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EXTRA-CRANIAL AND INTRA-CRANIAL ANGIOGRAPHIC CHANGES IN PATIENTS SUBJECTED TO CERVICAL INTERNAL CAROTID ARTERY STENTING

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ABSTRACT

Background: Stroke is the third most common cause of mortality. About 25% of cases are caused by carotid atherosclerotic diseases.

Objective: To explore and analyze the extra cranial and intracranial angiographic changes of the internal carotid artery like stenosis, prolonged circulation time, degree of dilation and associated pathological changes like elongation, kink and tortuosity in patients subjected to cervical internal carotid artery stenting.

Patients and Methods: The study was a prospective study that conducted on 13 patients with high-grade asymptomatic or symptomatic carotid artery stenosis who were scheduled to undergo carotid artery stenting. The patients were recruited from Neurosurgery Department, Al-Azhar University and Ministry of Health Hospitals during the period from august 2019 to December 2020.

Results: 69.2% of cases had no intracranial findings. 15.4% of cases had MCA and ACA attenuation with collaterals opening. 15.4% of cases had ICA stenosis at petrous bone. Diameter of stent increased much 2.7 times in cases without hypertension more than cases with hypertension.

Conclusion: Majority of cases of cervical internal carotid artery stenosis has no intracranial attenuation, and hypertension affected the degree of post stenting dilation, and subsequently the circulation time.

Keywords: Cervical internal carotid stenosis, cervical internal carotid stenting.

INTRODUCTION

Stroke is the third most common cause of mortality. About 25% of cases are caused by carotid atherosclerotic diseases. Other causes include emboli emerging from heart, occlusion of small cerebral arteries and hematological diseases and represent 75% of cases. Also, stroke is the primary cause of disability. Understanding carotid artery stenosis pathology and management play an important role in prevention of stroke. Doppler ultrasound examination has an important role in the diagnosis of cerebrovascular diseases *(Radic, 2017).*

The bifurcation of carotid artery into internal and external is the most common site affected by atherosclerosis. The most common site affected in ICA is the ostium. The artery itself and its branches are less affected with atherosclerosis *(KO, 2018).*

CAS (carotid artery stenosis) is a progressive narrowing of the carotid artery due to development of atherosclerosis, atherosclerosis leads to deposition of plaques in interior arterial wall and therefore, thickening of the interior arterial wall occurred. Plaque consists of lipid core with infiltration of inflammatory cells covered with a fibrous cap. Classical pathological types of plaque based on the progression of atherosclerosis are fatty streaks, fibrous cap, and complicated lesion. A plaque can be stable and asymptomatic or it may be a source of embolization *(Sarmah et al., 2020)*.

We aimed in this study to explore and analyze the extra cranial and intracranial angiographic changes particularly the arterial diameter, circulation time and associated pathological changes like elongation, kink and tortuosity in patients subjected to cervical internal carotid artery stenting.

PATIENTS AND METHODS

This study was a prospective study that included 13 successive patients with high-grade asymptomatic or symptomatic carotid stenosis who were scheduled for carotid artery stenting.

Inclusion criteria: Patients with asymptomatic carotid stenosis (more than 70%) subjected to carotid artery stenting, and patients with symptomatic carotid artery stenosis (more than 50%) subjected to carotid artery stenting.

Exclusion criteria: Patients with symptomatic carotid stenosis subjected to carotid artery endarterectomy, and patients with asymptomatic carotid stenosis subjected to medical treatment.

All patients were subjected to a thorough clinical assessment with history taking, general, and neurological examination. Laboratory investigations were to assess general condition of the patient and associated risk factors in form of complete blood count, lipid profile, fasting and two hours postprandial blood glucose level. Carotid duplex ultrasonography and MRI brain were performed for all patients.

Catheter based carotid angiography:

Technique:

The diagnostic procedures were performed under local anesthesia. The therapeutic procedures were performed under general anesthesia and endotracheal intubation.

The femoral approach through the right femoral artery using seldingers technique and a 6F sheath was chosen in all cases.

In therapeutic cerebral angiography: The 6 French sheath was replaced by an 8 French one. This allows accommodation of the sheath to guider 8 French catheters, then carotid stent was introduced over 0.14 mm hydrophilic micro wire. The wall stent (Boston Scientific) was used in all cases. Predication was required in one case. Post stenting dilation was performed in all cases using Sterling balloon 4-5mm in diameter (Boston Scientific). The nominal pressure has not been exceeded in any case.

Final control angiogram through CCA including both the cervical ICA and the intracranial circulation was performed to evaluate residual stenosis and intracranial blood flow.

Statistical Analysis:

The analyses were carried with SPSS software (Statistical Package for the Social Sciences, version 24, SSPS Inc, Chicago, IL, USA). Frequency tables with percentages were used for categorical variables, and descriptive statistics (mean ± SD) were used for numerical variables.

RESULTS

Within the study group, mean age of patients was 58.85 ± 10.04 years, 76.9% of patients were males and 23.1% of patients were females, 61.5% of cases had diabetes, 53.8% of cases had hypertension and 69.2% of cases had dyslipidemia **(Table 1)**.

Table (1): Demographic data of the study group (n=13)

Demographic data		**Study group** (n=13)
Age (year)	Mean ± SD Range	58.85 ± 10.04 45-77
Male Female	N (%) N (%)	10 (76.9%) 3 (23.1%)
Diabetes	**N**	**%**
Yes	8	61.5
No	5	38.5
Total	13	100
Hypertension		
Yes	7	53.8
No	6	46.2
Total	13	100
Dyslipidemia		
Yes	9	69.2
No	4	30.8
Total	13	100

Most of cases were focal stenosis (53.8%), while multifocal stenosis represented 7.7% of cases.23.1% of cases had segmental stenosis **(Table 2)**.

Table (2): Comparing distribution of pattern of stenosis in the study group (n=13)

Pattern of stenosis	**N**	**%**
Complete	2	15.4
Focal	7	53.8
Multifocal	1	7.7
Segmental	3	23.1
Total	13	100

Within the study group, 69.2% of cases had no intracranial finding, while 15.4% of cases had MCA & ACA attenuation with collaterals opening and ICA stenosis at petrous bone **(Table 3)**.

Table (3): Comparing distribution of associated intracranial findings in the study group (n=13)

Intracranial finding	**N**	**%**
No	9	69.2
MCA & ACA attenuation & collaterals opening	2	15.4
ICA stenosis at petrous bone	2	15.4
Total	13	100

*MCA: Middle cerebral artery, ACA: Anterior cerebral artery, ICA: Internal carotid artery

Mean diameter of artery increased 2.6mm after stent placement, and dilation in cases without hypertension, while increased 0.98 mm in cases with hypertension. The diameter increased 2.7 times in cases without hypertension compared to cases with hypertension. Circulation time decreased 1.3 seconds post-stenting in cases without hypertension, while decreased 0.98 mm in cases with hypertension, and circulation time decreased 2.7 times in cases without hypertension compared to cases with hypertension **(Table 4)**.

Table (4): Measurements according to incidence of hypertension

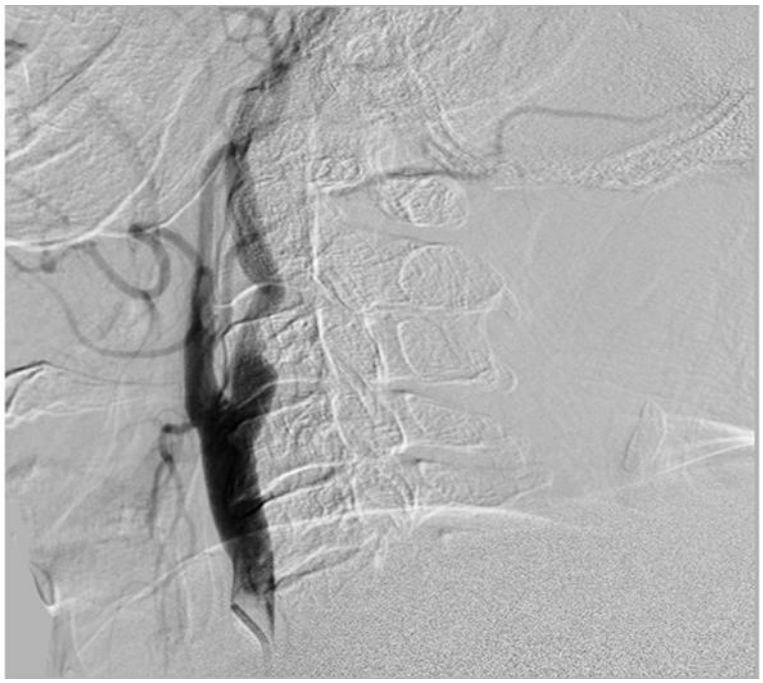
Blood pressure / **Measurements**	**Hypertension**		**No Hypertension**	
	Mean	SD	Mean	SD
Stenosis diameter (mm)				
Pre stent	2.69	0.90	1.52	0.75
Post stent	3.67	0.47	4.12	0.74
Difference (Post-Pre)	0.98	0.43	2.6	0.01
Circulation time (sec)				
Pre stent	5.47	0	4.83	0.75
Post stent	4	0.76	3.50	0.40
Difference (Post-Pre)	-1.47	0.76	-1.33	0.35

Mean diameter of artery increased 1.82mm post stent in cases without diabetes, while increased 1.75 mm in cases with diabetes, meaning nearly no difference, as the ratio of difference between cases without diabetes and cases with diabetes 1.04 (1.82/1.75). Circulation time decreased 1.39 second post stent in cases without diabetes, while decreased 1.5 second in cases with diabetes, meaning nearly no difference, as the ratio of difference between cases with diabetes and cases without diabetes 1.07 (1.5/1.39) **(Table 5)**.

Diabetes / Measurements	Diabetes		No Diabetes	
	Mean	**SD**	**Mean**	**SD**
Stenosis diameter (mm)				
Pre stent	1.97	0.57	2.38	1.41
Post stent	3.72	0.72	4.20	0.50
Difference (Post-Pre)	**1.75**	0.15	**1.82**	0.09
Circulation time (sec)				
Pre stent	5.25	0.70	5.06	1.00
Post stent	3.75	0.28	3.67	0.57
Diff*erence (Post-Pre)*	**-1.5**	-0.42	**-1.39**	-0.43

EXAMPLE (1)

Hypertensive patient



Right carotid angiography showing segmental stenosis

Diameter: 2.4 mm
Length: 7.1mm

Right carotid angiography showing insertion of stent

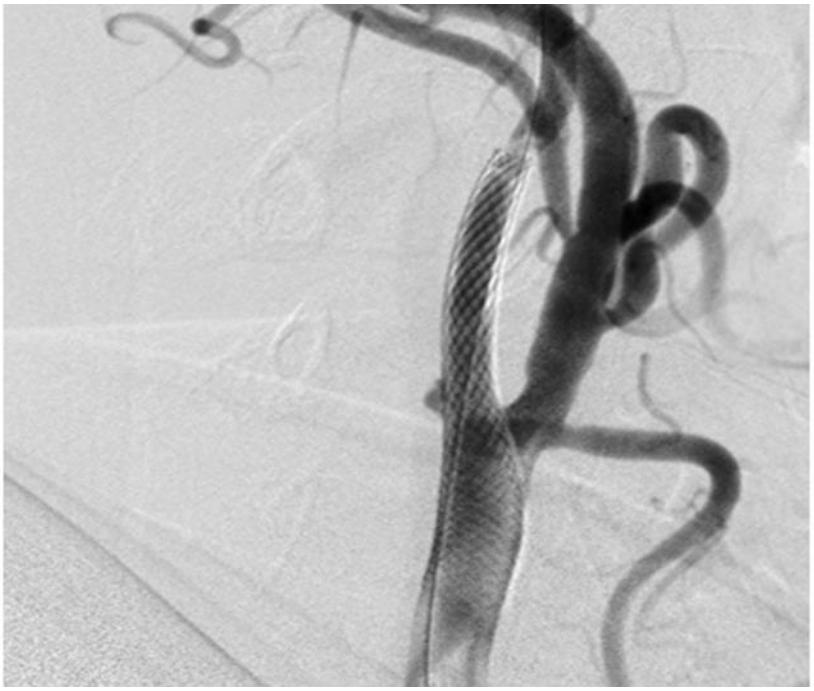
Diameter 4.2 mm

EXAMPLE (2)

Non-hypertensive patient

Carotid angiography showing right internal carotid focal stenosis

Diameter: 0.5mm



Carotid angiography showing stent insertion

Diameter: 3.7mm

DISCUSSION

Results of the current study revealed that the mean age of patients was 58.85 ± 10.04 years, 76.9% of patients were males and 23.1% of patients were females. These results were in agreement with a recent study done by *El Zayat et al. (2020)* who aimed to determine the difference between intracranial and extracranial steno-occlusive atherosclerosis and its correlation with risk factors of acute ischemic stroke using MRA and/or CTA with Duplex. They reported that the distributions of patients per gender were 38 (62.3%) males and 23 (37.7%) females, with an age range from 25 to 87 years, with a mean age of 64.5 years.

Within the study group, 61.5% of cases were diabetic, while 38.5% of cases were not diabetic, 53.8% of cases were hypertensive, while 46.2% of cases were not hypertensive, and 69.2% of cases had dyslipidemia, while 30.8% of cases had not dyslipidemia. These results were partially in agreement with *Soto-Cámara et al. (2020)* who aimed to describe the stroke patients' knowledge regarding the warning signs and risk factors associated with stroke with analyzing the possible relationship of this knowledge to the socio-demographic and clinical characteristics of the patients. They reported that high blood pressure (67.49%) and overweight/obesity (64.84%) were the most frequent risk factors reported by the patients then followed by dyslipidemia (49.52 %).

Regarding distribution of pattern of stenosis in the study group, most of cases had focal stenosis (53.8%), while multifocal stenosis represented 7.7% of cases. Results of this study revealed that 69.2% of cases had no intracranial finding, 15.4% of cases had MCA & ACA attenuation with collaterals opening and

15.4% of cases had ICA stenosis at petrous bone. The results of the present study resembled to some extent to the results of *Pienimäki et al. (2020)* who aimed to clarify whether ipsilateral carotid artery stenosis influences the collateral status in patients presenting with acute MCA occlusion. They reported that the presence of a severe ipsilateral carotid stenosis increased the odds of good Collateral score 4-times fold.

This study results showed that mean diameter of artery increased 1.82 mm post stent in cases without diabetes, while increased 1.75 mm in cases with diabetes, meaning nearly no difference, as the ratio of difference between cases without diabetes and cases with diabetes was 1.04 (1.82/1.75). Circulation time decreased 1.39 second post stent in cases without diabetes, while decreased 1.5 second in cases with diabetes, meaning nearly no difference, as the ratio of difference between cases with diabetes and cases without diabetes was 1.07 (1.5/1.39).

Results of the present study showed that mean diameter of artery increased 2.6mm post stent in cases without hypertension, while increased 0.98 mm in cases with hypertension, meaning that diameter increased 2.7 times in cases without hypertension compared to cases with hypertension. Circulation time decreased 1.3 seconds post stent in cases without hypertension, while decreased 0.98 mm in cases with hypertension, meaning that circulation time decreased 2.7 times in cases without hypertension compared to cases with hypertension.

The likely explanations of these differences between hypertensive and non-hypertensive patient's results could be attributed due to the pathogenesis of hypertension. It is a multifactorial process that involves the interaction of genetic and environmental factors. In varying degrees, abnormalities of volume regulation, enhanced vasoconstriction, and remodeling of the arterial wall (decreasing lumen diameter and increasing resistance) contribute to the development of hypertension. Various abnormalities in ion transport have been described in subsets of hypertensive individuals and in experimental models *(Förstermann et al., 2017)*.

These generally involve changes in sodium, calcium, and/or proton fluxes or concentrations. These changes in electrolyte metabolism enhance contractile response and hypertrophy and proliferation of vascular smooth muscle cells. The effects of blood pressure are also exhibited in larger arteries. The increased growth response of vascular smooth muscle is one of the characteristics of atherosclerosis in large arteries. Thus, increased vascular smooth muscle cell growth is another common feature in the pathogenesis of both atherosclerosis and hypertension *(Sun et al., 2018)*.

There is an increasing evidence that hypertension, like hyperlipidemia, induces oxidative stress in the arterial wall. It has even been suggested that superoxide anions might trigger the development of hypertension in some models, presumably by inactivating endothelium-derived nitric oxide and thus mitigating this important vasodilator mechanism *(Förstermann et al., 2017)*.

CONCLUSION

The majority of cases of cervical internal carotid artery stenosis have no intracranial attenuation, and hypertension affected the degree of post stenting dilation and subsequently the circulation time.

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تغيرات تصوير الشريان السباتى داخل وخارج الجمجمة فى المرضى الخاضعين لتدعيم الشريان السباتى بالرقبة بواسطة القسطرة

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خلفيـــة البحـــث: يعـــد ضـــيق الشـــريان الســـباتى مـــن أهـــم أســـباب الســـكتة الدماغيـــة ممـــا أعطـــى أهميـــة كبيـــرة لدراســـة طـــرق العـــلاج والتقنيـــات المســـتخدمة فـــى عـــلاج ضـــيق الشـــريان الســـباتى. ومـــن وســـائل عـــلاج ضـــيق الشـــريان الســـباتى تـــدعيم الشـــريان الســـباتى مـــن خـــلال القســـطرة المخيـــة. ويعـــد تـــدعيم الشـــريان الســـباتى مـــن خـــلال القســـطرة المخيـــة بـــديلا للتـــدخل الجراحـــى. ويـــتم تحديـــد المرضـــى المرشـــحين لتـــدعيم الشـــريان الســـباتى عـــن طريـــق القســـطرة المخيـــة بواســـطة الفحـــص الاكلينيكـــى للاعـــراض الظـــاهرة و دوبلـــر الموجـــات فـــوق الصـــوتيه علـــى الشـــريان الســـباتى بالرقبـــه، وأيضـــا الأشعة المقطعية والرنين المغناطيسى على شرايين المخ.

الهـــدف مـــن البحـــث: اســـتجلاء وتحليـــل تغيـــرات تصـــوير الشـــريان الســـباتى داخـــل وخـــارج الجمجمـــة فـــى المرضـــى الخاضـــعين لتـــدعيم الشـــريان الســـباتى بالرقبة بواسطة القسطرة.

المرضـــى وطـــرق البحـــث: أجريـــت هـــذه الدراســـه علـــى 13 مريضـــا يعـــانون مـــن أعـــراض نتيجـــة ضـــيق الشـــريان الســـباتى بالرقبـــة أو يعـــانون مـــن ضـــيق شـــديد بالشـــريان الســـباتى بالرقبـــة فـــى الفتـــرة بـــين أغســـطس 2019 وحتـــى ديســـمبر2020 بمستشـــفيات جامعـــة الأزهـــر حيـــث أجـــرى لهـــم قســـطرة تشخيصية للشريان السباتى داخل وخارج الجمجمة.

نتـــائج البحـــث: 69.2% مـــن الحـــالات لا يوجـــد بهـــا تغيـــرات فـــى تصـــوير الشـــريان الســـباتى داخـــل الجمجمـــة، 31.8% مـــن الحـــالات يوجـــد بهـــا تغيـــرات علـــى هيئـــة ضـــيق بالشـــريان الســـباتى داخـــل الجمجمـــة وفـــتح شـــرايين جانبيـــة داخـــل المـــخ. وازداد متوســـط قطـــر الدعامـــة بمعـــدل 2.7 مـــرات أكثـــر فى المرضى الذين لا يعانون من إرتفاع ضغط الدم.

الاســـتنتاج: غالبيـــة المرضـــى الـــذين يعـــانون مـــن ضـــيق شـــديد بالشـــريان الســـباتى بالرقبـــة، لـــيس بالضـــرورة ان يعـــانوا مـــن تغيـــرات بالشـــريان الســـباتى داخـــل الجمجـــة، كمـــا أن إرتفـــاع ضـــغط دم المـــريض يـــؤثر بالســـلب على إتساع الشريان بعد التدعيم.

الكلمـــات الدالـــة: ضـــيق الشـــريان الســـباتى بالرقبـــة، تـــدعيم الشـــريان الســـباتى بالرقبة.