ROLE OF CT ANGIOGRAPHY IN EVALUATION OF INTRACRANIAL HEMORRHAGE

By

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ABSTRACT

Background : The development of CT angiography (CTA) in imaging the cerebral vessels has evolved rapidly. The recent introduction of multi-slice CT scanners enables isotropic imaging and has further shortened acquisition time. This enables evaluation of the major arteries prior to endovascular access and at the same time visualization of the circle of Willis. we evaluated the efficacy of CTA in detecting the cause of intracranial hemorrhage (ICH) and its ability to display the vascular anatomy in order to choose appropriate treatment.

Objective : The aim of the study is to assess the role of multi-detector computed tomography (MDCT) with multi-planar reformation (MPR) and three-dimensional (3D) reconstruction in evaluation of the underlying etiology of intracranial hemorrhage.To accurately delineate the lesion and the associated anomalies to improve clinical management and proper intervention.

Methods : This study was carried out at Radio diagnosis Department, Zagazig University Hospitals, The present study was carried on 30 patients of intra-cranial hemorrhage. Diagnostic work up was done including MD-CT & MD-CTA.

Results : The MD-CTA were interpreted for the presence, location, size, ratios of the aneurysm (dome to neck ratio (D/N)), by using volume-rendering and multi-planar reformat techniques of MDCT was done for all patients. MD-CTA was able to detect the aneurysms in 16 patients (88.8 %). With male predominance, the commonest site was in the MCA. Their sizes ranged from 2.9 mm to 11.6 mm.

Conclusion: Our results indicate that the non-invasive MD-CTA provide valuable information for the assessment of intracranial vascular lesions. However, MD-CTA has an advantage of rapid evaluation in patients with intra cerebral haemorrhage and includes the ability to depict bone landmarks and brain parenchymal changes adjacent to the vascular lesion.

Keywords: MultidetectorCT; Angiography; Digital subtraction; Aneurysm.

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INTRODUCTION

Conventional CT scan is almost always the first imaging modality used to assess patients with suspected intracranial hemorrhage. Fortunately acute blood is markedly hyperdense compared to brain parenchyma, and as such usually poses little difficulty in diagnosis. CT angiography (CTA) is increasingly used to assess a vascular underlying cause, particularly in cases of subarachnoid hemorrhage, or intra-parenchymal hemorrhage [(1)].

In addition to detecting the intra cranial hemorrhage either intra or extra axial, CT scanning is useful for localizing the source of bleeding and associated pathology. This is particularly important in cases of multiple intracranial aneurysms, which occur in 20% of patients. Localization of SAH on CT scans correlates with the location of the ruptured aneurysm. The presence of blood in the anterior inter-hemispheric fissure or the adjacent frontal lobe suggests rupture of an anterior communicating artery aneurysm. Blood predominantly localized in the posterior fossa suggests bleeding from a posterior circulation aneurysm. The ability to discern the location of an aneurysm rupture is limited by the fact that many patients with SAH have a diffuse distribution of blood in the subarachnoid spaces and basal cisterns on CT scans. The effect of gravity has been suggested as a possible cause for misleading patterns of blood distribution, Published studies report a wide variation in the accuracy of CT scanning in localizing the bleeding source[(2,5)].

CTA is the standard imaging technique for the detection of intracranial aneurysms, arteriovenous malformations (AVMs), and fistulae. Aneurysms are detected as focal areas of outpouching or dilatation of the arterial wall. These frequently occur at arterial branching points in characteristic locations within or near the circle of Willis. Cerebral angiography reliably demonstrates the presence or absence of an intracranial aneurysm or an AVM, and it establishes the number and locations of aneurysms. Morphologic information, such as aneurysm size and shape, helps to determine which aneurysm has bled in a patient with multiple aneurysms. Specifically, the presence of a lobulation, tit, or a daughter aneurysm is highly suggestive that the aneurysm is the one that has bled. In the absence of any distinguishing aneurysm shape features or hemorrhage localization by a CT scan, the largest aneurysm is the most likely to have bled. Features such as aneurysm location, shape, neck size, and neck-to-maximal diameter ratio are crucial in determining whether the aneurysm is better treated with open craniotomy or with an endovascular technique [3,4].

MATERIALS & METHODS

Patients

This study was carried out at Radio diagnosis Department, Zagazig University Hospitals, during the period from September 2017 to November 2017. The present study was carried on 30 patients of intra-cranial hemorrhage as proved by clinical examination or CT study. Twenty one patients were males and nine were females. Their ages ranged between 23-67 years (mean age 48years). All patients were referred from the Neurosurgery and Neurology Departments. Diagnostic work up was done including MD-CT & MD-CTA.

All patients were subjected to the following:

a) Full clinical history: Personal history (name, age, sex, occupation and special habits). Present history: The main clinical presentation of these patients. Family history of similar cases.

b) Neurological examination: In order to detect the presenting neurological deficits.

c) MD-CT angiography: Carried out using: 128 multi-detector (Phillips ingenuity) machine.

Technique Positioning

The patient lies supine, with his head first. The acquisition volume was angled parallel to the superior orbito-meatal baseline, with the inferior margin at the superior surface of the posterior arch of the C1 vertebra (to include the posteroinferior cerebellar arteries and extended superiorly to above the level of the pericallosal arteries. The patients were cannulated using (18-gauge cannula) in the anticubital fossa.

Contrast medium:

For enhancement of intracranial arteries, non-ionic contrast (Ultravist 370) was injected intravenously at a flow rate of 4 mL/sec by using **a programmed dual head power injector pump.**

A dynamic single-axial-section study (one scan every 2 seconds) at the level of the first cervical vertebral body is started until the contrast material appears as hyperattenuating spots in the ICAs. By using this technique, the time interval between bolus administration and the beginning of data acquisition can also be determined individually.

Scan parameters

Scan Paramerters	Value
kV	120 kV
Tube Current	200 mA
FOV	120 mm
Matrix	512
Table Feed	2.7 mm per rotation
Rotation Time	0.5 seconds

Image reconstruction parameters were as follows: section thickness of 1.25 mm, overlapping steps of 0.5 mm, and field of view (FOV) of 120 mm2. The applied narrow FOV of 120 mm2 leads to an excellent in-plane resolution (0.23_ 0.23mm2). In addition, lateral parts of the skull are already eliminated, which simplifies the post processing of source data. It is possible to perform reconstructions in steps of 0.23 mm to produce isotropic data, thus yielding voxels of equal extent in all three dimensions.

Post-processing of Images

The basic principle of 2D and 3D post-processing is to input cross-sectional images into a computer and thereby to create a so-called volume. Once a volume is created, several methods for 2D and 3D visualization exist such as: Multi-planner reformations

(MPR): the easiest way to analyze a volumetric data set is multi-planar reformation (MPR), in which from a given angle of view a plane is reconstructed in a defined depth of the volume. This way it is possible to create coronal, axial, sagittal, as well as any kind of oblique sections.

Maximum intensity projections (MIP): MIP is not a 3D method, as it creates 2D images in which voxels from different locations within the volume are collapsed into one plane. Thus, depth information is lost and it is not possible to tell whether a structure is located in the front or back on the basis of a single MIP image. Because calcifications and bone are brighter than contrast material–filled arteries, it is possible to differentiate levels of attenuation.Volume rendering technique (VR): when VR is used to create CT angiograms, the voxels of high attenuation containing information about bony structures are selected separately from those voxels with attenuation between 100 and 300 HU containing information about contrast-enhanced vascular structures. This selection allows the creation of 3D images showing red arteries and white bone.

Image interpretation:

Cases were revised and interpreted by 2 radiologists using axial images (as source images), reconstructed images (including MPR (curved and oblique), MIP and volume rendering techniques).

Statistical Analysis:

The findings of imaging studies were evaluated and correlated to the post-operative results and digital subtraction angiography. Sensitivity, specificity and diagnostic accuracy were calculated regarding the detection of underlying pathology and associated anomalies.

RESULTS: (Table 2)

MD-CTA was able to detect the aneurysms in 16 patients (88.8 %). Aneurysm appeared as abnormal focal outpunching of the cerebral arteries. Their sizes ranged from 2.9 mm to 11.6 mm *as shown in Table (3).* Sites of the aneurysms varied as 3 cases at the ACoA artery, 5 cases at the MCA, 4 cases at ACA, 1 case at ICA, 1 case at basilar tip and 2 cases at the PcoA artery *as shown in Table (2).* While, the Post-operative sheet revealed aneurysms as the underlying pathology in 18 patients. The size of aneurysms ranged from 2.1 mm to 11.6 mm. Sites of the aneurysms varied as 3 cases at the AcoA artery, 6 cases at the MCA, 5 cases at ACA, 1 case at ICA, 1 case at basilar tip and 2 cases at the PcoA artery.

D/N ratio (dome /neck ratio) of 16 simple saccular (determined neck) cerebral aneurysms by MDCTA reveal that the D/N ratio of aneurysm at MDCTA was slightly higher compared with that measured at angiography but this was statistically insignificant (P = 0.095) *as shown in Table (4).*, The effect of dome to neck ratio on treatment techniques, we determined that coiling without remodeling techniques as stent or ballon placement was favored for aneurysms with a dome to neck ratio =1.5. For aneurysms with a dome to neck ratio < 1.3, coiling with remodeling techniques was favored. For aneurysms with dome to neck ratios between 1.3 and 1.5, the frequency of use of remodeling techniques was similar to the frequency of use of no remodeling techniques.

Table (2)

Findings	MD-CTA		Post-operative sheet	
	No	%	No	%
Detection of aneurysm	16	88.8	18	100
Site				
AcoA	3	18.7	3	16.6
MCA	5	31.2	6	33.3
ACA	4	25	5	27.7
Basilar tip	1	6.2	1	5.5
PcoA	2	12.5	2	11.1
ICA	1	6.2	1	5.5

Table (3)

Size of aneurysms	No. of aneurysms	%
Tiny (<3 mm)	1	6.25
Small (3–5 mm)	8	50
Medium (5–12 mm)	6	37.5
Large (>13 mm)	1	6.25
Total number of aneurysms	16	100

Table (4)

D/N ratio	MDCTA	Operative Sheet
>3	5	4
3–1.5	9	9
<1.5	2	5
Total	16	18

DISCUSSION

Intra cranial haemorrhage is a medical emergency, which can lead to a high rate of mortality and many severe complications. The performance of helical CT has improved during the last years, with faster gantry rotation, more powerful X ray tubes, and superior interpolation algorithms. However, the most significant advance in CT angiography has been the recent introduction of multi-section CT scanners. Currently capable of acquiring multiple channels of helical data simultaneously, multi detector CT scanners have achieved the greatest incremental gain in scan speed since the development of helical CT. These machines have profound implications for clinical CT scanning. The innovation of MD-CT has provided improved quality, spatial resolution and decreased scanning time, which makes it become a useful alternative imaging method for the evaluation of patient with suspected intracranial vascular lesions.

The present study included 30 patients with clinical and radiological findings suggestive of intracerebral vascular lesion. There were 30 patients, 18 males (60%) and 12 females (40%) with mean age 48 years. The final diagnosis of our patients was 16 patients with aneurysms (53.3%), 6 patients with AVM (20 %), 4 patients with cavernoma (14%) and no evident vascular lesion in 4 patients (14%).

Regarding cerebral aneurysms, the present study included sixteen out of thirty patients (70%) with intracerebral aneurysms, with male predominance. Their ages ranged between 23 to 68 years. The commonest age group of the selected patients was 50 – 60 years age group in which seven cases with diagnosed cerebral aneurysm. Eleven patients had manifestations of hypertension (68.75%). Aneurysms predisposing factors include age, sex, hypertension & familial predisposition. Regarding age, the commonest age group affected in our study was 50 – 60 years age group. In accordance with our study A. Badry et al (2013) and Norman Ajiboye et al. (2015) reported mean age 40-50 years. However, In discordance with our study, Gamal gihan (2014) & Luo et al. (2012) reported younger mean age 40-50 years age group but Asaithambi et al. (2014) reported older age group above 75 years._Regarding sex, 9/16 males (36.6%) & 7/16 females (26.6%) are diagnosed with cerebral aneurysm. In agreement with our study results Teksam et al. (2005) reported male predominance. However, female predominance was noted in many published studies, Norman Ajiboye et al. (2015) and G.H. Gamal (2014) reported an incidence of 78.5% females in their studies. This sexual predominance was also noted in the work of Chen et al. (2014) who reported that 70% were females and 30% were males. Other studies reported equal sex distribution, such as A. Badry et al. (2013).

Hypertension is considered as an important risk factor among our patients 11/16 (68.7%). In agreement with our study, Pankaj et al. (2010) reported that hypertension is a well-established risk factor in intracranial aneurysm formation and complication, also, there are many studies that highlight the role of hypertension in aneurysm formation and their strong association.

Regarding the sites, aneurysms were more common in the MCA 5/16 (31.2 %), AcoA 3/16 (18.7%) and PcoA 2/16 (12.5%) In agreement with our study; Molyneux et al. (2004), A. Badry et al. (2013) and Donmez et al. (2011), mentioned the most common location of intracerebral aneurysm was at the MCA (bi/trifurcation) (33.9%), in the International Subarachnoid Aneurysm Trial, demonstrated that more than 95% of the enrolled aneurysms were located in the anterior circulation, this high incidence of anterior circulation aneurysms more than other published data was attributed to their randomization criteria. Also in Teksam et al. (2004) series of 100 patients with aneurysmal SAH, 72/100 (72%) of the aneurysms located in the anterior circulation. The frequency of the MCA aneurysms was (45%). Regarding the size, MD-CTA was not able to detect two cases with aneurysm in the ACA and MCA measuring 2.1 and 2.9 mm respectively, while post-opertaive sheet revealed our false negative results, in agreement with Chen et al. (2016) who reported that the ability of MD-CTA drops precipitously for the detection of aneurysms smaller than 2.7 mm. However, Chen et al. (2016) used 320-detector row volumetric CT angiography, compared to the 128-row machine used in our study. This also goes in accordance with Xing et al. (2011) who reported limited sensitivity of MD-CTA in detection of cerebral aneurysms smaller than 4 mm.

Regarding MD-CTA sensitivity, specificity & accuracy, our study yielded results accounting MD-CTA overall sensitivity (92.59%), specificity (66.67%) & accuracy (90%) for cerebral vascular lesions detection & characterization in cases of intra cerebral haemorrhage. Regarding the MD-CTA sensitivity, in agreement with our study, Perry et al. (2004), Karamessini et al. (2004) & Goddard et al. (2005) reported sensitivity 92 %, 88.7 % & 90 % respectively. Also, Boesiger and Shiber's (2005) study, showed 100 % sensitivity for detection of cerebral vascular lesions using the GE Lightspeed 2.X (GE Healthcare, Piscataway, NJ). The authors describe this as a fifth-generation scanner but do not specify the number of detectors. The sample size in this study was small, with only 6 patients in the study having non-traumatic SAH, all of whom were diagnosed with MD-CTA. Regarding the MD-CTA specificity, in agreement with our study, Perry et al. (2004), Karamenssini et al. (2004), Xing et al. (2011) & Donmez et al. (2011) who reported 100 % specificity. Regarding the MD-CTA accuracy, in agreement with our study, Perry et al. (2004) reported accuracy 87.1 %. Also, Xing et al. (2011) & Donmez et al. (2011) reported accuracy 99.1% & 97.8% respectively.

Our results indicate that the non-invasive MD-CTA provide reliable information for the assessment of intracranial vascular lesions.

CONCLUSION

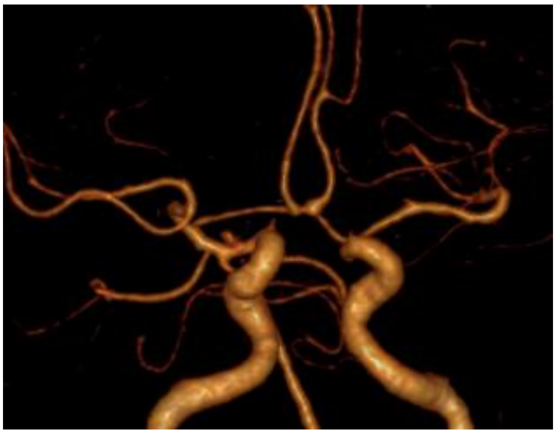
Intra-cerebral hemorrhage accounts for 8-13% of all strokes and results from a wide spectrum of disorders. Intra-cerebral hemorrhage is more likely to result in death or major disability than ischemic stroke or subarachnoid haemorrhage. Most of underlying vascular lesions are attributed to intracranial aneurysms which remain undetected until the time of rupture. Intra cerebral haemorrhage, is a medical emergency, by far the most common initial clinical presentation. Sudden onset of vigorous headache typically is the leading symptom in patients with rupture of an intracranial aneurysm. Mortality is high among patients with aneurysm rupture, and prompt localization of the aneurysm is critical to determine the appropriate neurosurgical or endovascular intervention.

This study was carried out at Radiodiagnosis Department, Zagazig University Hospitals, during the period from September 2017 to November 2017. The present study was carried on 30 patients of intra-cranial hemorrhage as proved by clinical examination or CT study. Twenty one were males and nine were females. Their ages ranged between 13-67 years (mean age 50 years). All patients were subjected to the following with the following order: Full history taking. Neurological examination. Laboratory investigation prior to contrast administration. Plain MD-CT, MD-CTA.

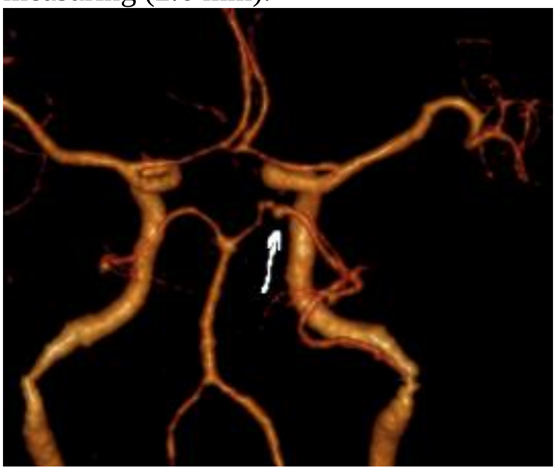
The males (21 patients) were affected more than the females (9 patients). Their ages ranged between 13 - 67 years with mean age 40 years. The final diagnosis of our patients was 21 patients with aneurysms, 7 patients with AVM & 2 patients with negative results for cerebral vascular lesion. Twenty one patients with intracerebral aneurysm, with male predominance. Their ages ranged between 13 to 67 years, MD-CTA was able to detect the aneurysms in 16 patients (85.7%). Aneurysm appeared as abnormal focal outpunching of the cerebral arteries. The size ranged from 3.1 mm to 12.9 mm. Sites of the aneurysms varied as 6 cases at the AcoA artery, 4 cases at the MCA, 4 cases at ACA, 2 cases at ICA, 1 case at basilar tip and 1 case at the PcoA artery. MD-CTA overall sensitivity, specificity & accuracy are calculated and the results were 85.71 %, 100 % & 86.66% respectively.

In conclusion, our results indicate that the non-invasive MD-CTA provide valuable information for the assessment of intracranial vascular lesions. However, MD-CTA has an advantage of rapid evaluation in patients with intra cerebral haemorrhage and includes the ability to depict bone landmarks and brain parenchymal changes adjacent to the vascular lesion, which may play an important role in treatment planning.

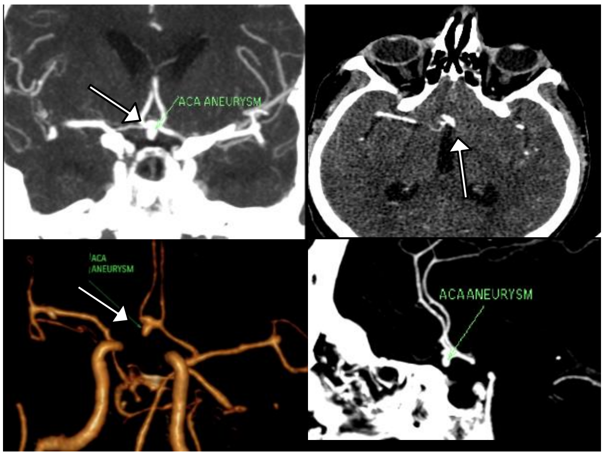
MD-CTA shows a promising diagnostic accuracy.



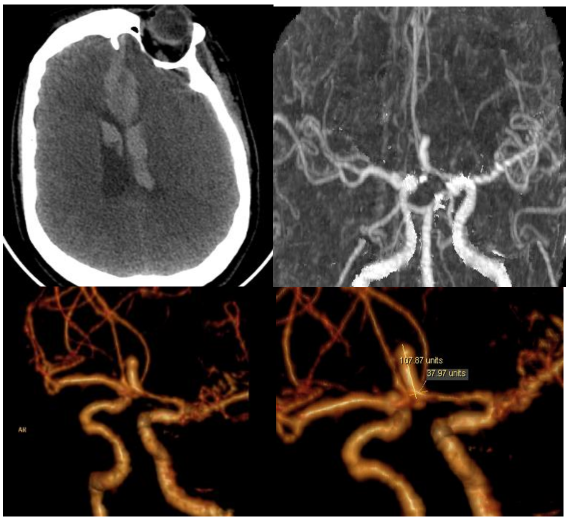
(Fig. 1) MD-CTA VR revealed anterior communicating artery aneurysm (arrows). It measures (6 x 4.1 mm) with its neck measuring (2.6 mm).



(Fig.2) MD-CTA VR revealed Rt. Posterior cerebral artery aneurysm (arrows). It measures 2.9 x 2.5 mm with its neck measuring 12 mm.



(Fig.3) **(**A & D**)** MIP MD-CTA coronal & sagittal views revealed left ACA aneurysm in relation to anatomical structures (arrows). (B) Enhanced axial cuts MD-CT brain study showed left ACA aneurysm. (C) Conventional VR MD-CTA revealed left ACA artery aneurysm (arrows). It measures 7.1 x 4.9 mm with its neck measuring 3.1 mm.



(Fig. 4) **A**: Non-Enhanced axial cut MD-CT brain showed left frontal hematoma with intra ventricular extension (fresh blood density at both lateral ventricles). **B**: MIP MD-CTA revealed left ACA aneurysm (arrows). **C & D:** Conventional VR MD-CTA revealed left ACA aneurysm (arrows). It measures 10.8 x 3.8 mm with its neck measuring 3.8 mm

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