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The value of CT venography in assessing cerebral venous malformations

Wartość wenografii TK w diagnostyce malformacji żylnych mózgowia

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Summary

Background: Venous malformations (VMs) are the most frequent cerebral vascular malformations (2/3 of the total). In most cases they are asymptomatic or present unspecific clinical symptoms (headache, seizures, focal signs). The frequency of hemorrhage is evaluated at around 0% to 15–30%. The "Medusa head" sign is considered as a typical CT, MR, and angiographic appearance of VMs. The aim of the study was to evaluate CT venography (CTV) in detecting and assessing cerebral venous malformations.

Material/Methods: 50 patients, referred due to suspicion of vascular malformation, headache, or seizures, were included in the study. All patients were examined with conventional pre- and post-contrast CT followed by CTV. In addition, 2 patients had MR and MR angiography, while another 4 had arteriography (DSA). CTV was performed in the spiral mode (slice thickness: 2 mm, pitch: 1–1.5, reconstruction every 1 mm, 100–120 ml of contrast medium at 5 ml/sec). Post-processing included MIP, SSD, VRT, and MPR reconstructions.

Results: In 29 (58%) patients CTV revealed the typical "Medusa head" pattern of VM and in 21 (42%) atypical venous vessels. The most common location was the frontal lobe (20 patients, i.e. 40%). In the patients examined by MR and DSA, the diagnosis of VM was confirmed. Hemorrhage was found on CT in 14 patients (28%), including 9 cerebral hematomas and 5 subarachnoid hemorrhages (SAH). The location of hemorrhage suggested VM as the source of hemorrhage in 8 cases with cerebral hematomas and in 1 patient with SAH. In 3 patients the bleeding originated from aneurysm, and in 2 cases the cause of hemorrhage was not established.

Conclusions: CTV combined with conventional pre- and post-contrast CT is an efficient, non-invasive method of VM assessment. In selected, unclear cases it can be followed by intra-arterial angiography.

Key words: **cerebral vascular malformations • venous malformations • venous angiomas • cerebral hemorrhage • CT • CT venography**

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Background

Venous malformations (VMs) are the most frequent cerebral vascular malformations, accounting for 2/3 of their whole number [1]. Its incidence in population is assessed for 1–2,6% [1, 2, 3]. VMs present abnormal venous drainage and comprise exclusively venous structure, thus they are considered by some authors as "developmental venous anomalies" [1, 4, 5].

In most cases VMs are asymptomatic or present unspecific clinical symptoms (headache, seizures, focal neurological deficit) [2, 6, 7]. The occurrence of hemorrhage associated with VM is very controversial. Many authors claim that bleeding from VMs is uncommon and occurs only when they coexist with other types of vascular malformations like aneurysms, arteriovenous (AVMs) or cavernous malformations [7, 8, 9, 10, 11, 12, 13, 14]. The other authors calculate the risk of VM originated hemorrhage from 15 up to 30% [1, 2].

Pathologically VM consists of multiple small medullary veins drained by a single larger venous vessel. The adjacent brain tissue is usually normal, with no signs of previous bleeding [4].

The gold standard of demonstration of the venous nature of the malformation is conventional cerebral angiography, preferably digital subtraction angiography (DSA) [8, 15, 16]. Typical angiographical appearance of VM during the late venous phase is "medusa head" sign. This appears as stellate pattern formed by enlarged medullary veins that join to drain into a larger collecting vein, which in turn drains into the superficial or deep venous system [4, 16, 17, 18]. The other described pattern is "thistle-shaped" collection of veins coursing to a single dominant draining vein [3, 15].

Despite high value of cerebral angiography it is usually not advocated in the patients without intracranial hemorrhage, i.e. in most cases of VMs. Therefore there is an increasing role of non-invasive methods: CT, MR, CT angiography, MR angiography [13, 17, 19, 20]. However their value in diagnosing VMs has not been established yet.

The aim of the presented study is to establish value of CT angiography of cerebral veins (CT-venography - CTV) in detecting and assessing cerebral venous malformations.

Material and methods

Material consists of 50 patients (32 females and 18 males) aged 3–67 years (mean 42,3), in whom CT and CTV studies revealed atypical venous vessels, consistent with VM. Most patients were referred to imaging studies with clinical suspicion of cerebral hemorrhage (N=14) or vascular malformation (N=16). The other clinical diagnoses included headache, ischemic stroke, seizures and other (Table 1).

The final diagnosis of VM was confirmed angiographically in 4 cases. Two patients have MR and MR angiography of venous phase (MR venography) which also confirmed CT and CTV diagnoses. CT was performed with sequential mode, before and after contrast medium (c.m.) administration. Slice thickness was 8mm, with the exception of posterior fossa lesions, in which 3 or 5 mm-thick slices were used. CTV was performed with spiral mode using following parameters: slice thickness 2 mm; pitch 1–1,5 reconstruction: every 1 mm; delay of acqusition: calculated

Table 1. Clinical diagnosis before the CT study.
Tabela 1. Rozpoznanie kliniczne przed badaniem TK.

Diagnosis	Number of patients	% of patients
vascular malformation	16	32
hemorrhage	14	28
headache	4	8
ischemic stroke	6	12
seizures	3	6
observation	7	14
Total	50	100

Table 2. CT findings in 14 cases of intracranial bleeding.
Tabela 2. Wynik badania TK w 14 przypadkach krwawienia wewnątrzczaszkowego.

CT findings	Number of patients
intracerebral hematomas	9
subarachnoid hemorrhage	5
Total	14

Figure 1. Post-contrast CT image. Enhanced abnormal linear structure in the left cerebellar hemisphere, consistent with venous malformation.
Rycina 1. Badanie TK po podaniu środka kontrastowego. Nieprawidłowa linijna struktura w lewej półkuli móżdżku, przemawiająca za malformacją żylną.

on the basis of CT seriography with 20 ml bolus of contrast medium; amount of contrast medium in main part of study 100–120 ml; speed of c.m. injection 5 ml/sec (automatic injector).

The obtained images were postprocessed on workstation, using MIP, MPR, SSD and VRT reconstructions, with special attention to venous vessels. Both source images (partitions) and reconstructions were evaluated.

Results

Plain CT studies revealed in 14 patients (28%) intracranial hemorrhage, including 9 intracerebral hematomas and 5 cases of subarachnoid hemorrhage (Table 2). In 8 patients there were abnormal linear structures, which enhanced markedly on post-contrast CT images, consistent with abnormal vessels (Fig. 1). CTV study showed different patterns of abnormal veins. The classical appearance of "medusa head" was found in 29 of 50 patients (58%) (Fig. 2). In 17 cases there were linear vascular structures (Fig. 3), while in 4 patients tortuous vessels (Fig. 4) (Table 3), the most frequent localization of VMs was frontal lobe, followed by cerebellum and parietal lobe (Table 4). Most of VMs were located in the supratentorial space (72%).

In 4 patients (8%) VMs were accompanied by aneurysms. All those patients had subarachnoid hemorrhage (SAH). In one case the aneurysm was located in vicinity of VM while in 3 patients in remote areas of the brain. Localization of SAH indicated aneurysm as a source of bleeding in 3 patients, while in 1 patient it was not possible to establish the source of bleeding due to the close location of both malformations. In 1 patient with SAH there was no other vascular malformation, thus VM was considered as the most probable source of bleeding.

On the other hand 8 of 9 cerebral hematomas were located close to the place of VM and no other vascular malformation has been found. Thus in these cases VM was considered as the cause of hemorrhage. In 1 case of cerebral hematoma located far from VM the cause of hemorrhage remains unknown.

Among all 14 patients with intracranial hemorrhage in 9 cases (8 cerebral hematomas and 1 SAH) VM was considered as the source of bleeding.

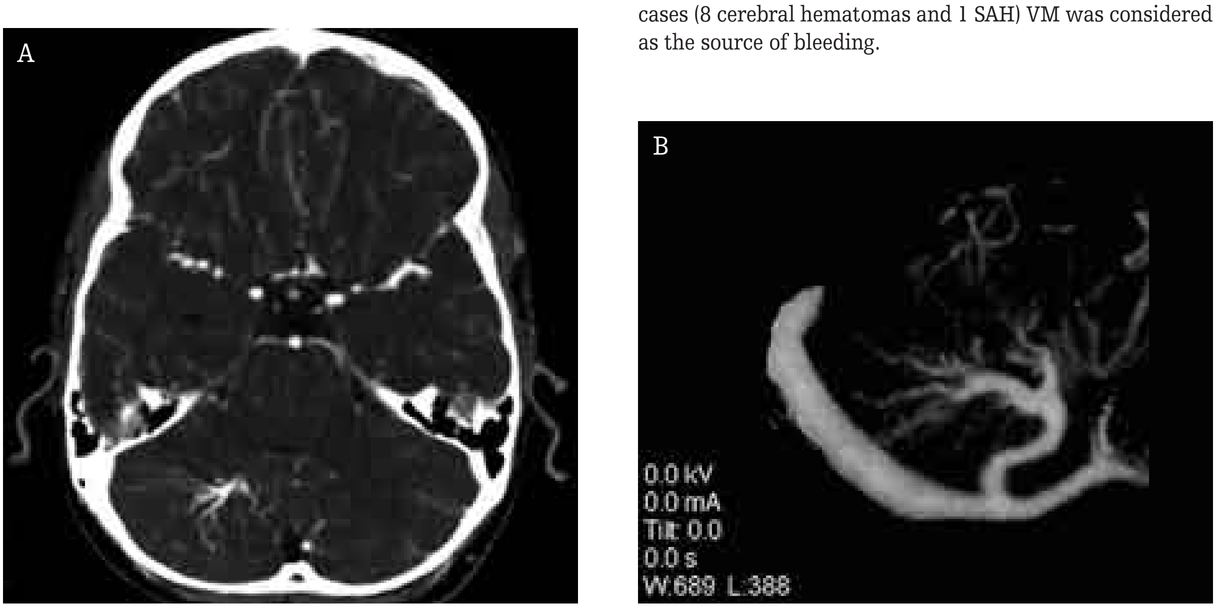

Figure 2. CT venography; **A.** partition, **B.** MIP. "Medusa head" in right cerebellar hemisphere: enlarged medullary veins draining into a larger collecting vein.
Rycina 2. Wenografia TK; **A.** partycja, **B.** MIP. „Głowa meduzy" w prawej półkuli móżdżku – poszerzone żyły rdzeniowe drenujące do szerokiej żyły.

Table 3. CT appearance of abnormal vein structures.
Tabela 3. Obraz TK nieprawidłowych struktur żylnych.

Patterns of abnormal vein structures	Number of patients	% of patients
"Medusa head"	29	58
Abnormal linear structures	17	34
Tortuous vessels	4	8
Total	50	100

Table 4. Location of VMs.
Tabela 4. Lokalizacja malformacji żylnych.

Location	Number of patients	% of patients
Supratentorial space	36	72
Frontal lobe	*20*	*40*
Parietal lobe	*7*	*14*
Occipital lobe	*5*	*10*
Temporal lobe	*4*	*8*
Infratentorial space	14	18
Total	50	100

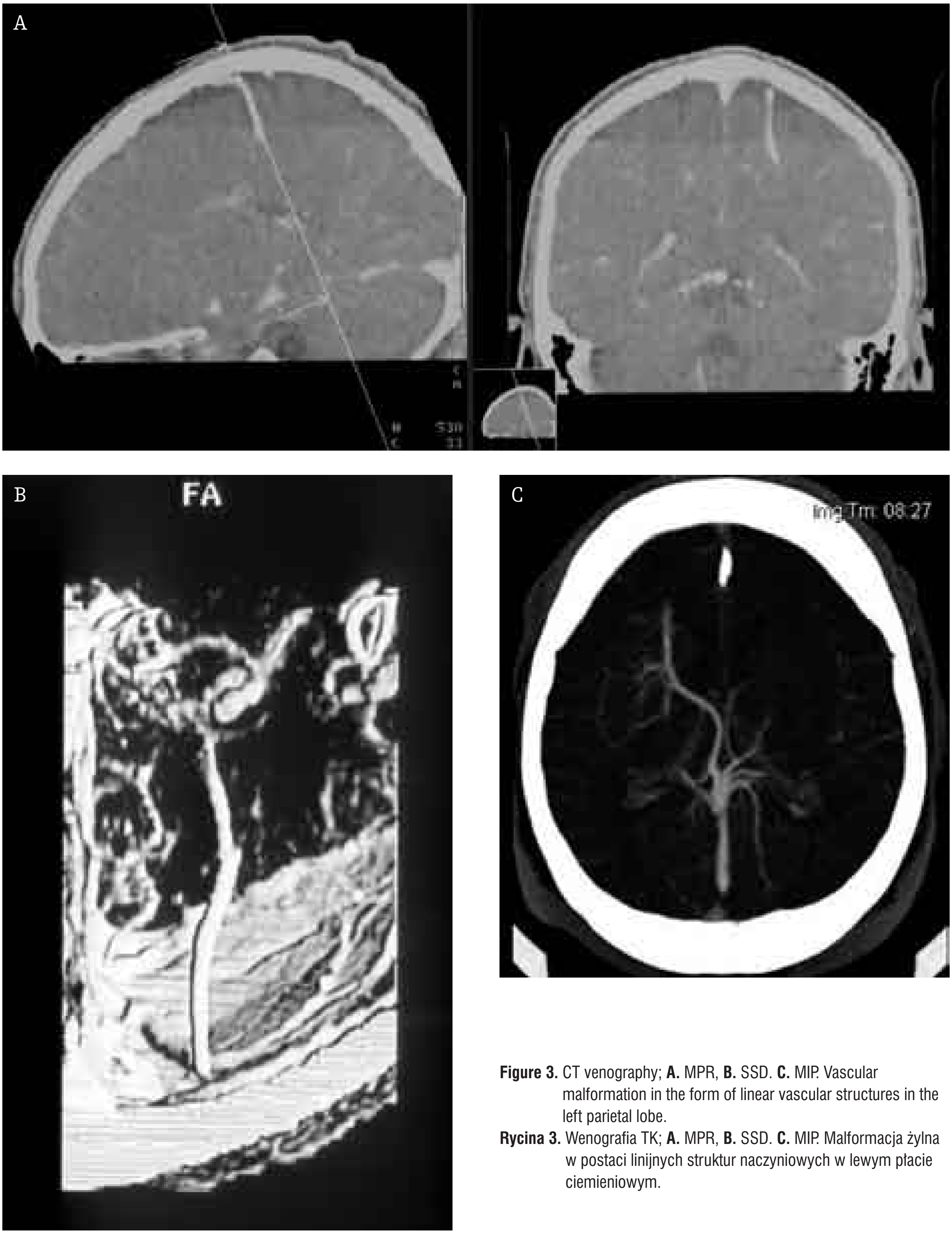

Figure 3. CT venography; **A.** MPR, **B.** SSD. **C.** MIP. Vascular malformation in the form of linear vascular structures in the left parietal lobe.

Rycina 3. Wenografia TK; **A.** MPR, **B.** SSD. **C.** MIP. Malformacja żylna w postaci linijnych struktur naczyniowych w lewym płacie ciemieniowym.

Discussion

Vascular malformations are commonly divided into 4 types: 1. arteriovenous malformations (AVMs) 2. cavernous angiomas (cavernomas) 3. capillary angiomas (teleangiectasias) 4. venous malformations [1, 14].

The natural history, clinical and imaging findings of first three categories mentioned above are well recognized. On the other hand venous malformations are still controversial. First of all there is no consensus concerning their clinical significance. Some authors claim that VM is an anatomical variant of cerebral venous system, without any clinical importance [2, 5]. Others consider VM as a potential source

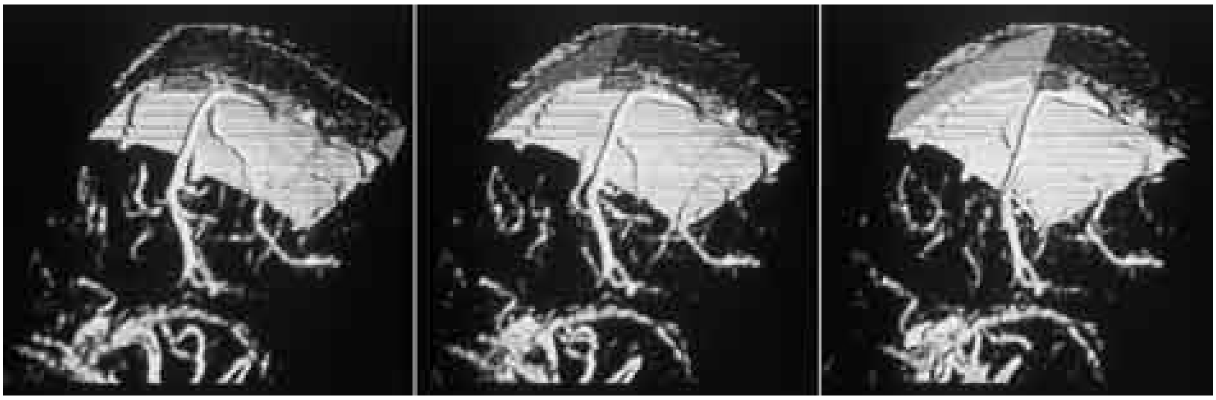

Figure 4. CT-venography: SSD. Vascular malformation in the form of tortuous vessels.
Rycina 4. Wenografia TK – SSD. Malformacja żylna w postaci krętych naczyń.

of venous infarction or intracranial hemorrhage [6, 7, 9, 11, 12, 13, 14]. Naff et al. evaluated the risk of hemorrhage associated with VM for 0,15% per lesion per year [6].

Many authors claim that hemorrhage occurs only in cases of VMs coexisting with other vascular malformation [7, 9, 11, 12, 13, 14]. This opinion has not been confirmed in our material because in 8 cases of cerebral hematomas and 1 case of SAH there were no other vascular malformations apart from VMs and bleeding was located close to abnormal veins.

Association of VMs and cerebral aneuryms was found in 4 out of 5 cases with subarachnoid haemorrhage. Locations of blood on CT indicated the aneurysm as the source of bleeding in 3 of 4 patients. Valavanis et al. claim that the most frequent form of intracranial hemorrhage associated with VM is subarachnoid hemorrhage [15]. Our results do not confirm this opinion, because only in one case VM has been suspected as the source of SAH.

VMs are usually single, although multiple lesions also occur [3, 21]. They are located intraaxially in any part of brain. According to Naff et al. 70% of VMs are located supratentorially, especially in frontal lobe [6]. In our material the distribution of VMs was very similar: supratentorial lesions accounted for about 75% of whole number, with predominance to frontal lobe.

Naff et al. noticed frequent paraventricular location of VMs, especially adjacent to frontal horn of lateral ventricle and to fourth ventricle [4, 6]. The intraventricular VMs have been also described [3, 4, 15]. In our material 6 VMs were located near frontal horn of the lateral ventricle, 5 were adjacent to 4th ventricle, and 3 other - to 3rd ventricle, while intraventricular VMs have been found in 2 patients. The total number of VMs associated with the ventricular system was 16 (about 1/3 of the whole number).

In the opinion of Trojanowski cerebellar VMs are more likely to bleed [1]. This is not compatible with our material, because only 2 out of 8 brain hematomas identified as originated from VMs were located infratentorially, while 6 supratentorially.

As it has been mentioned previously, VMs typically consist of small medullary veins drained by the large vessel. This vessel empties in turn into normal veins, either of superficial or deep venous systems [5, 14]. Posterior fossa VMs are drained by vein of Gallen, petrous and transverse sinuses or the confluence of sinuses [1, 2]. The most typical pattern is "medusa head", however in our material CTV revealed such apperance only in 58% of cases. The other malformations had less typical appearance, however the single draining vein was also present in this group of patients, hence we consider it as a very important diagnostic feature.

Imaging methods, which are helpful in diagnosing VMs include: CT, CT angiography of venous phase (CTV), MR, MR angiography of venous phase (MRV), conventional intraarterial angiography, DSA [9, 12, 14, 15, 16, 19, 21].

CT plays important role, because clinical findings are often not characteristic. First of all, plain CT should exclude or confirm intracranial hemorrhage. Detection of intraaxial or extraaxial blood is a direct indication to vascular imaging studies. If no hemorrhage is detected, the only sign which can direct our attention to VM is the presence of small slightly hyperdense linear structures located inside the brain [4]. Calcifications are uncommon and if they are present, the more probable diagnosis is cavernoma or tumor [4]. Postcontrast examination, which is mandatory in such cases shows a marked enhancement of the structures mentioned above, thus confirms their vascular origin. According to Trojanowski plain CT can reveal approximately 50% of VMs, while contrast-enhanced CT up to 90% [1]. However in our material abnormal vessels were found on contrast-enhanced CT only in 18 out of 50 cases (36%), while in 32 patients (64%) diagnosis was based on CTV (in some cases also on DSA or MRV). Therefore we believe that vascular imaging studies are necessary for proper diagnosis of VMs.

MR is considered as a gold standard in diagnosing cavernous angiomas. However in patients with VMs, MR appearance is variable depending on blood flow rate in pathological vessels. Some VMs depict signal loss due to fast flow, but in most cases the flow is rather slow, resulting in normal or even increased signal of VM's vessels [17]. Therefore in our opinion the role of MR in diagnosing VMs is limited.

Because of limited value of plain CT and MR the final diagnosis of VM, as has been already mentioned above, should be based on vascular imaging studies. Conventional intra-arterial angiography including venous phase is still the gold standard of diagnosing VMs [8, 15, 16], because thank to dynamic character of this study it can definitely exclude AVM, if pathological vessels are visible only in venous phase. As the abnormal veins of VMs are often very small, digital subtraction angiography (DSA) is preferred in these cases [17].

Despite the advantages of angiography described above, it is an invasive study, which should be avoided if it is possible, especially in cases without hemorrhage. The non-invasive methods like CT angiography and MR angiography play increasing role in all intracranial vascular malformations, especially aneurysms [22]. However, their value in VMs has been not established yet.

MR venography enables entirely non-invasive visualization of intracranial vessels. However due to same reasons as with plain MR (small-caliber veins with slow flow) VMs may be difficult to be assessed precisely with MRV [17], although in our two patients MRV visualization of VMs was quite convincing. Recent introduction of MR angiography after intravenous injection of paramagnetic contrast medium may improve capabilities of this method in the patients with VMs [23].

On the other hand our material of 50 cases demonstrates high value of CTV in assessing VMs. CTV has a higher contrast resolution comparing to MRV and is not dependent on blood flow rate. With this method abnormal venous patterns can be depicted in any plane not worse than with conventional angiography [17]. The only disadvantage is difficult differentiating of pathological veins from arteries. However if there is typical pattern of VM as it was described above, diagnosis can be made in our opinion exclusively on the base of CTV. We think intraarterial angiography should be reserved for malformations accompanied by hemorrhage, as well as for cases of combined vascular malformations and with atypical pattern of VM, which requires excluding of other types of vascular malformations.

Conclusions

CT venography is an efficient method of diagnosing VMs, which in most cases could replace intraarterial angiography.

Intraarterial angiography should be performed if CTV appearance is atypical, in patients with hemorrhage or multiple vascular malformations.

Our material supports the opinion that VMs can be complicated by intracranial hemorrhage, especially intracerebral hematomas.

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