The prevalence of extracranial carotid atherosclerosis detected via ultrasound imaging

A single-centre study in Jeddah, Saudi Arabia

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ABSTRACT

الأهداف: تحديد مدى انتشار تصلب الشرايين السباتية في جدة، المملكة العربية السعودية.

المنهجية: تم جمع بيانات عن المرضى الذين خضعوا لفحوصات التصوير الطبي بالموجات فوق الصوتية للشرايين السباتية بين عام 2017-2021م من أرشيف مستشفى جامعة الملك عبدالعزيز. تم استخراج بيانات خصائص المرضى، مستوى الدهون في الدم، صفات اللويحات في الشرايين السباتية من التقارير الطبية وصور الموجات فوق الصوتية.

النتائج: من اجمالي 1334 مريض، 13.5% تم تشخيصهم بوجود لويحات في الشرايين السباتية. متوسط عمر المرضى هو 69.8±10.4 سنة،76.1% منهم رجال. بلغت نسبة انتشار ارتفاع ضغط الدم والسكري عند المرضى 62.7% و50% على التوالي، في حين كان 7.2% من المرضى مدخنين. فيما يتعلق بمستوى الدهون في الدم، 6.5% من المرضى لديهم ارتفاع في مستوى الكوليسترول الكلي، و15.1% لديهم مستويات عالية من الدهون الثلاثية، و10.7% لديهم مستويات عالية من البروتين الدهني منخفض الكثافة. العدد الأوسطي لنسبة التضيق في الشرايين السباتية 34.4%، في حين كان العدد الأوسطي لطول و سُمك اللويحات 5ملم و 3ملم على التوالي. العدد الأوسطي لسُمك الجدار الداخلي للشرايين السباتية للمرضى1م. فيما يتعلق بأماكن وجود اللويحات، كان 62.7% في منطقة تفرع الشرايين السباتية، و28.3% في الشريان السباتي الداخلي، و6.1% في الشريان السباتي المشترك، و2.7% في الشريان السباتي الخارجي.

الخلاصة: معدل انتشار تصلب الشرايين السباتية بين المرضى في جدة بالمملكة العربية السعودية يعتبر منخفض، مع ملاحظة ارتفاع معدل انتشار مرضى ارتفاع ضغط الدم ومرض السكري (أكبر من أو يساوي 50%) من اجمالي المرضى الذين يعانون من تصلب الشرايين السباتية. هناك حاجة للمزيد من الدراسات متعددة المراكز لاستكشاف عوامل خطر تصلب الشرايين السباتية.

Objectives: To assess the prevalence of carotid atherosclerosis in Jeddah, Saudi Arabia.

Methods: Data on patients who underwent carotid ultrasound examinations between 2017-2021 were collected retrospectively from the archive of King Abdulaziz University Hospital, Jeddah, Saudi Arabia. Patient characteristics, blood lipid profiles, and plaque features were extracted from the medical records and ultrasound images. Descriptive data were presented as percentages.

Results: In total, 1334 patients were reviewed. Of these, 13.5% had carotid plaques and were included in the analysis. The mean patient age was 69.8±10.4 years, and 76.1% were men. The prevalence of hypertension was 62.7% and the prevalence of diabetes was 50%, and 7.2% of patients were smokers. Regarding blood lipid profiles, 6.5% of patients had high total cholesterol, 15.1% had high triglyceride levels, and 10.7% had high low-density lipoprotein levels. The median (interquartile range) stenosis was 34.4 (17.2) %, while the median plaque length was 5 (6) mm and thickness was 3 (1) mm. The median carotid intima-media thickness was 1 (0.3) mm. Regarding plaque distribution, 62.7% of plaques were in the carotid bulb. Additionally, 28.3% was in the internal carotid artery, 6.1% was in the common carotid artery, and 2.7% was in the external carotid artery.

Conclusion: The prevalence of carotid atherosclerosis among patients in Jeddah, Saudi Arabia, was low. A high prevalence of hypertension and diabetes (≥50%) was observed among the patients. Multicenter studies involving larger Saudi samples are warranted to explore carotid atherosclerosis risk factors.

Keywords: cardiovascular disease, atherosclerosis, carotid plaque, medical imaging, ultrasound

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Cardiovascular diseases (CVDs) affect the heart and blood vessels. They are an increasing global health concern and a leading mortality factor worldwide, affecting all ages, genders, and ethnicities.[1] Atherosclerotic CVD is a prominent cause of global mortality and disability.[2] In 2020, the World Health Organization (WHO) released a report highlighting the top 10 global causes of death, with strokes being the second leading cause. The report estimated that by 2030, approximately 23.6 million individuals will die from CVDs annually, highlighting the need for further research on atherosclerotic diseases and preventive measures.[3]

Carotid atherosclerotic plaque progression is associated with an increased risk of stroke and poor cognitive function.[4,5] Therefore, the non-invasive identification of carotid plaques is crucial for appropriate stroke management and prevention. Non-invasive ultrasound is the first-line imaging approach for assessing carotid intima-media thickness (cIMT) and atherosclerotic plaques; it provides information on plaque size, composition, and vulnerability.[6] The Society for Vascular Surgery's clinical practice guidelines for managing extracranial cerebrovascular disease consider a cIMT of ≥1 mm abnormal.[7] Studies have suggested that advanced atherosclerosis stages, which involve plaque formation, stenosis, and occlusion, are cardiovascular risk indicators.[2,8]

Variations exist in the prevalence of carotid plaques among different ethnic groups.[9] Therefore, it is crucial to understand the occurrence of carotid atherosclerosis in the Arab world and within the Saudi population to develop effective strategies for primary disease prevention and management. Therefore, we aimed to determine the prevalence and main risk factors associated with carotid atherosclerosis in Jeddah, Saudi Arabia.

Methods. We used data collected from the archive of King Abdulaziz University Hospital in Jeddah, Saudi Arabia, on patients referred to the Department of Radiology for carotid ultrasound examination between 2017-2021. The study was approved by the Unit of Biomedical Ethics Research Committee of the Faculty of Medicine and the Department of Radiology at King Abdulaziz University and King Abdulaziz University Hospital, Jeddah, Saudi Arabia (reference no: 584-21). In total, 1334 patients were reviewed. Adult patients with carotid plaques detected via ultrasound imaging were included in the analysis. Patients with no carotid plaques under ultrasound examination were excluded.

Patient information and clinical data, including age, gender, presence of other chronic diseases (namely, hypertension and diabetes), and smoking history, were extracted from patient files. Lipid profiles (namely, total cholesterol, triglyceride, and low-density lipoprotein [LDL] levels) were also retrieved. A standardized carotid ultrasound examination was carried out to ensure both consistency and repeatability. A trained vascular sonographer carried out the examinations. A medical ultrasound consultant evaluated and interpreted all images to ensure their precision and quality. The carotid ultrasound examinations were carried out using a 9-3 MHz broadband linear-array transducer with a high-resolution ultrasound imaging system (IU-22, Philips Healthcare, Bothell, Washington, United States of America). The common, internal, and external carotid arteries were evaluated bilaterally in the long and short axes. Two-dimensional B-mode images were acquired following carotid pre-sitting. Depth adjustments were carried out to exclude underlying tissues, and a singular focus point was positioned at the vessel level of interest to enhance lateral resolution. The overall gain, time-gain compensation, and dynamic range settings were optimized to ensure superior image quality. For cIMT measurements, the distance from the lumen-intima interface to the media-adventitia interface was assessed in a plaque-free region of the far wall proximal to the carotid bifurcation.[10] Plaques and focal structures with a thickness of >1.5 mm that protruded into the carotid artery lumen were assessed. Plaque length and thickness were measured. The degree of stenosis in the carotid arteries was determined by measuring the minimum residual luminal diameter.[11,12] Both cIMT and the degree of stenosis were measured using electronic calipers and were evaluated offline in the longitudinal view.

Statistical analysis. Descriptive data on gender, hypertension and diabetes history, smoking history, number of carotid plaques per patient, and largest plaque site were presented as frequencies. Regarding blood lipid profiles, values greater than 6.2 mmol/L for total cholesterol, 2.25 mmol/L for triglyceride, and 4.11 mmol/L for LDL, were considered high.[13] The data analysis was carried out using the Statistical Package for the Social Sciences, version 21.0 (IBM Corp., Armonk, NY, USA). A Shapiro-Wilk test was used to test data normality.

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Results. Of the 1334 patients reviewed, 180 patients with carotid plaques were included in the analysis. A summary of patient characteristics, clinical information, and plaque features are presented in Table 1.

The mean patient age was 69.8±10.4 years, and 137 (76.1%) were men, while 43 (23.9%) were women. Additionally, 113 (62.7%) were hypertensive, 90 (50%) were diabetic, and 13 (7.2%) were smokers. A total of 99 (55%) patients had one plaque, and 81 (45%) had multiple.

Among 167 patients, the median (interquartile range [IQR]) total cholesterol level was 3.5 (1.5) mmol/L, with 11 (6.5%) individuals showing high levels. Among 165 patients, the mean triglyceride level was 1.1 (0.67) mmol/L, with 25 patients (15.1%) exhibiting high levels. In a subset of 140 patients, the median LDL level was 2.1 (1.5) mmol/L, with 15 (10.7%) patients demonstrating high levels.

The plaques caused a median stenosis of 34.4 (17.2)%. The median plaque length was 5 (6) mm and thickness was 3 (1) mm, and the median cIMT was 1 (0.3) mm. Overall, 113 (62.7%) plaques were located in the carotid blub area (35%; on the right side and 27.7% on the left side), 51 (28.3%) were in the internal carotid artery (17.2%; on the right side and 11.1% on the left side), 11 (6.1%) were in the common carotid artery (3.9%; on the right side and 2.2% on the left side), and 5 (2.7%) were in the external carotid artery (1.1%; on right side and 1.6% on the left side).

Table 1 - Summary of the patient's characteristics, blood lipid profiles, and plaque features.

Patient characteristics	Patients with carotid plaque (n=180)
Age (years), mean±SD	69.8±10.4
Gender	
Men	137 (76.1)
Women	43 (23.9)
Hypertension	
Yes	113 (62.7)
No	67 (37.3)
Diabetes	
Yes	90 (50.0)
No	90 (50.0)
Smoking	
Yes	13 (7.2)
No	167 (92.8)
No. of plaques/patient	
One	99 (55.0)
More than one	81 (45.0)
Blood lipid profile, median (IQR)	
Total cholesterol (mmol/L)	3.5 (1.5)
High, n(%)	11 (6.5)
Triglyceride (mmol/L)	1.1 (0.67)
High, n(%)	25 (15.1)
Low-density lipoproteins (mmol/L)	2.1 (1.5)
High, n(%)	15 (10.7)
Plaque site and features	
Common carotid artery	11 (6.1)
Internal carotid artery	51 (28.3)
External carotid artery	5 (2.7)
Carotid bulb	113 (62.7)
Degree of stenosis (%), median (IQR)	34.4 (17.2)
Plaque length (mm), median (IQR)	5 (6.0)
Plaque thickness (mm), median (IQR)	3 (1.0)
cIMT (mm), median (IQR)	1 (0.3)

Values are presented as numbers and precentages (%) or median interquartile range (IQR). cIMT: common carotid intima-media thickness, SD: standard deviation

Discussion. This study provides insight into patients' lipid profiles and plaque characteristics, including cIMT, plaque sites and sizes, and degree of stenosis. The mean age of patients with carotid plaques was 69.8±10.4 years. There was a higher prevalence of carotid plaques in men. The median total cholesterol was 3.5(1.5) mmol/L, 1.1(0.67) mmol/L was for triglyceride, and 2.1(1.5) mmol/L was for LDL levels. The median cIMT was 1 (0.3) mm, 34.4 (17.2)% for degree of stenosis, 5 (6) mm for plaque length, and 3 (1) mm for plaque thickness. Most plaques were found in the carotid bulb area.

Three previous studies have assessed the frequency of carotid artery diseases in Saudi populations in Riyadh and Al-Madinah Al-Munawarah. The first study, by Al Rajeh et al,[14] involved 500 Saudi stroke patients admitted to King Fahad National Guard Hospital in Riyadh. The average patient age was 63 years. Ischemic strokes were the most prevalent, with 381 (76.2%) patients diagnosed. Additionally, 260 (52%) cases were attributed to large infarctions and 121 (24.2%) to lacunar infarctions. Intracerebral hemorrhage was observed in 107 (21.4%) cases, while subarachnoid hemorrhage was rare, occurring in only 12 (2.4%) cases. Male predominance was seen across all stroke types. Regarding other conditions, 280 (56%) patients were hypertensive, 210 (42%) were diabetic, and 165 (33%) had cardiopathy. Within the first month post-stroke, 61 (12%) patients died.[14] In the second study, of the 435 patients admitted to the King Abdulaziz Medical City stroke unit in Riyadh, 40 (9.2%) had severe carotid artery stenosis, with 48 affected vessels in total.[15] The third study investigated the prevalence of carotid artery stenosis among patients undergoing cardiac surgery at the Cardiac Center in Al-Madinah Al-Munawarah.[16] Of the 261 patients, 187 (71%) exhibited carotid artery stenosis, and diabetes and hypertension were significantly associated with its presence. Carotid artery diseases are

relatively uncommon in the Saudi population; however, these studies highlight the significance of the early identification and management of risk factors, such as hypertension and diabetes, for preventing and treating carotid artery diseases and minimizing their impact on the Saudi population.

Song et al[17] carried out a systematic review and meta-analysis to calculate the first estimate of the global epidemiological burden of carotid atherosclerosis. They found that 28% of individuals aged 30-79 years globally (equal to over one billion individuals) had an abnormal cIMT (≥1.0 mm). Furthermore, 21% (816 million individuals) had carotid plaques, and 1.5% (58 million individuals) exhibited carotid stenosis. Age and gender were significant factors, with increased cIMT, carotid plaque, and carotid stenosis more prevalent in older individuals and men.[17] Similar to our findings, hypertension and diabetes were considered risk factors, being associated with increased cIMT and carotid plaque presence.

A strong association between hypertension and extracranial carotid atherosclerosis has been reported, with hypertension being a significant predictor of carotid stenoses of ≥50%.[18] Hypertension accelerates atherosclerosis progression and induces endothelial lining damage.[19,20] Diabetes is another significant risk factor for the development of extracranial carotid atherosclerosis.[21] Diabetes affects the vascular endothelium, reducing nitric oxide availability, a key anti-atherosclerotic agent.[22] Elevated lipid levels contribute to the development of atheromas or fibrofatty plaques, gradually narrowing the arterial passages. As these plaques grow, they progressively obstruct the arterial lumen, impeding blood flow and leading to potential stroke.[23] Most patients in our study had lipid levels within the desirable range. However, a small proportion exhibited high levels of total cholesterol, triglycerides, or LDL, which may increase their cardiovascular risk.[13] This emphasizes the importance of regular lipid profile monitoring, risk factor management, and individualized interventions to optimize lipid levels and reduce the risk of atherosclerosis and its associated complications in patients with carotid plaques.

Study limitations. The relatively small sample size and use of data collected from a single center and from patients who underwent carotid ultrasound examination is a limitation of the current study. This may limit the generalizability of the findings to the broader Saudi population or other regions. Furthermore, retrospective studies are prone to limitations in data availability. This study used demographic information, including age and gender. Including further demographic factors, such as ethnicity and socioeconomic status, and potential risk factors, such as family history, obesity, or physical activity levels, could enable a more comprehensive understanding of the population under study and allow the full range of risk factors associated with carotid atherosclerosis to be explored. Further longitudinal studies are required to assess the long-term outcomes and clinical significance of these plaques in terms of stroke incidence and other cardiovascular events.

In conclusion, carotid atherosclerosis is not highly prevalent in Jeddah, with only 13.5% of the patients in this study demonstrating carotid plaque presence. There was a higher prevalence of plaques in men compared to women. A high prevalence of hypertension and diabetes (≥50%) was observed in patients with carotid atherosclerosis, which likely contributes to the development of carotid atherosclerosis. A small proportion of patients exhibited high lipid levels. Most plaques were located in the carotid bulb. Further multicenter studies involving larger samples are warranted to validate these findings and explore additional risk factors associated with carotid atherosclerosis.

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