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Traumatic Lesions of Middle Meningeal Artery in Association with Extradural Hematoma

by

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As carotid angiography becomes an increasingly popular technique in the aid of diagnosis of intracranial hematomas, attention is being focused on the differential diagnosis between extradural and subdural hematomas on the angiogram. Some criteria have been mentioned in this regard[3),4)]. Among these, the most characteristic feature of the extradural hematoma on the angiogram is a displacement of the middle meningeal arterial channels away from the inner table of the skull. This finding was seen in 23 out of 46 cases (50%) of extradural hematoma in which common carotid angiography was done preoperatively in our clinic.

The main source of extradural clots is a tear of the middle meningeal artery or of its branches, particularly in the classical acute cases. Extravasation of contrast medium through a tear in the middle meningeal artery provides a reliable indication of extradural hematomas in angiographic diagnosis, but the actual demonstration by angiography of a hemorrhage occurring from this artery has been thought to be a very rare occurrence[30)].

In our experience, however, the extravasation of contrast medium is not such an uncommon finding in the cases of extradural hematoma; this particular feature was found on preoperative angiograms in 14 out of 46 cases (30%).

Furthermore, aneurysm of the middle meningeal artery, which is also a rare clinical entity[1),16)] was demonstrated on angiograms in two other cases in our series. The angiographic features of these 16 cases of traumatic lesions of the middle meningeal artery are reported in this paper.

There were 9 acute cases, operated on within 72 hours from the time of injury, and 7 subacute or chronic cases, operated on later than 72 hours following injury. The two cases with pseudoaneurysm of the middle meningeal artery were operated on 7 days and 22 days, respectively, following trauma. Of the 9 acute cases, 5 patients died (mortality 55.6%), while all of the subacute and chronic cases are alive.

In all cases, skull fractures were demonstrated on plain films or were found

during operation. Fracture lines crossed the middle meningeal artery or one of its major branches in all cases, and the extravasation of contrast medium, as well as the pesudoaneurysms, was localized at or near the junction of the fracture line and the artery.

On anteroposterior angiograms, a shift of the anterior cerebral artery toward the contralateral side was observed in 13 cases, while in 3 cases the anterior cerebral artery was not opacified. An avascular space between the vault of the skull and the surface of the brain was demonstrated in 12 cases. In the other four cases, anteroposterior angiograms revealed the hematomas to be localized in the low temporal region without any avascular space.

Extradural clots were removed through the large craniotomy in all patients. In most cases the main situation of the hematoma corresponded to the site of the lesion of the middle meningeal artery. The localization of the hematoma was found during operation to be frontal in 2 cases, temporal in 11, and parietal in 3.

In all cases the extravasation of contrast medium was seen in both the anteroposterior and lateral view of the angiogram, while that shown on both arterial and venous phases in 10 on anteroposterior view and 8 on lateral view. In the others, the extravasation was verified only by either arteriogram or phlebogram.

The extravasations appeared in various configurations and sometimes even as different figures in one individual. In some cases the extravasations presented different appearances between arteriogram and phlebogram or between anteroposterior and lateral views.

Table 1. Extravasations of contrast medium from the middle meningeal artery classified according to configuration and their frequency of appearance in the different projections and sequences of carotid angiograms.

Types of Extravasate shadows	AP Arteriogram	AP Phlebogram	Lateral Arteriogram	Lateral Phlebogram
Single Globular or Triangular	3	3	5	0
Multiple Spotty or Fleckly	1	1	1	4
Irregular Clubbed or Bead-like	4	6	2	3
Radial	2	1	2	0
Linear	1	1	1	2
Tram-track-like	0	0	3	0
Total	11	12	14	9

As can be seen from Table 1, an attempt was made to classify by configuration of the extravasate shadows appearing on the angiograms. Single globular or triangular shadows were most frequently seen on lateral arteriograms, while multiple spotty or fleckly shodows were observed more often on lateral phlebograms. A signle spot attached to a branch of the middle meningeal artery resembled a leaf on a twig in the anteroposterior orbital view (Fig. 1). The multiple spotty or fleckly shadows appeared as a crowd of fine spots within a limited area (Fig. 2) or as scattered flecks along the course of the middle meningeal artery (Fig. 3).

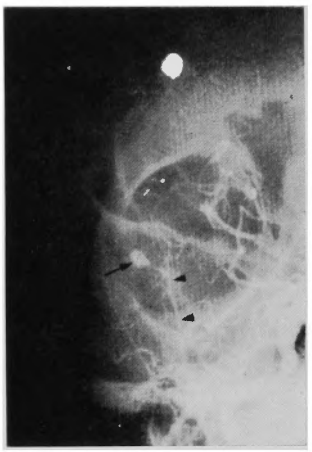

Fig. 1. Right common carotid angiogram, anteroposterior orbital view, of early arterial phase. The black arrow indicates a single globular form of extravasation of contrast medium which appears as a leaf on a twig coming from the middle meningeal artery (the black arrowheads).

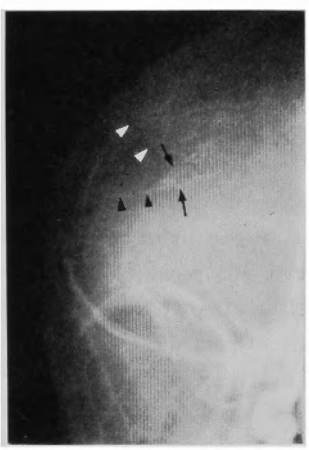

Fig. 2. Right common carotid angiogram, anteroposterior view, of early arterial phase. The arrows indicate multiple spotty shadows of extravasation of contrast medium. The parietal branch of the middle meningeal artery is stretched and compressed by a huge extradural hematoma (the two black arrowheads). The white arrowheads indicate a fracture line.

Fig. 3. Right common corotid angiogram, lateral view, of late arterial phase. Diffusely scattered flecks of extravasation of contrast medium is seen along the course of the branches of the meningeal artery.

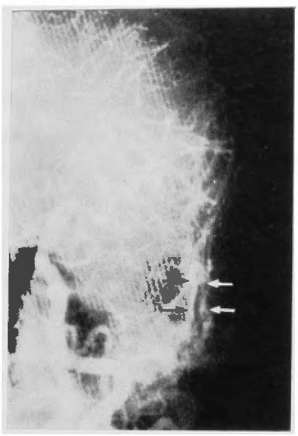

Fig. 4. Left common carotid angiogram, anteroposterior view, of arterial phase. Irregular clubbed form of extravasation of contrast medium is indicated by the black arrows. The shadow is bent in its uppermost portion and appears worm-like. The two white arrows indicate the parietal branch of the middle meningeal artery which is compressed by an extradural hematoma.

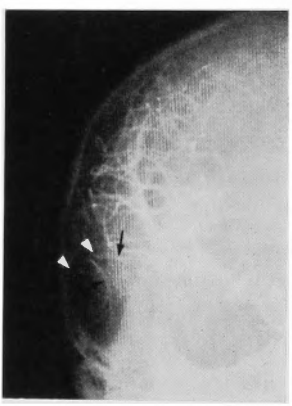

Fig. 5. Right common carotid angiogram, anteroposterior view, of arterial phase. The two black arrows indicate a radial form of extravasation of contrast medium from the middle meningeal artery. The extravasation resembles a spray which originate at the fracture line (the two white arrowheads). The proximal part of the middle meningeal artery is not traceable in this case.

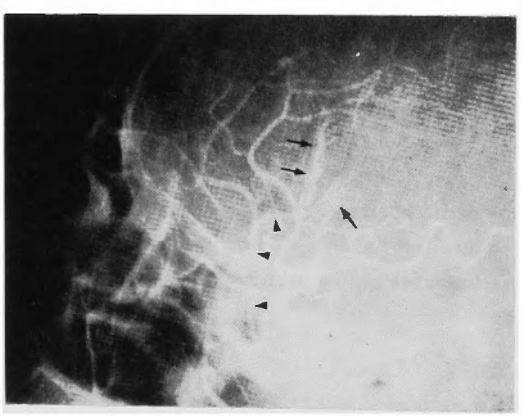

Fig. 6. Right common carotid angiogram, lateral view, of early arterial phase. The three streaks of flame-like extravasate shadow which radiate from the middle meningeal artery are shown by arrows. The three arrowheads indicate the main trunk of the middle meningeal artery.

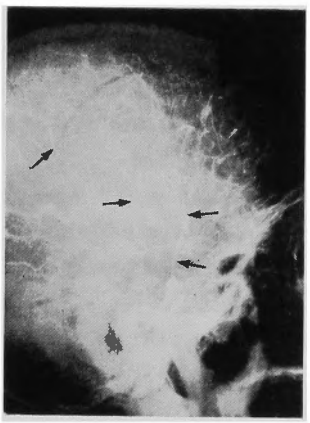

Fig. 7. Left common carotid angiogram, lateral view, of early venous phase. The arrows indicate extravasates of contrast medium, showing linear form.

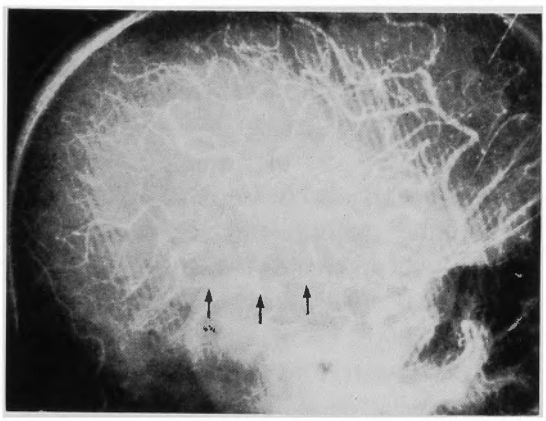

Fig. 8. Left common carotid angiogram, lateral view, of arterial phase. Three parallel lines are seen running along the course of the temporal branch of the middle meningeal artery, showing a "tram-track" appearance.

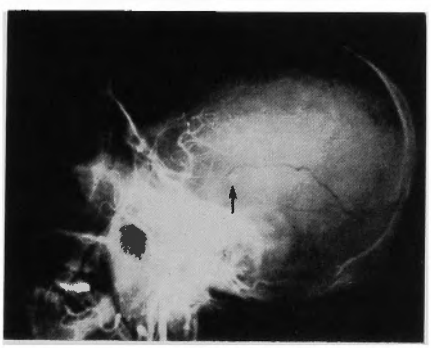

Fig. 9. Right common carotid angiogram, lateral view, of early arterial phase. The round shadow of a pseudoaneurysm of the middle meningeal artery is indicated by the arrow. It is localized at the bifurcation of the temporal branch of the middle meningeal artery near the crossing of the artery and the temporo-occipital skull fracture.

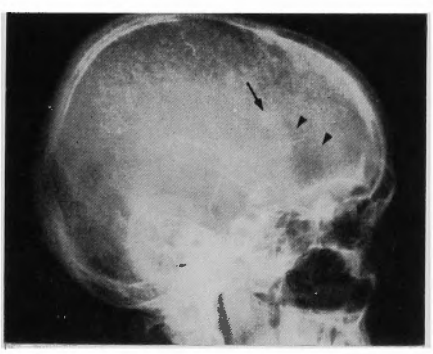

Fig. 10. Left common carotid angiogram, lateral view, of early arterial phase. The oval shadow of a pseudoaneurysm of the anterior branch of the middle meningeal artery is indicated by the arrow. The two arrowheads indicate a hair-line fracture of the frontal bone.

The commonest appearance of the extravasates in the anteroposterior view was an irregular clubbed or bead-like shadow, but this was less common on the lateral angiograms. The width of the shadows was not always uniform and sometimes the shadow bent irregularly, presenting a worm-like appearance (Fig. 4).

Radial shadows resembling a spray (Fig. 5) or flames (Fig. 6) were the most distinctive feature of the radial extravasates. The shadows originated from the site of tear in the middle meningeal artery, corresponding to the crossing of fracture line and the arterial channel in the most cases, and spread widely. This type of extravasate was seen more often in the arterial phase than in the venous phase, in both anteroposterior and lateral projections.

Linear shadows were relatively few. (Fig. 7). A particular feature of extravasate is the appearance of two or three parallel lines, creating a "tram-track" appearance (Fig. 8.) LESLIE, et al[18], have stated that this represents the paired middle meningeal veins on either side of the artery. This was observed on only the lateral angiograms in 3 cases and suggested the leak of contrast medium via an arteriovenous fistula of the meningeal vessels.

The angiographic appearance of the two pseudoaneurysms of the middle meningeal artery was most illustrative. One was seen as a round shadow, 5 mm in diameter, at the bifurcation of the posterior branch of the middle meningeal artery, close to the fracture line (Fig. 9). The other appeared as an oval shadow, 12 × 9 mm, on th course of the anterior branch of the middle meningeal artery at the junction with the hair-line fracture in the frontal bone (Fig. 10). Both aneurysmal shadows had the characteristic feature of increased peripheral density with distinct, smooth borders. Both shadows were opacified during the arterial phase, and were located at the lower edge of the avascular space, in contact with the inner table of the skull on anteroposterior angiograms.

Operation revealed the pseudoaneurysms to be at the sites indicated by the angiographic demonstrations in both cases, although no histological study was made.

DISCUSSION

A traumatic extravasation is the leakage of contrast medium during angiography from a torn artery injured by trauma. The first description of intracranial extravasation was made by LÖHR in 1936[21], and has been followed by several others.

Angiographic demonstrations of extravasates from ruptured middle meningeal arteries have been reported by JAMIESON (1952)[13], LINDGREN (1954)[19], LOFTSTROM, WEBSTER and GURDJIAN (1955)[20], VAUGHAN (1959)[21], TIWISINA and STÄCKER (1959)[29], HUBER (1962)[12], LESLIE, SMITH and ZOLL (1962)[18], CRONQVIST and KÖHLER (1963)[3], WORTZMAN (1963)[32], HIRAI et al (1965)[9], SCHECHTER, ZINGESSER and RAYPORT (1966)[27], WEINMAN and JAYAMANNE (1966)[31], KATSURADA, SUGIMOTO and KURODA (1968)[14], and KURAMOTO et al (1969)[17].

The angiographic demonstration of the extravasation of contrast medium from the torn middle meningeal artery is not as infrequent as had earlier been believed in the cases of extradural hematoma. Recent literature has shown, in agreement with

my opinion, a relatively high incidence of this particular feature on angiograms. HUBER[12] reported in 1962 that the visualization on angiograms of extravasates of contrast medium from the middle meningeal artery was found in 7 of 24 cases (29%) of extradural hematoma. WORTZMAN[32], in 1963, also noted the same finding in 4 of 12 cases (33%). These figures are quite in accord with our own of 30%.

Observation of this extravasation from the middle meningeal artery is not possible when the internal carotid artery has been selectively punctured, and therefore common carotid angiography is desirable in diagnosis of extradural hematoma. Some authors have recommended the use of selective external carotid angiography[8),24),26)]. In our experience, however, common carotid angiography is sufficient to produce clear shadows of extravasation from the middle meningeal artery. My opinion is that prolonged time spent for preoperative examination is inappropriate in emergency cases. Therefore, common carotid angiography may be a method of choice for such cases, because it is not only the easiest approach to be punctured, but is also useful for studying changes in the internal carotid system, such as midline shift of the anterior cerebral artery or avascular space with a collection of blood beneath the skull, as well as lesions of the meningeal vessels.

HUBER[12] stated that the shorter the interval between trauma and angiography, the greater the posssibility was of observing the shadows of extravasation. In his report he stated that no extravasate shadow was seen in those cases in which more than 32 hours had elapsed from the time of trauma to the time of angiography. In our patients, however, in 8 of 14 cases, angiography was performed within 48 hours from the time of injury, and the other 6 cases were examined later than 3

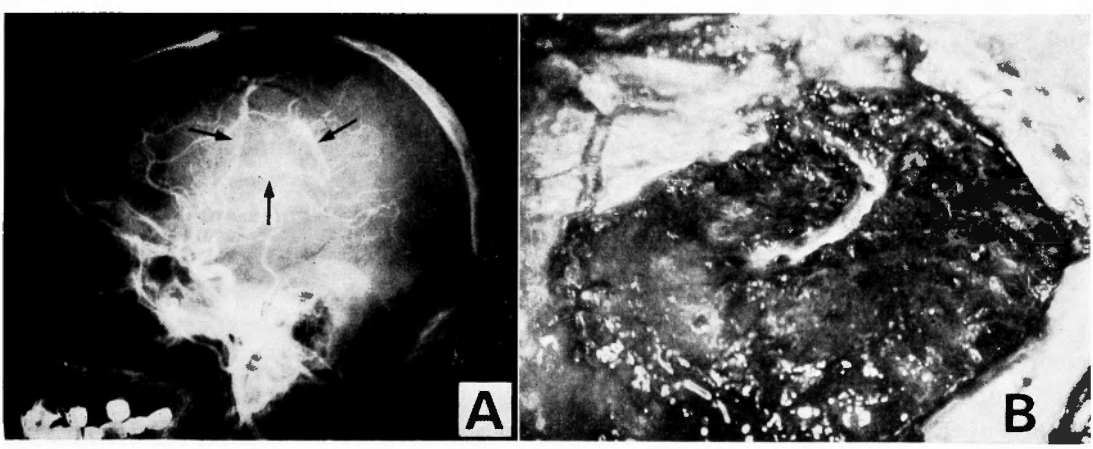

Fig. 11. (A) Right common carotid angiogram, lateral view, of arterial phase. Irregular clubbed form of extravasation of contast medium is indicated by arrows.

(B) Photograph taken during operation of the same patient. Part of an extradural clot is removed, and narrow tunnel communicating with arterial lumen is excavated. The floor of the tunnel constructed by smooth dural surface is clearly seen. The configuration of the tunnel corresponds to extravasation shadow appearing on the angiogram.

days after the trauma. This is not in accord with HUBER's description. Among those, it is surprising that two patients having a prolonged course of 2 weeks also showed such particular appearance on angiogram. An explanation for such a delayed occurrence of extravasation may be that the unusually high pressure exerted into the lumen of the artery during angiography caused a second rupture at the site of arterial tear, which had already been sealed by a clot.

In a patient having a course of 15 days following the trauma, we found a tunnel within extradural clot corresponding extravasation shadow on angiograms during operation (Fig. 11). The floor of this tunnel was constructed by smooth dural surface and it formed a channel permitting leakage of blood from the torn meningeal artery. This fact leads to another explanation for such a delayed occurence of extravasation; continuous leak of pulsatile arterial flow may allow to constitute a narrow free space encapsulating by clot, and this space remains for a considerable period following completion of clot formation, preserving a communication with the arterial lumen. In fact, this type of extravasation is rather similar to a pseudoaneurysm of the meningeal artery on the basis of its pathogenesis.

The appearance of extravasates on angiograms varies from case to case and according to angiogram projection and phase. Despite such variation, however, several of the configuration of the extravasates show some common chracteristics, so as to allow classification into several groups on a morphological basis. I classified the configurations into six groups.

SCHECTER and his coworkers[27] classified the extravasation of contrast medium from the torn middle meningeal artery on the basis of the particular protective mechanism which operated on the hemorrhage from the ruptured artery: (a) leak into epidural space— no protective mechanism; (b) fistula formation between arterial and venous channels; (c) leak through fracture line into subgaleal area; and (d) paseudoaneurysm formation.

The majority of our cases, excepting the "tram-track" type of extravasation, belong to the group without protective mechanism, but the fact that the extravasation of medium has also been demonstrated even in some cases with prolonged course is not compatible with their theory. In this respect, it should be remembered that the increasing pressure of the hematoma may also serve as a protective mechanism against continued hemorrhaging from the torn artery.

We experienced two unusual infantile cases in which extradural hematoma communicated to the subgaleal space through wide skull fractures[7], These cases were successfully treated by repeated subgaleal punctures because of the semi-liquid nature of the contents of the hematoma. In these patients no extrvasation of contrast medium through the fracture line, as described by SCHECHTER et al[27], was demonstrated on the angiograms.

The angiograms also revealed in three cases extravasations of a "tram-track" appearance, double or triple parallel lines along the course of the midle meningeal arterial channels. This particular appearance is explained as a direct middle meningeal arteriovenous fistula, or as an escape of contrast medium from a ruptured artery along both sides of the artery[32]. SCHECHTER et al[27], thought that such an

arteriovenous fistula served as a protective mechanism aganist massive hemorrhaging from the ruptured artery. VAUGHAN[30] also suggested that with rising pressure in the extradural hematoma, reabsorption of blood may occur via the venous channels. In fact, according to the description by SCHECHTER et al.[27], one of their cases with a middle meningeal arteriovenous fistula formation recovered completely without surgery.

They apparently identified the pseudoaneurysm as extravasation of medium, thinking that the pseudoaneurysm was a protected form of extravasation[27], though the two have been reported as different entities by others. On the contrary, HOLLAND and THOMSON[11] emphasized that it is necessary to distinguish between traumatic extravasates and aneurysms.

In my opinion, the pseudoaneurysm has a somewhat different angiographic appearance from the single globular form of extravasates. The characteristic appearance of the pseudoaneurysm is a round or oval shadow, with increased peripheral density and a distinct, smooth border, on the course of one of the branches of the middle meningeal artery.

The first case of traumatic aneurysm of the middle meningeal artery shown by angiography was described by POUYANNE et al[25] in 1959. Seventeen cases of traumatic aneurysm of the middle meningeal artery have so far been reported in world literature[1),5),8),10),11),15),16),22),24)),25),27),28)]. Developemental aneurysmal malformations of the meningeal vessels have also been reported by several suthors[2),23)]. All of the 17 cases reported were traumatic in origin, while one of the 3 pseudoaneurysms reported by HOLLAND and THOMSON[11] had had no history of head injury, although the pseudoaneurysm was accompanied by extradural hematoma, with a spontaneous onset of severe symptoms.

A traumatic aneurysm of the middle meningeal artery is not necessarily a false aneurysm. A case reported by AULD et al[1] was revealed to be a true aneurysm with a lining of intima, which was continuous with the main vessel.

The fact that, in the majority of reported cases, aneurysms of the middle meningeal artery were situated at or near the fracture line, and anatomical speciality of the meningeal artery that was pointed out by HASSLER[6] as a congenital defect of tunica media are enough to explain the susceptibility of the middle meningeal artery to aneurysmal formation sebsequent to trauma.

Unlike the cases with extravasation of contrast medium, the majority of the reported cases of traumatic aneurysms of this artery exhibited a subacute clinical course; our 2 cases also had courses of one and 3 weeks respectively. Such a delayed manifestation of aneurysms indicates a favorable protective mechanism operating against rapid hemorrhaging from the ruptured artery, as emphasized by SCHECHTER et al[27]. Perhaps the caliber of the artery may not be large enough to permit a rapid and forceful spout from the site of the tear, and the clotting mechansim of the extravasated blood may help to seal off the tear.

However, clinical importance exists in the possibility of a delayed rupture of the aneurysmal sac. If this occurs, the outcome of the patient may be endangered. MARKWALDER and HUBER[22] reported on two cases in which traumatic aneurysm of the meningeal artery caused secondary rupture and led to fatal hemorrhage.

SUMMARY

In spite of common knowledge that the lesion of the middle meningeal artery is a cause of traumatic extradural hemorrhage, angiographic demonstration of the extravasation of contrast medium from the torn meningeal artery has been regarded as a very rare occurrence. We encountered such extravasation on angiograms in 14 cases, corresponding to 30% of the cases with extradural hematoma in which the common carotid angiography was performed preoperatively. In addition, pseudoaneurysms of the middle meningeal artery, which are also very rare entities, were demonstrated in angiograms in two cases in this series.

Although the appearance of the extravasation of contrast medium in angiograms varies according to projection and phase of the angiogram, the configurations were classified into six basic groups: single globular or triangular; multiple spotty or fleckly; irregular clubbed or bead-like; radial; linear; and tram-track-like.

The angiographic appearance of aneurysmal sac of the middle meningeal artery has a characteristic feature, Allowing it to be easily differentiated from a simple extravasation: it is a smoothly-outlined round or oval shadow with increased peripheral density.

Angiographic demonstration of traumatic lesions of the middle meningeal artery gives a clear indicator in the differential diagnosis between extradural and subdural hematomas, and the correct preoperative diagnosis helps considerably in surgery. Therefore, puncture of the common carotid artery at the time of angiographic examination is advisable in the cases of suspected intracranial hematoma, and careful scrutiny of the course of the middle meningeal artery on angiograms is necessary.

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和文抄録

外傷性硬膜外血腫の脳血管写にみられる中硬膜動脈の破綻像について

山口大学医学部外科学教室第2講座（主任：石上浩一教授）

東　　健一郎

最近では脳血管写が広く行なわれるようになって，外傷性頭蓋内血腫の診断は比較的容易となったが，硬膜外血腫と硬膜下血腫との鑑別診断については，まだ充分な注意が払われていないようである．

硬膜外血腫に特有な脳血管写像としては，中硬膜動脈の血腫底への弧状の圧迫像があり，これは通常前後像動脈相でみられるものである．われわれは46例の外傷性硬膜外血腫の患者に，術前に総頸動脈穿刺による頸動脈写を行ない，その半数にこのような所見を確認した．したがって頭蓋内血腫の血管写診断に際しては，脳血管の偏位ばかりではなく硬膜血管の走行にも注意を払えば，術前に硬膜外血腫の診断のつく場合がすくなくない．

一方硬膜外血腫は大部分が中硬膜動脈の破綻によっておこるのであるから，新鮮な血腫症例では，中硬膜動脈からの造影剤の脈管外漏出像をみとめることがある．このような所見は硬膜外血腫に特有なものであり，この所見がみとめられれば，硬膜外血腫と診断してほとんどまちがいない．

このような中硬腫動脈破綻部位からの造影剤の漏出像は，以前は稀なものとされていたが，注意してみるとかなりの頻度に出現するもので，われわれの経験では46例中14例（30%）にこの所見をみとめた．

血管写フィルム上にみられる中硬膜動脈からの造影剤の漏出像は，前後像と側面像とで，あるいは動脈相と静脈相とでその形状が異なるものもあるが，その形状を次の6つの形に分類した．(1)単一球状あるいは三角形，(2)多発性点状あるいは斑状，(3)不規則楔状あるいは珠数状，(4)放射状，(5)線状，(6)軌道状．

単一球状あるいは三角形の陰影は側面像動脈相に最も多くみられるが，多発性点状あるいは斑状の陰影は側面像静脈相に多くみられた．不規則楔状の陰影は前後像に多くみられた．放射状の陰影は，中硬膜動脈が骨折線と交わる点の近くからスプレー様または扇状，あるいは焔状にひろがるもので，，前後像・側面像ともに動脈相に多くみられた．線状の陰影は比較的すくないものであるが，その変形として軌道状の陰影がある．これは中硬膜動脈の走行に一致して2条あるいは3条の平行線がみられるもので，中硬膜動静脈間に動静脈瘻が存在するか，あるいは動脈の両側にこれに沿う造影剤の漏出がおこるためにみられるといわれる特異な陰影である．

次に，血管写における造影剤漏出像の一種とも考えられるが，中硬膜動脈の偽動脈瘤もまた硬膜外血腫に際して稀にみられるもので，われわれは46例中2例にこのような陰影をみとめた．この偽動脈瘤は，中硬膜動脈の走行に一致してみられる円形または楕円形の，平滑かつ明瞭な輪廓を有し，周辺部が中央部よりも濃い陰影として造影される．

以上の脳血管写上にみられる中硬膜動脈の破綻像は，当然のことながら外頸動脈の末梢に出現するものであるから，内頸動脈穿刺によっては発見できない．頭蓋内血腫の診断に際しては，脳血管の異常，たとえば前大脳動脈の正中線からの偏位であるとか，無血管領野などの発見とともに，中硬膜動脈の異常をも発見することを期待すれば，総頸動脈写を行なうことが必要である．また通常は見逃されがちな，中硬膜動脈の走行を注意深く読影することによって，かなり高率に硬膜外血腫の的確な診断がなされうる．