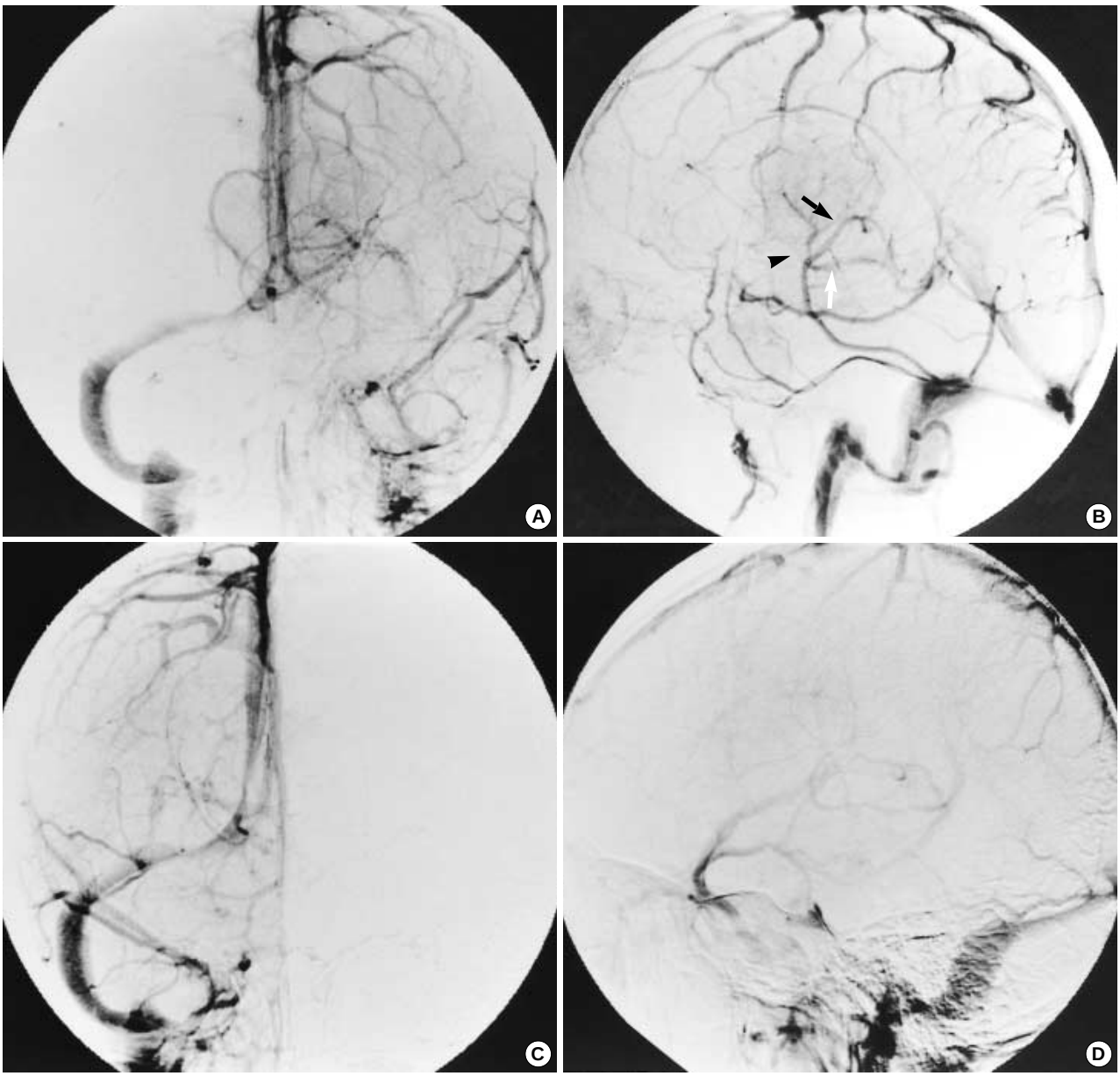

Fig. 4. In case 14, the antero-posterior (A) and lateral (B) views of the late venous phase in the left internal carotid angiogram reveals that the thalamostriate vein (closed arrow), tortuous and enlarged, is elevated upward medially, whereas the internal cerebral vein (open arrow) is depressed. Characteristically, the venous angle (arrow head) formed between these structures is widened. In contrast, the contralateral anteroposterior (C) and lateral (D) views of the late venous phase reveals that the small-calibered thalamostriate vein is only stretched due to the ventriculomegaly. The venous angle is simply widened and stretched as shown in the case of severe ventriculomegaly.

(Fig. 3). The vascular stainings were homogeneous and lasted to the late venous phase. Four patients showed scanty tumor-staining, and three patients displayed no vascularity in the tumor. The tumor-staining was observed only from the ipsilateral carotid angiography. Two patients had a tumor with less than 3 cm in maximum diameter and showed no vascularity in the tumor. Eleven patients possessed a tumor with 3 to 6 cm of range in maximum diameter. In terms of the degree of tumor-staining, vascularity was nil in one, scanty in four, moderate in four, and marked in two patients. Among the four patients who had a tumor larger than 6 cm in maximum diameter, one patient showed moderate vascularity while three patients showed marked vascularity (Table 2).

Venous phase

The draining veins from the tumor were the veins of the internal cerebral-Galenic system. There was no cortical draining

Table 2. Size of tumor versus vascularity

Vascularity	Size of tumor			Total
	≤ 3 cm	3.1-6 cm	> 6 cm	
Nil	2	1		3
Scanty		4		4
Moderate		4	1	5
Marked		2	3	5
Total	2	11	4	17

vein from the tumor. The draining veins from the tumor were exclusively ipsilateral as well. Tortuous and bizarre intraventricular veins, including a thalamostriate vein, drained into the enlarged ipsilateral internal cerebral vein, and the venous angle was widened irregularly. In the contralateral side, the normal-sized and well-demarcated thalamostriate vein drained into the same side of the internal cerebral vein, and the venous angle was smoothly widened. In lateral projection, the internal cerebral vein was depressed, and therefore, the arc of the vein of Galen was widened in the ipsilateral side. The thalamostriate vein and several veins around the tumor mass, usually tortuous and enlarged, were elevated upward, whereas the internal cerebral vein was depressed downward in the lateral projection of the carotid angiography. Therefore, the venous angle formed between these structures was irregularly widened. Contralaterally, however, the size of the elevated thalamostriate vein and the depressed internal cerebral vein looked normal, and the venous angle made from those structures was open as shown in the case of ventriculomegaly (Fig. 4). In all the tumors showing vascularity, the tumor-staining remained in the late venous phase.

Description of Tumor Attachment at the Operation Field

The attachment sites of the tumor described in the operation records were found on the following locations: seven on the floor of the lateral ventricle, three in septum, four on the lateral wall of the lateral ventricle, and three cases at multiple sites. In the two patients with a tumor of less than 3 cm in diameter, the ventricular floor was described as the attachment site of the tumor. In seven of the nine patients with a tumor between 3 and 6 cm in diameter, the floor and lateral wall of the lateral ventricle were described as the attachment sites of tumor in four and three cases, respectively. In the four patients with a tumor over 6 cm in diameter, the floor and the lateral ventricle were described as the attachment site of the tumor in two cases each, respectively.

DISCUSSION

Angiography showed marked or moderate vascularity of the tumors in 10 of 17 patients in this series. The blood supplies to the tumors were exclusively ipsilateral through three routes: choroidal arteries, pericallosal arteries, and lenticulostriate arteries. However, the tumors rarely had a blood supply from the thalamoperforating arteries, which normally supply to the thalamus and basal ganglia. The degree of tumor-staining seemed to be related to the size of the tumor; the larger the tumor, the more prominent the staining. When the tumor was detected early as in its longest dimension of less than 3 cm, the central neurocytoma was usually found to be a relatively hypovascular mass. When the tumor was detected late as in its longest dimension of more than 6 cm, however, juxta- or intra-ventricular vessels such as anterior choroidal artery, lenticulostriate arteries, and pericallosal arteries supplying to the tumor increased, and the tumor became more hypervascular as a result. Total resection is sometimes troublesome in the patients with large-sized central neurocytoma because of profuse bleeding during the operation and of the size of the tumor itself.

Vascular staining in the cerebral angiography was observed in 14 cases in our series. However, there was no evidence in the angiographic findings suggestive of a malignant tumor such as arteriovenous shunting or an early draining vein in the early arterial phase. These angiographic findings seem to be consistent with the benign histology and clinical behavior of central neurocytoma. However, there are several reports claiming that central neurocytoma can present as a malignant form (7, 9, 12). A high degree of vascularity in the lateral ventricular brain tumors of a benign histological grade and a good long-term outcome are also found in the case of intraventricular meningioma or choroid plexus papilloma (4, 10). However, there were some differences between central neurocytoma and other intraventricular tumors such as meningioma or choroid plexus papilloma (18). Central neurocytoma is located in the anterior portion of the lateral ventricle while meningiomas and choroid plexus papillomas are located in the trigone of the lateral ventricle. In the case of central neurocytoma, there was a tendency toward an increased degree of tumor-staining as the size of the tumor increased. In contrast, angiographies usually show hypervascularity in cases of intraventricular meningioma or choroid plexus papilloma regardless of the size.

There are two theories about the histogenesis of central neurocytoma. In the first description of the tumor by Hassoun et al., it was suggested that central neurocytoma may originate from some of the small gray nuclei of the septum pellucidum as this appeared to be the attachment site of the tumor (1). Another hypothesis is that central neurocytomas originate postnatally from the remnants of the subependymal germinal plate of the lateral ventricles, and bipotential progenitor cells present in the periventricular matrix of the mammalian brain (11, 20-22).

In this study, several findings were observed to claim that the central neurocytoma might not be a tumor of septal origin, and the details of the findings are as follows: first, the feeding vessels of the central neurocytoma originated exclusively from the ipsilateral internal carotid system and/or vertebrobasilar system; second, MR images revealed that the contour of the septum was preserved and deviated to the contralateral side from the ipsilateral ventricle where the main portion of the tumor was

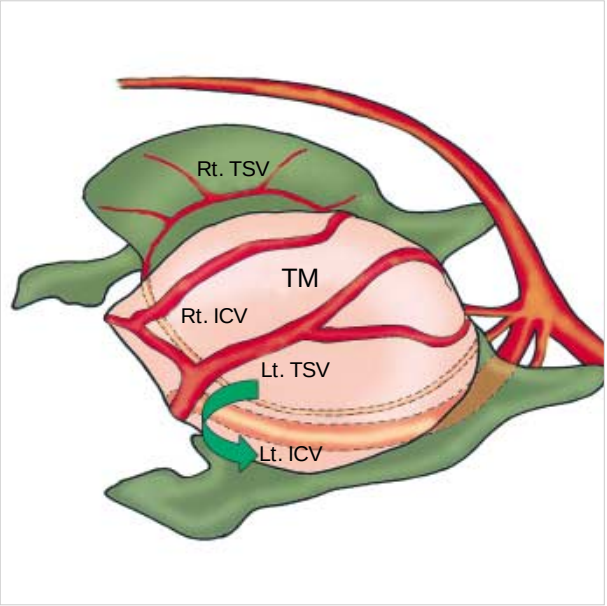

Fig. 5. Schematic drawing illustrates the relationship between the tumor (TM) and the associated venous system. The ipsilateral thalamostriate vein (marking as Lt. TSV), tortuous and enlarged, is elevated and the internal cerebral vein (Lt. ICV) is depressed by the tumor located in the left lateral ventricle. And the venous angle is widened with an irregular contour (curved green arrow). In contrast, the size of the contralateral thalamostriate vein (Rt. TSV) and internal cerebral vein (Rt. ICV) is normal although the venous angle is smoothly widened.

located and the ventricle was more enlarged. Therefore, the septum delineated the medial margin of the tumor located in the lateral ventricle; and third, the ipsilateral thalamostriate vein, tortuous and enlarged, was elevated, and the internal cerebral vein was depressed. The venous angle was also irregularly widened. In contrast, the contralateral thalamostriate vein was not enlarged, and the venous angle was smoothly widened as shown in the case of ventriculomegaly. A schematic drawing explaining the relationship of these venous structures with the tumor is illustrated in Fig. 5.

These angiographic findings illustrated that the origin of central neurocytoma could be inferred as being in the lateral ventricle; in general, however, the central neurocytoma should be located above the thalamus. For this development of the central neurocytoma, it can be explained as the result of the posterior medial and lateral choroidal arteries taking their courses above the thalamus via the velum interpositum and the floor of the lateral ventricle were compressed by the tumor mass in this study (Fig. 2). And the central neurocytoma should be located in the side of the lateral ventricle around the foramen of Monro between the thalamostriate vein and the internal cerebral vein. Because the venous angle between the enlarged thalamostriate vein and the internal cerebral vein was acutely widened in the ipsilateral side, the tortuously enlarged thalamostriate vein was displaced upward while the internal cerebral vein was shifted downward (Fig. 4). Moreover, the contour of the septum, deviated to the contralateral ventricle from the ipsilateral ventricle where the main portion of tumor was located and the ventricle was more enlarged, is found to be preserved as seen from the MR images (Fig. 1). Considering the above findings we can designate the neuronal cell mass around the foramen of Monro in the floor of the lateral ventricle between the thalamostriate vein and the internal cerebral vein as being the origin of central neurocytoma. There are many reports describing the origin of the tumor as the septum pellucidum (1, 5-7). Even in this study, there were three cases in which the surgical records described the tumor as being attached to the septum. However, the attachment to the septum was usually associated in cases of medium- to large-sized tumors. On the other hand, the floor of the lateral ventricle was described as an origin in two cases in which the size of tumors was less than 3 cm in diameter. It seemed that the tumor can grow over the origin of the tumor itself as it increases in size, and ultimately to contact and adhere to the surrounding ventricular walls, including the septum. Therefore, the previous reports claiming on a septal origin of central neurocytoma could be understood, if the size of the tumor was large enough to make it difficult to verify the origin due to the adhesion of the tumor to the surrounding structures.

Recent results of cell culture experiments support the hypothesis that the origin of central neurocytoma might be the subependymal plate of the lateral ventricles, a region of cytogenesis in the developing brain, possessing a persistent capacity to reenter into mitosis in response to injury (20, 21, 23-25). Our observation of the angiographic findings of central neurocytoma also supports the proposition that central neurocytoma might originate from the lateral ventricle around the foramen of Monro rather than from the septum pellucidum. To discern the clues concerning the origin of central neurocytoma further studies such as primary cell culture will be needed.

In conclusion, the vascular staining was found in 14 of the 17 cases (82%), and feeding arteries and draining veins were exclusively ipsilateral. Based on characteristic displacement and increased size of the associate venous system, it is suggested that the central neurocytoma might originate from a neuronal cell mass of the subependymal zone located on the floor of the lateral ventricle around the foramen of Monro rather than from the septum pellucidum.

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