DOI: https://doi.org/10.53350/pjmhs221651509

ORIGINAL ARTICLE

Diagnostic Accuracy of Three Dimentional Digital Substraction Angiography (3D DSA) in Correlation with Computed Tomographic Angiography (CTA) and Magnetic Resonance Angiography (MRA) in Evaluation of Aneurysmal Subarachnoid Haemorrhage

TABASSUM BEGUM[1], ZUBAIR JANAN ORAKZAI[2], MOHSIN KHAN[3], BAKHT ROKHAN[4], AYESHA KAMRAN[5], MUHAMMAD NUMAN AKRAM[6]

[1,2]Assistant Professor, Diagnostic Radiology, Mardan Medical Complex Mardan
[3]Assistant professor, Diagnostic radiology, Gajju khan medical college /Bacha khan medical complex Swabi
[4]Associate professor Radiology, Saidu Medical College / Saidu Teaching Hospital Saidu Sharif Swat
[5]Assistant Professor Radiology, Sargodha Medical College DHQ Hospital Sargodha
[6]Consultant Neurophysician, Department of Neurology, Allied Hospital / Faisalabad Medical University Faisalabad
Corresponding author: Zubair Janan Orakzai, Email: zjaurakzai@hotmail.com, Cell: +923329297432

ABSTRACT

Background: Subarachnoid hemorrhage is cause by ruptured aneurysms. Early diagnosis is necessary for prevention of the disease. For detection of size and location of intracranial aneurysms in aneurysmal subarachnoid haemorrhage different diagnostic tool are used. The 3D DSA imaging modalities parameters were considered as gold standard in diagnosis of aneurysms. MRA and CTA competencies in diagnosis of ruptured aneurysms were also evaluated.

Objective: The aim of the study was to evaluate the sensitivity of 3D DSA, CTA and MRA in diagnosis of intracranial aneurysms in referred patients. The imaging modalities parameters of 3D DSA was considered as gold standard.

Study design: It was retrospective observational study with statistical approach.

Methods: The 27 consecutive patients of subarachnoid haemorrhage visited the neurology and radiology department of BKMC / MMC Mardan from August 2021 to January 2022 was included in the study. All the patients passed the inclusion criteria while those who are reluctant to undergo through CTA, MRA were excluded. The three dimensional constructed images of each patient underwent through CTA, MRA and 3D DSA were recorded. The obtained data was analyzed for the results.

Results: CTA and MRA has variable sensitivity range in diagnosis of intracranial aneurysms. It varied according to the size of aneurysms. For the diagnosis of small sized aneurysms the CTA and MRA has the sensitivity of 57.1 %, while it changes to 88.8 % in diagnosis of medium sized aneurysms. For diagnosis of large sized aneurysms, the CTA and MRA has same sensitivity of 100%. Hence for the detection of small and medium sized aneurysms the sensitivity of CTA and MRA reduced to 20% as compared to the sensitivity of 3D DSA.

Conclusion: It was concluded from the results that the 3D DSA is most accurate tool with higher sensitivity for diagnosis of intracranial aneurysms in patients of subarachnoid haemorrhage. The results obtained by using 3D DSA are 20% more sensitive than the results obtained by using CTA and MRA.

Keywords: (SAH) Subarachnoid hemorrhage, CTA) Computed Tomographic Angiography, (MRA) Magnetic Resonance Angiography.

INTRODUCTION

The word ana means across and eurys means broad. Aneurysm is characterized by bulging of the arterial walls. The main cause of Subarachnoid hemorrhage (SAH) is ruptured cerebral aneurysm. The 5-15% strokes are because of ruptured intracranial aneurysms[1-2]. Re-bleeding and cerebral vasospasm are major complications of SAH. Electrolyte disorders, hyperglycaemia, cardiac insufficiency and hypertension are non-neurological complications of SAH. This ruptured aneurysm is more common in the young age people. High mortality and morbidity cases of subarachnoid hemorrhage are reported. The incidence rate of subarachnoid hemorrhage is 9 per 100000 population per year. The most common and catastrophic symptom are re-bleeding and delayed cerebral ischemia. Prompt treatment and early diagnosis can reduced the mortality rates. The people of age 55 years are more prone to develop the disease[2].

The 20% strokes are because of non-aneurysmal, perimesencephalic SAH. The nicotine or alcohol abuse induced the structural defects that ultimately leads to cerebral aneurysms. The out-pouching of aneurysmal into the subarachnoid space present at the base of the brain is because of intravascular shear stress caused by chronic aneurysm. The main site of development of aneurysms is vascular bifurcation. The patients survived from this devastating type of stroke often suffer from cognitive impairment[3]. Anterior circulations and middle cerebral artery are more prone to aneurysms development with the ratio of 80-90%. The posterior circulation shares second number with 10-20% ratio.For initial screening of screening of subarachnoid hemorrhage the non-contrast CT brain is usually used. For detection of intracranial aneurysm angiography is considered as gold standard tool[4].

Rotational Digital Substraction Angiography with 3D reconstructed images is considered as more accurate techniques for visualization of intracranial vascular lesions. The sensitivity and accuracy level of this techniques are more than the previously used techniques[5-6]. CT Angiography (CTA) and MR Angiography (MRA) being non-invasive techniques with higher accuracy, multiplanar imaging and short acquisition time. Their working principle is based on non-contrast methods, therefor they don't use ionizing radiations[7-8]. CTA and MRA are highly used tool for detecting size and location of intracranial aneurysms. The 3D DSA reconstructed images is considered more accurate with high sensitivity and other parameters, this shared the gold standards in diagnosis of subarachnoid haemorrhage[9-10].

MATERIAL AND METHODS

This prospective study was carried out at the tertiary teaching hospital. All the patients diagnosed with subarachnoid haemorrhage attended the neurology and radiology department of BKMC / MMC Mardan from August 2021 to January 2022 was included in the study. All the patients diagnosed with subarachnoid haemorrhage after CT scan was included in the study. All these patients were suspected of aneurysmal SAH. The consent was taken from the patients. The patients with intra cerebral haemorrhage and traumatic subarachnoid haemorrhage was excluded for the study. A pre-procedure work was done before starting the study. The information about age, sex, hypertension, smoking habits, and previous incidence of SAH was collected. The patient drug history, family history of subarachnoid haemorrhage

and kidney disease was also collected. Examination finding and clinical features of every patients were noted.

In order to facilitate the present study further biochemical analysis like complete blood count (CBC), blood sugar, serum creatinine and serum lipid profiling, ECG, and Chest X-ray were conducted. The CTA, MRA and digital substraction angiography of each patients was conducted and three dimensional images were analyzed. For later evaluation the results were recoded.

RESULTS

This study was conducted on 27 patients attended the neurology department of hospital in the six month time period. The 46 was the mean age of the patient diagnosed with characteristics subarachnoid haemorrhage. 1:5:1 was the calculated male female ratio respectively. Out of all the included patients 100% has the complaint of headache and vomiting while, other 44% were presented with unconsciousness. The 64% patients reported the signs of meaningful irritation while the other 16% reported with weakness of extremities. Out of all the patient included in the study 48% have the history of smoking and other 56% have the hypertension. Out of the 27 patients the 18 patients aneurysms was identified on DSA. The ratio of male to female remain constant as 1:1. The 9 cases of aneurysms in female and 9 cases of aneurysms in male were reported (showed in table 1).

Table 1: Aneurysmal cases with their distribution (gender)

Aneurysms cases identified by DSA	Frequency	percentage
Male	9	50%
Female	9	50%
Total	18	100%

The patients whose aneurysms was identified on DSA have mean age of 49 years. Mean age of male among them was 48.6 years, while 49.7 was the mean age of female among them.

Table 2: Aneurysmal cases with their respective information

Number	Age	Site of development	Sex	No of aneurysmal cases	Categorized as	Diagnosed by DSA	Diagnosed by CTA	Diagnosed by MRA
1	34	Left PCA	M	1	Medium	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
2	38	Bilateral MCA	M	2	Medium Medium	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
3	65	Left MCA	F	1	Small	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
4	42	Basilar	M	1	Large	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
	50	Right ACA	F	1	Medium	Correctly diagnosed	Missed	Correctly diagnosed
6	52	Basilar, Right ICA	F	2	Medium Small	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
7	35	Acom	M	1	Small	Correctly diagnosed	Missed	Missed
8	81	Left ICA	M	1	Large	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
9	48	Acom	F	1	Medium	Correctly diagnosed	Missed	Correctly diagnosed
10	60	Left ICA, Right ACA	M	1	Small	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
11	48	Right ICA	F	2	Large Small	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
12	30	Right ACA	F	1	Small	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
13	55	Left ACA	F	1	Medium	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
14	50	Right AICA	F	1	Medium	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
15	45	Bilateral MCA	M	1	Medium	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
16	54	Right MCA	M	1	Large	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed
17	55	Right ACA	M	1	Small	Correctly diagnosed	Missed	Missed
18	30	Acom	F	2	Large Small	Correctly diagnosed	Correctly diagnosed	Correctly diagnosed

The M in the table is used for Male, F for Female, MCA for Middle Cerebral Artery, AIC for Anterior Inferior Cerebellar Artery, Acom for Anterior Communicating Artery, ACA for Anterior Cerebral Artery, ICA for Internal Carotid Artery, and PCA for Posterior Cerebral Artery. Aneurysms was categorized as small, medium and large on the basis of size number. The aneurysms of size equal to 4mm or greater than 4mm was categorized as small, the aneurysms of size 5-12mm was categorized as medium. While the aneurysms of size 13 or greater than 13 was labelled as large sized aneurysms. The 7 cases of small sized aneurysms, 9 cases of medium size aneurysms and 4 cases of large size aneurysms were identified on DSA. The MRA didn't show the 3 cases of small sized aneurysms. These also failed to report the 9 cases of medium sized aneurysms. The 4 cases of large sized aneurysms was diagnosed by all CTA, MRA and 3D DSA. The percentage sensitivity of MRA and CTA was calculated to be 57% in small sized aneurysms and 88% in medium sized aneurysms. While it is 100% in cases of large sized aneurysms. It was observed that the sensitivity of 3D DSA in diagnosis of small and medium

DISCUSSION

The rupture of intracranial aneurysm caused a serious condition generally known as subarachnoid haemorrhage. It is characterized by both vascular and neural pathologies. The development of spasm in cerebral vessel is the most common defining characteristic for SAH. About 70% cases of SAH are due to intracranial ruptures. About 15% patients die before reaching the hospitals. The average mortality rate is 44%[11]. The reported prevalence of intracranial aneurysms is 3.6%. Neurological dysfunction developed in about 50% of the SAH surviovors. This is increasing the monetary burden by decreasing quality of the life.

This is more common in women. The patients having rapid access to the neurocritical care showed better outcomes, as compared to the patients with delayed treatments. Therefore early diagnosis and prompt treatment can save the life of many patients[12]. The ruptures aneurysms have higher risk of hemorrhage. For timely and accurate management of the disease the accurate assessment is needed. For the accurate assessment the neuroimaging is highly recommended[13].

For the method to be labelled as ideal for diagnosis and examination of the intracranial aneurysms it must have few characteristics. It must be non-invasive with high accuracy and sensitivity. It must be easy to perform with minor complication and false positive results[14]. This method is preferably used for diagnosis as it is cheap, readily available with rapid results. It provides with the accurate knowledge of SAH distribution within six hours. It also provide with the better idea of aneurysms location, degree of hydrocephalus with 100% sensitivity. The presence and absence of Intra ventricular hemorrhage can also be assessed through CT scan[15].

CT can't be used for diagnosis 6 hours to one week after hemorrhage. As the after the six hours, the degradation of hemorrhagic blood product start, and it is not possible to detect the product by CT scan. In such cases the negative non-contrast CT scan used for the diagnosis. This techniques is usually facilitated by lumber puncture[16]. To increase the detection rate of ruptures cerebral aneurysms in highly suspicion patients the negative non-contrast CT angiography (CTA) is used. The study conducted by McCormack et al. showed that there is 99% probability of negative results of aneurysmal subarachnoid hemorrhage in a case undergoing negative non-contrast CT after negative CT angiogram[17].

Multi-planar reformats and three dimensional reconstructions are obtained by performing CTA on multi-detector helical CT scanners. With the advent of spatial resolution feature in current multi-detector scanners, the aneurysms greater than 4mm can be diagnosed with 100% sensitivity. For the diagnosis of aneurysms smaller than 3mm, CT scan technology has been showed to be inadequate. For high resolution and rapid scans, the higher number of detectors are required. These not only help to achieve the better contrast bolus timing but also facilitate in diagnosis of smaller aneurysms[18]. For evaluation of the dynamics flow of aneurysms, s. Time-resolved CTA, or 4D-CTA can be used. The different blood flow phases can be differentiated by using this tool. For the detection of aneurysms pulsation with the cardiac cycle Electrocardiogram-gated 4D-CTA are used. Computational fluid dynamics work by stimulating the blood flow within the aneurysm. In this way, the variables such as peak wall tension and aneurysmal wall shear stress that correlate presumably with rupture risk can be calculated easily. It play significant role in the management of cerebral aneurysms[19].

The patients with a high pretest probability of aneurysmal subarachnoid hemorrhage usually suggested with MRI. MRI is less suitable imaging modality because of higher cost and long acquisition time. But the MRI is considered much better modality for diagnosis of aneurysms after comparing it with CT-scan. CT scan working principle is highly dependent on usage of ionizing radiation and intravenous contrast agents. The other pathologies such as meningeal carcinomatosis, adjacent neoplasms and leptomeningeal metastasis that share the similar symptoms can also be diagnosed by suing MRI[20].

If one use time-of-flight (TOF) sequences on MRA, than there is no need contrast agents. To eliminate flow related artifacts the CE-MRA is preferred. Small branch vessels can be visualized by using 3T MRA. Digital subtraction angiography (DSA) is an invasive imaging modality, its working principle is highly dependent on ionizing radiation and iodinated contrast. It has significantly low complication rates. The high spatial resolution and temporal resolution feature of DSA are key factors for improving the performance. For detection of small sized aneurysms, the 3-dimensional rotational angiography (3DRA) is highly recommended as it detect small sized aneurysms with higher sensitivity. Endovascular therapy and diagnosis through DSA can done simultaneously[21].

CONCLUSION

To determine size, location and rupture status of cerebral aneurysms the imaging modality is required. For the diagnosis of large sized aneurysms the 3D DSA, MRA and CTA showed same sensitivity. However for the diagnosis of small sized and medium size aneurysms the 3D DSA is most accurate non-invasive imaging modality with higher sensitivity. Hence it was concluded that the sensitivity and accuracy of 3D DSA in evaluation of small and medium sized aneurysmal SAH is much better than MRA and CT-scan.

REFERENCES

1. Hayakawa M, Tanaka T, Sadato A, Adachi K, Ito K, Hattori N, Omi T, Oheda M, Katada K, Murayama K, Kato Y. Detection of pulsation in unruptured cerebral aneurysms by ECG-gated 3D-CT angiography (4D-CTA) with 320-row area detector CT (ADCT) and follow-up evaluation results: assessment based on heart rate at the time of scanning. Clinical Neuroradiology. 2014 Jun;24(2):145-50.
2. Islam M, Chowdhury AH, Chowdhury MS, Islam MN, Nayeem A, Khan S, Rahman KM, Sarkar R, Mohammad QD. A comparative study of computed Tomographic Angiography and digital subtraction Angiography in evaluation of Aneurysmal Subarachnoid Haemorrhage. Journal of Dhaka Medical College. 2013;22(2):195-200.
3. Suarez JI, Tarr RW, Selman WR. Aneurysmal subarachnoid hemorrhage. New England Journal of Medicine. 2006 Jan 26;354(4):387-96.
4. D'Souza S. Aneurysmal subarachnoid hemorrhage. Journal of neurosurgical anesthesiology. 2015 Jul;27(3):222.
5. Gaastra B, Ewbank F, Tapper W, Bulters D, Galea I. Long-term cognitive outcome following aneurysmal subarachnoid haemorrhage. Journal of Stroke and Cerebrovascular Diseases. 2022 Jan 1;31(1):106184.
6. Roe T, Welbourne J, Nikitas N. Endocrine dysregulation in aneurysmal subarachnoid haemorrhage. British Journal of Neurosurgery. 2022 Feb 15:1-0.
7. Al-Khindi T, Macdonald RL, Schweizer TA. Cognitive and functional outcome after aneurysmal subarachnoid hemorrhage. Stroke. 2010 Aug 1;41(8):e519-36.
8. Dodel R, Winter Y, Ringel F, Spottke A, Gharevi N, Mǘller I, Klockgether T, Schramm J, Urbach H, Meyer B. Cost of illness in subarachnoid hemorrhage: a German longitudinal study. Stroke. 2010 Dec 1;41(12):2918-23.
9. Nieuwkamp DJ, Setz LE, Algra A, Linn FH, de Rooij NK, Rinkel GJ. Changes in case fatality of aneurysmal subarachnoid haemorrhage over time, according to age, sex, and region: a meta-analysis. The Lancet Neurology. 2009 Jul 1;8(7):635-42.
10. Berg P, Roloff C, Beuing O, Voss S, Sugiyama SI, Aristokleous N, Anayiotos AS, Ashton N, Revell A, Bressloff NW, Brown AG. The computational fluid dynamics rupture challenge 2013—phase II: variability of hemodynamic simulations in two intracranial aneurysms. Journal of biomechanical engineering. 2015 Dec 1;137(12).
11. da Rocha AJ, da Silva CJ, Gama HP, Baccin CE, Braga FT, de Araújo Cesare F, Veiga JC. Comparison of magnetic resonance imaging sequences with computed tomography to detect low-grade subarachnoid hemorrhage: role of fluid-attenuated inversion recovery sequence. Journal of computer assisted tomography. 2006 Mar 1;30(2):295-303.
12. Sailer AM, Wagemans BA, Nelemans PJ, de Graaf R, van Zwam WH. Diagnosing intracranial aneurysms with MR angiography: systematic review and meta-analysis. Stroke. 2014 Jan;45(1):119-26.
13. Yan R, Zhang B, Wang L, Li Q, Zhou F, Ren J, Zhai Z, Li Z, Cui H. A comparison of contrast-free MRA at 3.0 T in cases of intracranial aneurysms with or without subarachnoid hemorrhage. Clinical imaging. 2018 May 1;49:131-5.
14. Nael K, Villablanca JP, Mossaz L, Pope W, Juncosa A, Laub G, Finn JP. 3-T contrast-enhanced MR angiography in evaluation of suspected intracranial aneurysm: comparison with MDCT angiography. American Journal of Roentgenology. 2008 Feb;190(2):389-95.
15. Futami K, Sano H, Misaki K, Nakada M, Ueda F, Hamada J. Identification of the inflow zone of unruptured cerebral aneurysms:

comparison of 4D flow MRI and 3D TOF MRA data. American Journal of Neuroradiology. 2014 Jul 1;35(7):1363-70.

16. Bakker NA, Groen RJ, Foumani M, Uyttenboogaart M, Eshghi OS, Metzemaekers JD, Lammers N, Luijckx GJ, Van Dijk JM. Repeat digital subtraction angiography after a negative baseline assessment in nonperimesencephalic subarachnoid hemorrhage: a pooled data meta-analysis: A systematic review. Journal of Neurosurgery. 2014 Jan 1;120(1):99-103.
17. Molyneux A, Kerr R, International Subarachnoid Aneurysm Trial (ISAT) Collaborative Group. International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomized trial. Journal of stroke and cerebrovascular diseases. 2002 Nov 1;11(6):304-14.
18. Williams, L.N. and Brown, R.D., 2013. Management of unruptured intracranial aneurysms. Neurology: Clinical Practice, 3(2), pp.99-108.
19. Dakshit D, Chakraborty P. Diagnostic accuracy of three dimentional digital substraction angiography (3d DSA) in correlation with computed tomographic angiography (CTA) and magnetic resonance angiography (MRA) in evaluation of aneurysmal subarachnoid haemorrhage: a comparative study in a tertiary care hospital. PJR. 2018 Dec 4;28(4).
20. Mees SD, Rinkel GJ, Feigin VL, Algra A, van den Bergh WM, Vermeulen M, van Gijn J. Calcium antagonists for aneurysmal subarachnoid haemorrhage. Cochrane database of systematic reviews. 2007(3).
21. Baharoglu MI, Germans MR, Rinkel GJ, Algra A, Vermeulen M, van Gijn J, Roos YB. Antifibrinolytic therapy for aneurysmal subarachnoid haemorrhage. Cochrane Database of Systematic Reviews. 2013(8).