The Reliability of Hyperdense Fillings on Infusion Computerized Tomography of Patients with Intracranial Aneurysms

Kafa İçi Anevrizması Olan Hastalarda Kontrast Madde İnfüzyonuyla Çekilen Bilgisayarlı Tomografide Hiperdens Lezyonların Güvenilirliği

SERHAT ERBAYRAKTAR, E. METİN GÜNER, ÜMİT D. ACAR, ZAFER YÜKSEL

Dokuz Eylül University School of Medicine Department of Neurosurgery, İzmir, Turkey

Abstract: Computerized tomography is highly reliable in the diagnosis of subarachnoid haemorrhage, especially during the first week. When contrast material is administered, it is also possible to demonstrate an aneurysm. In this retrospective study, we looked for any relationship between hyperdense fillings on infusion computerized tomographic scans and angiographic aneurysm size since it could be helpful in making a decision for an angiogram on a patient with a possible incidental aneurysm or a suspicious warning leak. In addition, the demonstration of the presence of a ruptured aneurysm in a moribund patient with intracerebral haematoma could lead to simultaneous clippage and haematoma removal at the same stage. We investigated 120 patients with an angiographically proven aneurysm. The sizes of the aneurysms were in a positive correlation with the hyperdense computerized tomographic fillings. The size of the aneurysm was important especially in anterior communicating and middle cerebral artery aneurysms for computerized tomographic demonstration. Best correlations were observed in aneurysms greater than 16.0 mm in diameter. The accuracy of angiographic detection of an aneurysm in 96 patients with hyperdense CT fillings was 94%.

Key Words: Cerebral aneurysm, infusion computed tomography, subarachnoid haemorrhage

Özet: Bilgisayarlı tomografi subaraknoid kanama tanısında özellikle birinci hafta içinde oldukça güvenilirdir. Kontrast madde verildiğinde ise bir anevrizmayı gösterebilmek olasıdır. Bu geriye dönük çalışmada, rastlantısal anevrizması olabilecek yada uyarıcı sızıntı şüphesi olan bir hastada anjiografi kararının verilmesine yardımcı olabileceği düşünülerek kontrastlı bilgisayarlı tomografide izlenen hiperdens dolumlar ile anjiografik anevrizma boyutu arasındaki ilişki araştırılmıştır. Ayrıca intraserebral hematoma bağlı kötü durumda olan bir hastada rüptüre bir anevrizmanın bulunduğunun gösterilmesi de hematom boşaltılması ile aynı seansta anevrizmanın klipajına da olanak sağlayabilecektir. Anjiografik olarak anevrizması saptanan 120 olgu araştırıldı. Anevrizma boyutları ile bilgisayarlı tomografideki hiperdens dolumlar arasında olumlu bir ilişki mevcuttu. Anevrizma çapları özellikle anterior ve posterior komünikan anevrizmalarının bilgisayarlı tomografide gösterilmesinde önemliydi. Bu ilişki en iyi olarak 16mm'den büyük anevrizmalarda gözlendi. Bilgisayarlı tomografide hiperdens dolum saptanan 96 olguda anjiografik olarak anevrizma saptama oranı ise %94'tü.

Anahtar Sözcükler: İnfüzyon bilgisayarlı tomografi, serebral anevrizma, subaraknoid kanama.

INTRODUCTION

In the diagnosis of subarachnoid haemorrhage (SAH) and intracranial aneurysms, computerized tomographic (CT) findings may not be specific and angiography is necessary to delineate the nature of the lesion(13). CT may, however, offer a more accurate information about the actual size of the aneurysm since only the lumen of the aneurysm can be visualized on angiograms. Thus, CT may show the presence of haematoma and its associated effects on the brain when the aneurysm has ruptured (17). In the cases with aneurysmal haematomas, the accuracy in predicting the site of bleeding ranges from 100% for aneurysms of the anterior cerebral artery complex to 66% for those of the internal carotid artery (ICA)-proximal middle cerebral artery (MCA) complex (4). When infusion computed tomography scans which require approximately 10 to 15 minutes to perform are obtained, it is possible to detect 97% of aneurysms greater than 3-5 mm in size(10,16). These contributions of CT scanning may be important especially in the demonstration of an aneurysm in a patient admitted with suspicious warning signs of SAH, or an incidental aneurysm of a patient suffering from another pathology and in detecting ruptured aneurysms of a moribund patient with an intracerebral haematoma(9).

The aim of this study was to investigate the reliability of hyperdense fillings which were predicted as a possible enhancement of an aneurysm on infusion CT scans, and its relationship with the aneurysm size that was measured retrospectively on angiograms with a new method.

MATERIALS and METHODS

The medical reports of 271 patients who had been investigated for the demonstration of an aneurysm, were retrospectively reviewed. Incidental aneurysm was detected in 23 of them, and a subsequent operation was performed in all (Figure 1). Patients with multiple or intracavernous aneurysms, and insufficient medical records were excluded. Cases with incidental aneurysms were also not included in the statistical analysis. All of the cases had undergone a plain CT scanning, and contrast material was administered to only 134 (79%) of them. Among these 134 patients, 22 (16%) had intracerebral haematomas(ICH). In 18 (82%) of the cases with ICH, a hyperdense filling on infusion CT scan was observed and 4 of them had undergone to simultaneous urgent haematoma removal and clippage procedure(Figure 2). Three of them had survived. A subsequent angiography that had been performed after a hyperdense filling was found on infusion CT scan, revealed a ruptured aneurysm in 120 (90%) of them, and a detailed review of these 120 patients was presented in this study. Thirty-seven (31%) of these cases were admitted after an attack of warning leak, and infusion CT scanning was able to visualize a hyperdense filling suggesting an aneurysm in 29 (78%) of them (Figure 3).

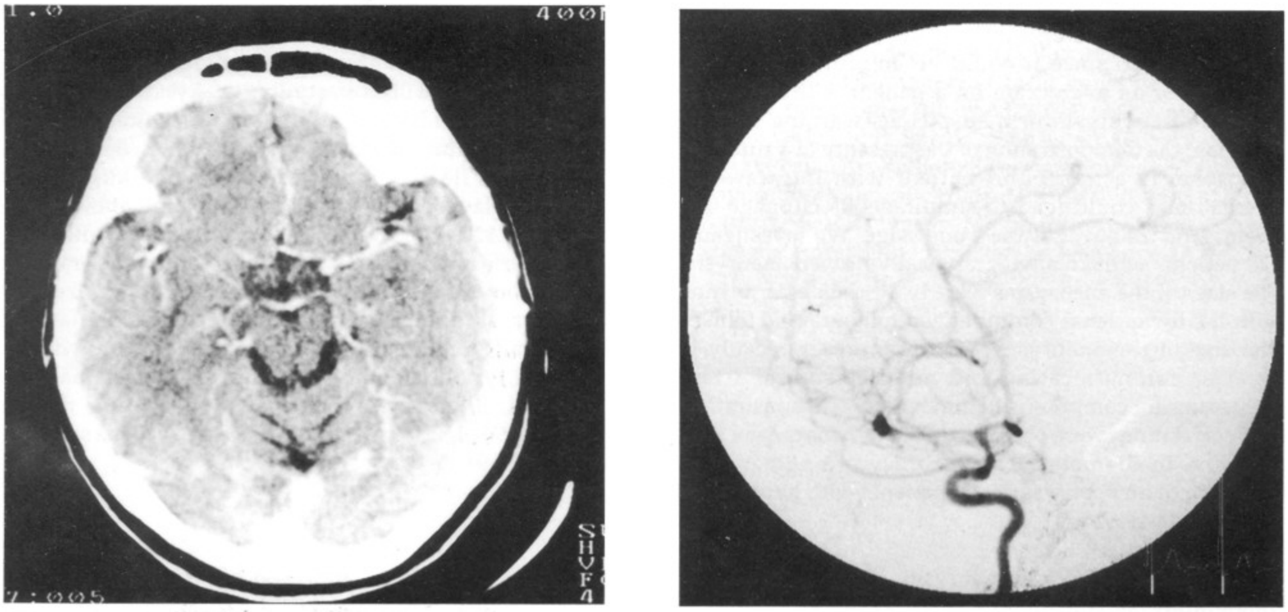

Figure 1 a. Preoperative CT scan of a 56 -year-old patient with chronic headache, demonstrating a hyperdense filling at the left MCA bifurcation, b. carotid angiogram revealing an aneurysm of the left MCA bifurcation.

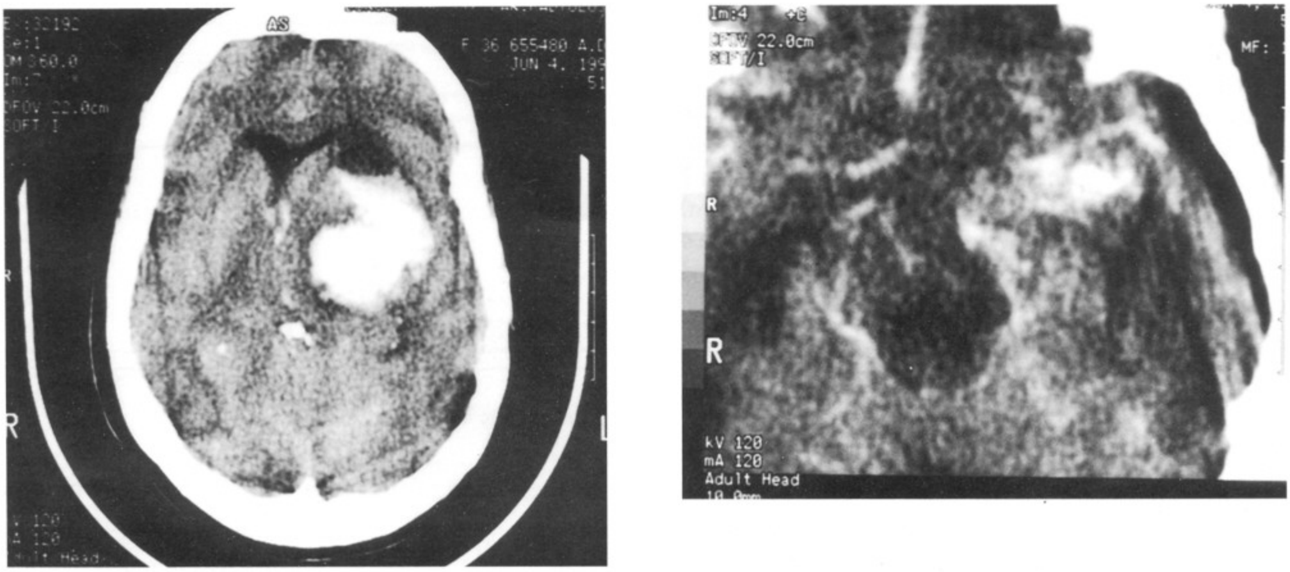

Figure 2 a. Preoperative CT scan demonstrating a large left perisylvian haematoma extending to the basal ganglia in a 56 year-old patient, b. Infusion CT scan which had been photographed at intermediate window showed a hyperdense filling on the left MCA branch. Patient immediately underwent simultaneous removal of haematoma and clippage of the aneurysm, which was located on the M2 segment of the left MCA.

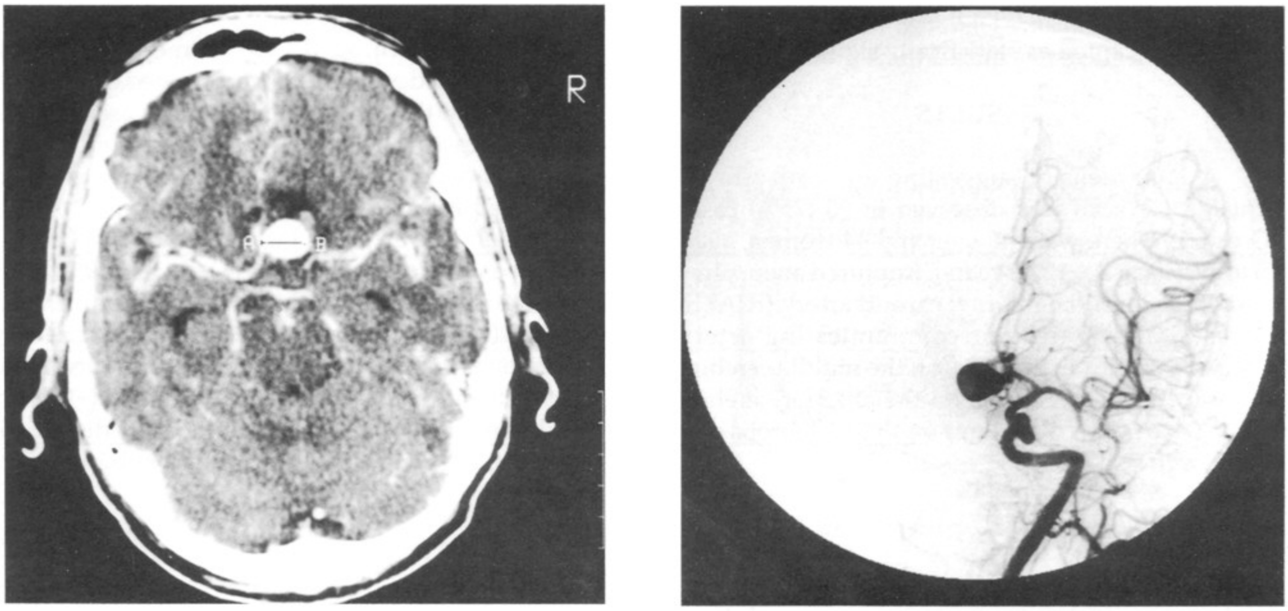

Figure 3 a. Preoperative infusion CT scan of a 56-year-old patient who presented with warning leak, showing a hyperdense filling at the ACoA complex, b. Left carotid angiogram revealing an aneurysm at the ACoA complex.

Patients were considered in two main groups for comparison; Group I consisted of 90 patients with a hyperdensity suggesting an aneurysm on infusion CT scanning; Group II consisted of 30 patients with no finding of aneurysmal enhancement. Subarachnoid haemorrhage on CT scan was classified according to Fisher's Scale (3). In all cases we measured the aneurysmal sac diameter by using a new method, since it was not possible to predict the exact size on conventional angiograms because of the magnification problem. For this purpose, we have considered the ratio between the aneurysmal sac diameter (ASd) and the proximal intracavernous portion of internal carotid artery diameter (PIICAd) which varies between 3.3 and 5.4 mm (avarage of 4.0 mm) (8,22). Both groups are also investigated according either to the localization or size of the aneurysms. The subgroups according to the aneurysmal sac diameters on angiograms were constituted as: A: those with the ratios lower than 2 (<8.0mm); B: those with the ratios between 2 (8mm) and 4 (16mm); C: those with the ratios greater than 4 (>16mm). Angiographic spasm was also investigated to evaluate its role in the computerized tomographic demonstration of an aneurysm.

The correlation between sizes of computerized tomographic and angiographic measurements were examined with regression analysis test in Group I. Aneurysm sizes of both groups were analysed according to aneurysm site with independent-samples t-test. The subgroups established according to aneurysm size from Group I were investigated with respect to their contributions in producing hyperdense fillings on infusion CT scans with one-way analysis of variance (ANOVA) and multiple comparisons were done with Tukey-honestly significant difference (HSD) test. P-values less than 0.05 were accepted as statistically significant.

RESULTS

A hyperdensity suggesting an aneurysm on infusion CT scan was observed in 90 (75%) cases (Group I). There were 46 men and 44 women, aged 10 to 69 (mean 50±12.50 years). Ruptured aneurysms were located on the internal carotid artery (ICA) in 24 cases, at the anterior communicating artery (ACoA) complex in 23 cases, on the middle cerebral artery (MCA) in 25 cases, on the anterior cerebral artery (ACA) in 5 cases, and on the vertebrobasilar artery system (VBS) in 12 cases.

In Group I, 16 (18%) patients had normal CT scan (Fisher I). The amount of subarachnoid blood on CT scanning was classified as Fisher II in 30 (33%), Fisher III in 21 (23%) and Fisher IV in 23 (26%) cases. The mean ratio for the sizes of the hyperdense fillings on infusion CT scans was 11.15±7.67mm (ranging from 4.0 to 45.0). Angiographic spasm was observed in 29% of Group I patients and the mean ratio for ASd/PIICAd on angiograms was 2.96±2.08 (ranging from 1 to 13.5). This mean ratio corresponds to 11.84mm.

The second group consisted of 30 (25%) cases that had ruptured aneurysm which had not led to any hyperdense filling on CT scans. There were 17 men and 13 women, aged 17 to 71 (mean 45.9±13.24 years). Ruptured aneurysms were located on the ICA in 10 cases, at the ACoA complex in 7 cases, on the MCA in 7 cases, on the ACA in 3 cases, and on the VBS in 3 cases. CT scans of the patients were interpreted as Fisher I in 3 (10%), Fisher II in12 (40%), Fisher III in 12 (40%), and Fisher IV in 3 (10%) cases. Angiospasm rate was the same as group I (29%). The mean ratio for ASd/PIICAd on angiograms was 2.2±0.92 (ranging from 0.6 to 4.50). This mean ratio corresponds to 8.80 mm. Detailed informations about measurements of the hyperdense fillings on CT scans and the aneurysm sizes on angiograms are discussed according either to main groups and subgroups in Table I.

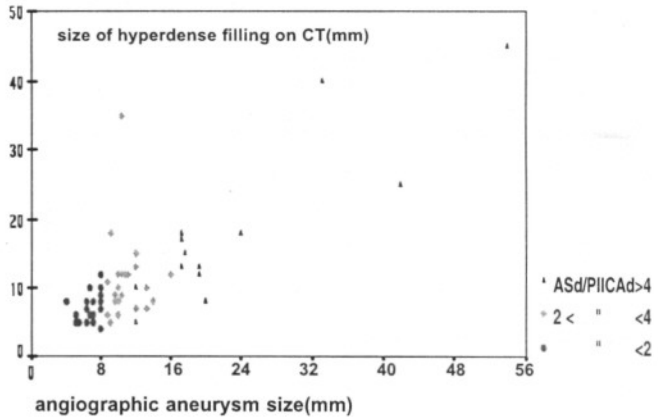

Figure 4. The relationship between the angiographic aneurysm size and the hyperdense filling on infusion CT scan. The actual sizes of the aneurysms were in a positive correlation with the hyperdense fillings on CT scans with regression analysis test (p<0.05). ASd:Aneurysmal sac diameter; PIICAd: Proximal intracavernous internal carotid artery diameter.

Cisternal Haemorrhage:

The incidence of detecting an aneurysm in a patient admitted with a SAH clinic was found to be 95% when both cisternal haemorrhage and a hyperdensity on infusion CT scanning were considered together. However, especially in patients with unrecognised warning leak, or in cases whose CT scans were obtained beyond the first week following the ictus, the clinical suspicion about a possible attack of SAH was very important because the angiographic demonstration of an aneurysm was achieved in 86.3% of cases with no sign of haemorrhage on CT scans (Table II).

Table I. CT Findings in SAH Patients.

Localization		Group I size of hyperdense filling on CT scan	Group I ASd/PIICAd on angiogram		Group II ASd/PIICAd on angiogram	
ICA	●	15.07 ±10.86	3.85±2.75	□15.40mm	2.83 ±0.97	□11.32mm
ACoA	◆	9.05 ±3.90	2.53±0.89	□10.12mm	1.62 ±0.77	□6.48mm
MCA	◆●	9.61 ±3.04	2.42 ±0.86	□ 9.68mm	1.67 ±0.35	□6.68mm
ACA		5.75 ±0.50	1.70 ±0.56	□ 6.80mm	1.30±0.89	□5.20mm
VBS	●	19.00 ±14.89	5.42±4.60	□21.68mm	1.50 ±0.71	□6.00mm
Total	◆●	11.15 ±7.67	2.96±2.08	□11.84mm	2.20 ±0.92	□8.80mm
ASd/PIICAd						
< 2		7.60 ±2.42	1.73 ±0.32	□6.92mm		
2 to 4		11.17 ±5.92	2.70 ±0.46	□10.80mm		
> 4	■	18.38 ±11.86	5.86 ±3.09	□23.44mm		

ASd:Aneurysmal sac diameter; PIICAd: Proximal intracavernous internal carotid artery diameter; ICA: Internal carotid artery; ACoA: Anterior communicating artery; MCA: Middle cerebral artery; ACA: Anterior cerebral artery; VBS: Vertebrobasilar artery system.

●The size of the aneurysm was in a positive correlation with the hyperdense filling on CT scans with regression analysis test ($p<0.05$).

◆Significant difference for aneurysm sizes acording to its location was observed between groups with Independent-Samples T test ($p<0.05$).

■Significant difference for the size of hyperdense filling during infusion CT scanning was observed between subgroups which had been established according to ASd/PIICAd ratioes from Group I patients after one-way ANOVA and Tukey-HSD tests were done ($p<0.05$).

Table II: Comparison of CT Findings in Ruptured Aneurysm Diagnosis with Angiography.

CT FINDINGS	ANEURYSM (+)	ANEURYSM (-)	TOTAL
Cisternal haemorrhage (+)			
Hyperdense filling (+)	74(95%)	4(5%)	78(58%)
" " (-)	27(79%)	7(21%)	34(26%)
Cisternal haemorrhage (-)	16(89%)		
Hyperdense filling (+)	3(75%)	2(11%)	18(13%)
" " (-)		1(25%)	4(3%)
Total	120(90%)	14(10%)	134

CT: Computerized tomography.

Hyperdense filling on infusion CT scanning correlated much with the diagnosis of a ruptured aneurysm in patients with suspected subarachnoid haemorrhage. The accuracy of angiographic detection of an aneurysm in patients with hyperdense CT fillings was 94%.

Angiospasm:

The rate of angiographic spasm in each group of patients was 29% and didn't seem to be a significant factor in explaining the production of hyperdense fillings on CT.

Hyperdense fillings on infusion CT scans and angiographic aneurysm size:

The mean for measurements of hyperdense fillings in Group I patients was 11.15±7.67 (ranging from 4.0 to 45.0 mm), the mean for ASd/PIICAd ratio was 2.96±2.08 (ranging from 1.0 to 13.5). We observed a positive correlation between the sizes of hyperdense fillings on infusion CT scan and aneurysms on angiograms in patients with ICA, MCA and vertebrobasilar artery system aneurysms ($p<0.05$). Also, a positive correlation was found when these parameters were investigated in all patients regardless of the aneurysm site (Table II). The measurements for these two parameters in vertebrobasilar artery aneurysms were significantly different than the aneurysms of other locations. Thus, it is possible to predict an appropriate hyperdense filling over 12 mm on infusion CT scan as an aneurysm with a diameter between 9.76-15.98mm in this site.

In order to understand the significance of the aneurysm diameter in producing a hyperdense filling during infusion CT scanning, we compared the two main group of patients according to their aneurysm sizes. We found a statistically significant lower diameters in the second group ($p<0.05$). This discrepancy was stemping from ACoA, MCA and VBS aneurysms. For a more accurate prediction of the effect of the aneurysm size in producing hyperdense filling during CT scanning, we looked for relationships between subgroups which had been established according to the aneurysm sizes measured in Group I patients. Statistical analysis revealed that aneurysms which were four times greater than PIICAd (over 16.0mm in diameter), were significantly better visualized on infusion CT scans.

DISCUSSION

Computed tomography is a reliable technique for examining patients with SAH and intracranial aneurysms. Extravasated blood is easily recognized and the location of the ruptured aneurysm may frequently be predicted by its distribution into the subarachnoid spaces and brain parenchyma(12).

Preoperative angiography clearly provides definitive vascular anatomy and should be performed before elective surgery in patients with good clinical grades (5,11,18); however, angiography, even of a single vessel, may cause a life-threatening delay in a comatose patient who continues to deteriorate because of a large aneurysmal haematoma. If an aneurysm and its location is known to be present, haematoma evacuation can be directed to minimize inadvertent rupture of the aneurysm (9). Moreover, simultaneous clipping of the ruptured aneurysm at the time of clot removal appears to lead to better outcome and allows aggressive treatment of vasospasm (15,19). Le Roux, et al. reported that infusion CT scanning had provided sufficient information in all 25 moribund patients with a ruptured aneurysm before an emergency craniotomy and clippage, and 12 (48%) of them survived. We also performed a simultaneous haematoma evaquation and clippage procedure in 4 moribund patients whose CT scans had made us predict an aneurysm, and 3 of them survived. Although the etiology of intracerebral haematoma can be predicted with a high degree of accuracy from CT characteristics, enough doubt often exists to warrant further investigation (15). Nearly 15% of aneurysmal intracerebral haematomas coming to autopsy are in the external capsule(1) and similarly may involve the basal ganglia, frontal or temporal lobes (11). In addition, hypertensive intracerebral haematomas can extend into the Sylvian fissure. The decision of whether performing angiography or not in such patients may be more accurate after having an infusion CT scan.

The treatment of incidentally discovered aneurysm has been controversial(6,14). The total rate of haemorrhage during the first decade after detection of the aneurysm was reported as 9.8%, or approximately 1% per year (20). Rupture is not associated with the size of the aneurysm and that the majority of small aneurysms also rupture (2). Because the patients are conscious and have good surgical conditions, operative mortality rates are lower than one percent and morbidity rates are about 6.5% in various series (20,21). Thus, the catastrophic effects of a major haemorrhage can be avoided in patients with incidental aneurysms since the results seem to be acceptable. At this point, the relatively noninvazive and accurate diagnosis of incidental aneurysm in a healty individual is very important, and infusion CT scanning, magnetic resonance (MR) or MR-angiography may serve this task (7,9). In our study, hyperdense filling on CT scan was found useful in the diagnosis of the incidental aneurysms in 43% of patients whose primary complaints were not suggesting an attack of SAH. Furthermore, these investigations may be helpful in the interpretation of patients exhibiting warning signs with no accompanying finding of haemorrhage on CT scans or on lumbar puncture. The differential diagnosis may sometimes be very hard to establish, and CT findings can help the neurosurgeon to decide whether to perform an angiography, or not. In this way, we were able to diagnose an aneurysm in 78% of our patients who had been presented with warning leak and a hyperdense filling on the infusion CT scan.

Our study demonstrated that infusion CT scanning discovered the presence of an aneurysm in 67.1% of the cases who had undergone this investigation, and the accuracy of angiographic detection of an aneurysm in patients with hyperdense CT fillings was 94%. It takes a very short time and can be performed even in emergency conditions. In the false negative cases, the age and associated atherosclerosis, amount of administered contrast materal, thickness of the CT slices, studied window to allow distinction between blood and contrast material, or angiospasm may play a significant role. Among these, age and angiospam criteriae didn't seem to be important in our patients since Group II patients were younger and the rate of angiospasm was the same in each group.

Correspondence: Metin Güner
Dokuz Eylül Üniversitesi Tıp Fakültesi
Nöroşirürji ABD, 35340,
Balçova İzmir, Turkey
Tel: 232 2595959

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