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Correlation between the patient's demographic variables and magnetic resonance Angiography (MRA) at 3 Tesla

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One of the most valuable imaging diagnostic tools for vessel occlusions in Magnetic Resonance Imaging (MRI) is called Time of Flight (TOF) and Contrast Enhancement (CE) MRA magnetic resonance angiography. The aim of the current study is to correlate the patient's demographic variables (age and gender) with TOF-MRA and CE-MRA.at 3 Tesla.50 participants from King Salman Specialized hospital in Hail, Saudi Arabia were selected for performing this study, the majority of them (46.6%) were suffering from headaches, no other signs or symptoms were affecting this study. A complete MR imaging protocol included brain imaging sequences (axial DWI, T2 FLAIR, and SWI), angiography sequences without contrast media (3D TOF), angiography sequences with the first bolus of contrast injection (CE-MRA), and perfusion-weighted imaging with a second bolus of contrast injection (CE-MRA). The most prevalent age range was 35-49 years old with (46%) and approximate equality of males and females. These results affirmed that there is no relation between the gender or age and the non-contrast TOF-MRA ($p<1.228, p<5.47$), non-contrast TOF-MRV ($p<0.952$, $p<5.045$), respectively, where statistical significance was set as a p-value of<0.05.There is strong relation between gender and CE-MRA ($p<0.01$). There is no relation between the age and CE-MRA ($P<2.2$).We can conclude that in MRI of different types, there is no significant relation between the gender and age with the MRA results, except there is a strong relation between age and CE-MRA. Being male or female will not influence the results or the imaging, only some dependent variables may, such as the type of MR imaging and the Test measurement. Also, there is an improvement and accuracy of using TOF-MRA to identify and image vessel stenosis at 3 Tesla

Keywords: Magnetic Resonance Imaging (MRI), Time of Flight (TOF), Contrast Enhancement (CE), Magnetic Resonance Angiography (MRA)

INTRODUCTION

Clinical and research applications have been enhanced through the recent introduction of a 3 Tesla (T) very high field magnetic resonance (MR) system into clinical practice. The main benefit of 3T MR imaging is its increased signal-to-noise ratio (SNR), which increases approximately linearly from 1.5T to 3.0T. The improved SNR is expected to compete with catheter Digital Subtraction Angiography (DSA), previously considered the gold standard for evaluating intracranial vascular disease. In addition to better SNR, superior background suppression and excellent fat suppression at 3T result in better visualization of intracranial vessels Alvarez-Linear, J. (2008).

Researchers and clinicians alike are becoming more interested in magnetic resonance imaging of the brain for research and treatment, and the hardware and software of MRI scanners are becoming more advanced. The use of higher resolution, field strength, and more sensitive sequences may reveal subtle or minor brain abnormalities that weren't previously evident. Imaging intracranial vasculature is an essential method for assessing cerebrovascular disease clinically. Magnetic Resonance Angiography (MRA) is one of the most commonly utilized imaging procedures in clinical practice to assess cerebral artery stenosis(Chen et al.2011)

Time of Flight Magnetic Resonance Angiography (TOF-MRA) is a diagnostic imaging technique that uses overlapping thin slices that cover a volumetric area of interest. The images are then processed using a maximum intensity projection technique, which extracts the brightest pixels from the data set to create the blood flow image Cirillo et al. 2013 Tesla (T) provides measures for measuring the strength of a magnetic field. Before the 3 Tesla (3T) Machine, the high-field benchmark was 1.5 Tesla. Magnetic fields produced by our scanner are as strong as 1.5 Tesla machines and as strong as low field or open MRI scanners Dedicated 3T MRI - Insight Medical Imaging. 2022,

An MRI technique known as time-of-flight angiography (TOF) allows doctors to see how blood flows through vessels without a contrast agent. Based on the flow-related amplification of spins that enter an imaging slice, it is a flow-dependent technique. The unsaturated nature of these spins provides more signals than stationary spins around them. Several thin imaging slices are acquired in 2-D TOF using a flow-compensated gradient echo sequence. By integrating these pictures, a 3-D image of the vasculature can be created using a technique like maximum intensity projection (MIP). 3-D TOF obtains a volume of images concurrently by phase-encoding in the slice-select direction. MIP can also be used to create an angiographic look like 2-D TOF [1].It is possible to perform (Angiography) as a non-contrast magnetic resonance angiography (MRA) method for assessing intracranial stenosis, but it has not been tested fully against digital subtraction angiography (DSA) or 3D-time-of-flight (3D-TOF) MRA Cirillo et al. 2013.The aim of the current study is to correlate the patient's demographic variables (age and gender) with TOF-MRA and CE-MRA (Flament-Durand,1980, Holle D, Obermann M,2013, Hu et al.2008, Kim, Y. (2019). Lanciego et al.2012, Lanciego et al.2012

MATERIALS AND METHODS

This study was conducted in the Department of Radiology at King Salman specialist Hospital, Hail, Saudi Arabia From Jan 2021 until June 2022. The study was conducted according to the Principles of the Declaration of Helsinki and was approved by the human research and ethics committee of the University of Hail and King Salman specialist Hospital (No. H-2022-096) in the year 2022, and all patients gave written informed consent. In this retrospective study across-sectional design, patients were examined with sequences (TOF-MRA and CE-MRA) at 3-Tesla MR Magnetom Skyra (Siemens, Erlangen, Germany) scanner with a head and neck 20 channel coil array figure 1. The study comprised 50 participants, who were examined to ensure the accuracy of employing (TOF-MRA) and (CE-MRA) to detect intracranial vascular obstruction or dilatation without any surgical procedure. The inclusion criteria include that; Patients aged 20 to 70 years had suspected occlusions or stenosis, Clinical symptoms were suggestive of acute ischemic stroke, Patients who had a severe headache-related to unknown reasons, Patients who had a history of carotid artery disease. The exclusion criteria include that Patients over 70 years, Any illness not caused by clogged arteries and veins, Patients with cerebral hemorrhage, Patients had one contraindication of MRI such as a pacemaker and metal implants and pregnant women. The dependent variables include TOF 3D and CE-MRA, and independent variables gender, age, occlusion localization, stenosis degree.

Figure 1: 3-Tesla MR MagnetomSkyra (Siemens, Erlangen, Germany) scanner with a head and neck 20 channel coil array in king Salman specialist hospital

A complete MR imaging protocol included brain imaging sequences (axial DWI, T2 FLAIR, and SWI), angiography sequences without contrast media (3D TOF), angiography sequences with the first bolus of contrast injection (CE-MRA), and perfusion-weighted imaging with a second bolus of contrast injection (CE-MRA). The average acquisition time for MR imaging sequences was 17 minutes (figure 1). The table 1 below shows parameters of the MRA acquisition.

Table 1: The MRA examinations using TOF-MRA and CE-MRA

Parameter	3D TOF-MRA	CE-MRA
Receive coil	head and neck 20 channel coil array	head and neck 20 channel coil array
TR/TE (ms)	21/4.**57**	2.97/1.05
Flip angle	18	25
Acquisition plane	Axial	coronal
FOV (mm)	200 × 200	420×420
Reconstructed voxel size (mm)	0.3×0.3×0.5	1.1×1.1×1.1
Slice oversampling (%)	18.2	7.1
Slice per slab	44	112
No. of slabs	5	1
Slice thickness (mm)	0.55	1.10
Partial Fourier (phase and slic e directions)	6/8 and 6/8	6\8 and 6\8
Total acquisition time	5:35	0.15

Figure 1: Fast CE-MRA and TOF-MRA. Both TOF-MRA (left, scan) and fast CE-MRA (right, scan) demonstrate an occlusion in the right middle cerebral artery (arrows). CE = contrast-enhanced, MRA = magnetic resonance angiography, TOF = time-of-flight.

Data Analysis

The data will be analyzed using SPSS (v26). Data are presented as numbers (%) or mean± standard deviation and with a 95% confidence interval (CI) when appropriate. Statistical significance was set as a two-sided p-value of<0.05. The calculated Frequencies & Percentages are summarized in table (2). The Chi-Square test was used for checking the relation between study variables. Multiple Response Analysis was used for summarizing symptoms and signs. Chi-Square test has two hypotheses, the null hypothesis "there is no relation" while the alternative hypothesis "there is a relation". Based on P-value the test can determine if there is a relation (p-value <0.05) or there is no relation (p-value>0.05).

RESULTS

50 participants were enrolled and completed the study. The demographic and clinical characteristics of patients are shown in Table (2). The median age was 36 years and 40% were male. A majority of patients had a history of headaches (46.6%).

According to Table (2), it is notable that 46% of the respondents' ages were between 35-49. 60% of the respondents were female. 54.3% of the respondents were normal in Non-contrast (TOF) MRA Finding. 52.9% of the respondents were not normal in Non-contrast (TOF) MRV findings. 64.7% of the respondents were not normal in Contrast-Enhanced (CE) MRA Finding. According to a table (3), it is notable that 46.6% of the signs & symptoms were Headache, 11% T2DM, 9.6% HTN, 6.8% stroke, and 5.5% Hypothyroidism.

Table 2: Calculated Frequencies & Percentages of study data

Variables	Frequency	Percent	
Age	25-34	15	30.0
	35-49	23	46.0
	50-59	7	14.0
	60 or more	5	10.0
	Total	50	100.0
Gender	Female	30	60.0
	Male	20	40.0
	Total	50	100.0
Non-contrast (TOF) MRA Finding	Normal	19	54.3
	Not-Normal	16	45.7
	Total	35**	100.0
Non-contrast (TOF) MRV Finding	Normal	16	47.1
	Not-Normal	18	52.9
	Total	34**	100.0
Contrast-Enhanced (CE) MRA Finding	Normal	6	35.3
	Not-Normal	11	64.7
	Total	17**	100.0

Table 3: summary statistics for signs & symptoms

Items		N	Percent
Signs & Symptoms	Headache	34	46.6%
	T2DM	8	11.0%
	HTN	7	9.6%
	Dizziness	4	5.5%
	Stroke	5	6.8%
	Hypothyroidism	4	5.5%
	Epilepsy	2	2.7%
	Vomiting	1	1.4%
	Tinnitus	2	2.7%
	Covid – 19	3	4.1%
	Other	3	4.1%
Total		73	100.0%

Table 4: relation between gender and Non-contrast (TOF) MRA Finding

			Gender		Total	Chi-Square
			Female	Male		
Non-contrast (TOF) MRA Finding	Normal	n	13	6	19	1.228
		%	61.90%	42.90%	54.30%	
	Not-Normal	n	8	8	16	
		%	38.10%	57.10%	45.70%	
Total		N	21	14	35	
		%	100.00%	100.00%	100.00%	

Table 5: relation between gender and Non-contrast (TOF) MRV Finding

			Gender		Total	Chi-Square
			Female	Male		
Non-contrast (TOF) MRV Finding	Normal	N	10	6	16	0.952
		%	41.70%	60.00%	47.10%	
	Not-Normal	N	14	4	18	
		%	58.30%	40.00%	52.90%	
Total		N	24	10	34	
		%	100.00%	100.00%	100.00%	

Table 6: relation between gender and Contrast-Enhanced (CE) MRA Finding

			Gender		Total	Chi-Square
			Female	*Male*		
Contrast-Enhanced (CE) MRA Finding	Normal	n	4	2	6	0.016
		%	36.40%	33.30%	35.30%	
	Not-Normal	n	7	4	11	
		%	63.60%	66.70%	64.70%	
Total		n	11	6	17	
		%	100.00%	100.00%	100.00%	

Table 7: relation between age and Non-contrast (TOF) MRA Finding

			Age				Total	Chi-Square
			25-34	35-49	50-59	60 or more		
Non-contrast (TOF) MRA Finding	Normal	N	6	11	1	1	19	5.47
		%	75.00%	61.10%	20.00%	25.00%	54.30%	
	Not-Normal	N	2	7	4	3	16	
		%	25.00%	38.90%	80.00%	75.00%	45.70%	
Total		N	8	18	5	4	35	
		%	100.00%	100.00%	100.00%	100.00%	100.00%	

Table 8: relation between age and Non-contrast (TOF) MRV Finding

			Age				Total	Chi-Square
			25-34	35-49	50-59	60 or more		
Non-contrast (TOF) MRV Finding	Normal	N	4	10	2	0	16	5.045
		%	30.80%	55.60%	100.00%	0.00%	47.10%	
	Not-Normal	N	9	8	0	1	18	
		%	69.20%	44.40%	0.00%	100.00%	52.90%	
Total		N	13	18	2	1	34	
		%	100.00%	100.00%	100.00%	100.00%	100.00%	

Table 9: relation between age and Contrast-Enhanced (CE) MRA Finding

			Age			Total	Chi-Square
			25-34	35-49	50-59		
Contrast-Enhanced (CE) MRA Finding	Normal	N	1	3	2	6	2.22
		%	16.70%	37.50%	66.70%	35.30%	
	Not-Normal	N	5	5	1	11	
		%	83.30%	62.50%	33.30%	64.70%	
Total		N	6	8	3	17	
		%	100.00%	100.00%	100.00%	100.00%	

It is notable that there is no significant relation between gender and Non-contrast (TOF) MRA Finding where the p-value >0.05. as shown inTable (4). It is notable that there is no significant relation between gender and Non-contrast (TOF) MRV Finding where the p-value >0.05, as shown in Table (5).

According to table (6), it is notable that there is no significant relation between gender and Contrast-Enhanced (CE). According to table (7), it is notable that there is a significant relation between gender and Non-contrast (TOF), MRA Findingwhere p-value >0.05.

There is no significant relation between age and Non-contrast (TOF) MRV, as shown in Table (8), or Contrast-Enhanced (CE) MRA,as shown in Table (9), the p-value >0.05.

DISCUSSION

MRI is one of the most important diagnostic tools in medicine and is one of the best models for diagnosing many musculoskeletal and neurological conditions [11]. Meanwhile, magnetic resonance angiography (MRA) or magnetic resonance angiogram (MRA) is a type of MRI that looks specifically at the blood vessels of the body. In contrast to the traditional angiogram, which requires insertion of a catheter into the body, MRA is less invasive and less painful as well Shipp, 2007 .To compare TOF-MRA and CE-MRA for these participants, the SPSS program was used, and the majority of them (46.6%) had previously suffered a head injury, which enabled us to determine the likelihood that the brain occlusions could be detected. According to the general variables, four out of five respondents were between 35 and 49 years old. According to Tang et al. (2019) study, 60% of the respondents were women, which is in accordance with our survey. Tang et al. collected 56 patients with dizziness (33 males and 23 females, mean age 53.4 + 18.6 years) between March 2017 and July 2017. But only five patients were diagnosed with vessel stenoses compared to our survey.

Contrast-enhanced magnetic resonance angiography and non-contrast magnetic resonance angiography differ in that contrast-enhanced MRA is considered the gold standard for displaying and imaging the vessels, but nowadays new sequences have been described that do not require administration of contrast agents; this is a quantitative method that can be interchanged with CE-MRA.

According to the report, 54.3% of the respondents were normal based on non-contrast (TOF) MRA results, while 52.9% were not of the same status based on non-contrast (TOF) MRV results, and 64.7% were not of the same status based on contrast-enhanced (CE) MRA results. Additionally, CE-MRA allowed visualization of an aneurysmal neck as well as calculation of the sac/neck ratio for all 34 aneurysms with a neck detected at DSA. On the other hand, only 24/34 of the 34 aneurysms had a neck visible on 3D TOF-MRA. The 3D CE-MRA showed 15 aneurysms with branches originating from the sac and/or neck, but only 12/15 aneurysms with branches were identified by the 3D TOF-MRA.

Among the signs and symptoms, the most common symptom was headache, which is the most common complaint of headache in general according to Holle D et al. (2013),other symptoms are not as critical .Due to the variations in the CE and TOF-MRA results, we examined whether there is a relationship between any parameter and these results. In attempting to determine whether gender and TOF-MRA findings are associated, it was noted that there is no significant relationship between gender and Non-contrast TOF-MRA findings, no significant relationship between gender and Non-contrast TOF-MRV findings, no significant relationship between gender and CE-MRA findings, all the studies were assumed to have a p-value greater than And this was in agreement with Chen et al. (2011) study which performed 3D-TOF-MRA on 1 side of 126 female and male patients and reported that the results were not affected by gender at all (Yadava et al.2019)And when we tried to get the relation between gender and artifact, we cannot calculate chi-square because it requires at least two categories in each variable.

We observed no significant relationship between age and TOF-MRA findings, no significant relationship between age and TOF-MRV findings, and no significant relationship between age and CE-MRA findings when we attempted to get a relationship between age and TOF-MRA findings. This is in agreement with Yu et al. (2012) studies he conducted with 12 women aged between 16 and 37 years old who reported that gender had no effect on their results As reported in Hu et al. (2008), there is a significant correlation between Contrast-Enhanced CE-MRA and Non-contrast TOF-MRV, where the P-value is 0.05, which is in agreement with Hu et al. (2008) who reported that CE MRA and TOF MRV results are deemed equivalent and there is no statistical significance when Wilcoxon signed-rank test is used.

CONCLUSION

In MR images of different types, there is no significant relation between the gender and age with the MRA results, except there is a strong relation between age and CE-MRA. Being male or female will not influence the results or the imaging, only some dependent variables may, such as the type of MR imaging and the Test measurement. Also, It will not affect the imaging findings to be in any particular age group; in any case, all age groups will have the same results when other parameters are fixed. We are recommending studying more participants with severe cardiovascular and neurological defects to detect the imaging and investigate the relation and difference between TOF-MRA and CE-MRA and MRV.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

ASA and MTA Write and perform the measurements, ARA and ASA. were involved in planning and supervised the

work, ASA and ARA were Collect data, performed the analysis, drafted the manuscript and designed the figures. Professor QTA aided in interpreting the results and worked on the manuscript. All authors discussed the results and commented on the manuscript. All authors read and approved the final version.

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