Atherosclerosis in Ancient and Modern Egyptians☆

The Horus Study

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ABSTRACT

Background: Although atherosclerosis is usually thought of as a disease of modernity, the Horus Team has previously reported atherosclerotic vascular calcifications on computed tomographic (CT) scans in ancient Egyptians.

Objectives: The purpose of this study was to compare patterns and demographic characteristics of this disease among Egyptians from ancient and modern eras.

Methods: We compared the presence and extent of vascular calcifications from whole-body CT scans performed on 178 modern Egyptians from Cairo undergoing positron emission tomography (PET)/CT for cancer staging to CT scans of 76 Egyptian mummies (3100 BCE to 364 CE).

Results: The mean age of the modern Egyptian group was 52.3 ± 15 years (range 14 to 84) versus estimated age at death of ancient Egyptian mummies 36.5 ± 13 years (range 4 to 60); $p < 0.0001$. Vascular calcification was detected in 108 of 178 (60.7%) of modern patients versus 26 of 76 (38.2%) of mummies, $p < 0.001$. Vascular calcifications on CT strongly correlated to age in both groups. In addition, the severity of disease by number of involved arterial beds also correlated to age, and there was a very similar pattern between the 2 groups. Calcifications in both modern and ancient Egyptians were seen peripherally in aortoiliac beds almost a decade earlier than in event-related beds (coronary and carotid).

Conclusions: The presence and severity of atherosclerotic vascular disease correlates strongly to age in both ancient and modern Egyptians. There is a striking correlation in the distribution of the number of vascular beds involved. Atherosclerotic calcifications are seen in the aortoiliac beds almost a decade earlier than in the coronary and carotid beds.

Atherosclerotic vascular disease is a major health problem with the highest rate of morbidity and mortality worldwide. Atherosclerosis is often thought of as a "modern" disease, a product of lifestyles and diets much different than that found in ancient civilizations. The Horus Team has previously published on the use of computed tomography (CT) to detect vascular calcifications, a pathognomonic feature of atherosclerosis, in many ancient Egyptians living as long as 3,500 years ago [1–6]. Accordingly, we thought to compare patterns and demographic characteristics of vascular calcifications between modern and ancient Egyptians to better understand the determinants of atherosclerosis in modern and ancient humans.

METHODS

Study cohort

CT scans obtained in 178 consecutive modern Egyptian patients were reviewed for the presence and degree of vascular calcifications. All patients had been referred by their primary physicians to Alfa Scan Outpatient Radiology Center in Cairo, Egypt, for clinically indicated positron emission tomography (PET) studies for cancer staging. Informed consent was obtained prior to scanning. Results were compared with the CT scans of 76 old Egyptian mummies (3100 BCE to 364 CE) reported earlier by Horus Team [4–6].

Imaging

All modern Egyptian patients underwent imaging with Philips Gemini TF PET/CT 64 slices scanner (Eindhoven, Netherland). All images were obtained during a single session proceeding caudally from the base of the skull to the level of the knee. CT images were obtained at 1-mm slice thickness with average time interval of 0.8 ms. Interpretation was done searching for vascular calcifications in different vascular beds. The vascular

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TABLE 1. Demographic characteristics of the modern Egyptian group

Modern Egyptians included	178
Age, years	52.3 ± 14.9
Male	104 (58.4)
Atherosclerosis	108 (60.7)
Number of affected vascular beds	
0	70 (39.3)
1	25 (14)
2	28 (15.7)
3	24 (13.5)
4	31 (17.4)

Values are n, mean ± SD, or n (%).

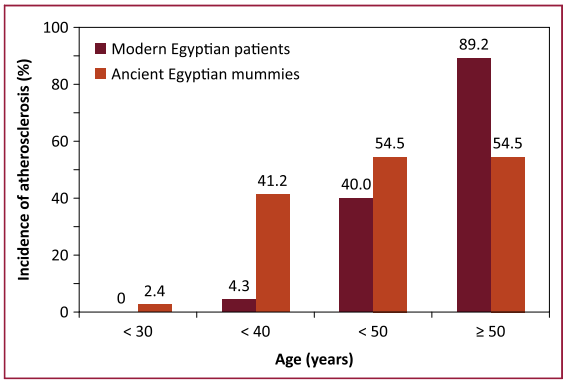

FIGURE 2. Incidence of vascular calcification in relation to age in modern and ancient Egyptian groups.

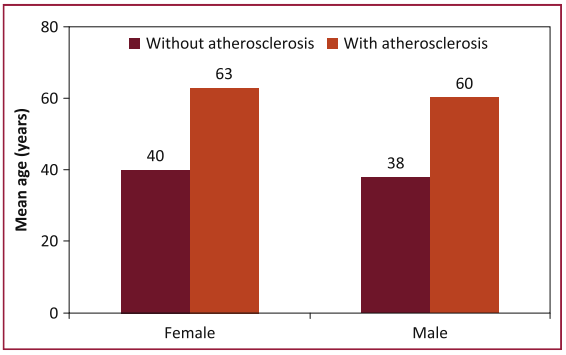

FIGURE 1. Relation between atherosclerosis and mean age in modern Egyptian population. Men and women with atherosclerotic calcifications are older on average than those without calcifications.

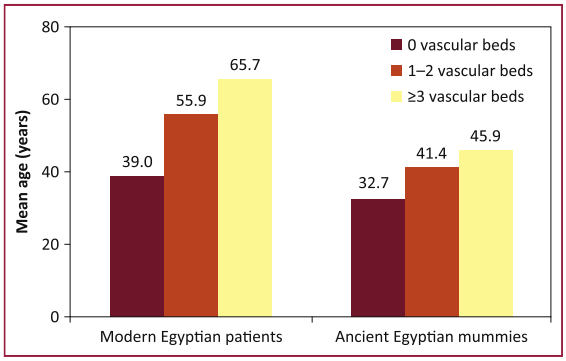

FIGURE 3. Category of vascular calcification severity in relation to mean age in modern and ancient Egyptian groups.

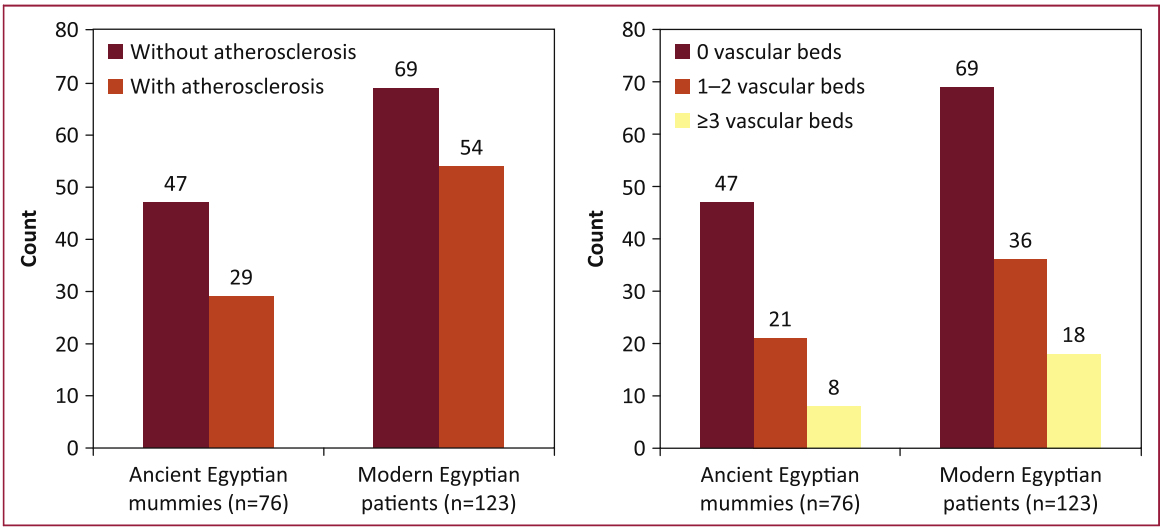

FIGURE 4. Incidence of vascular calcification present or absent and extent of vascular disease among ancient and modern Egyptians after excluding modern patients >60 years of age.

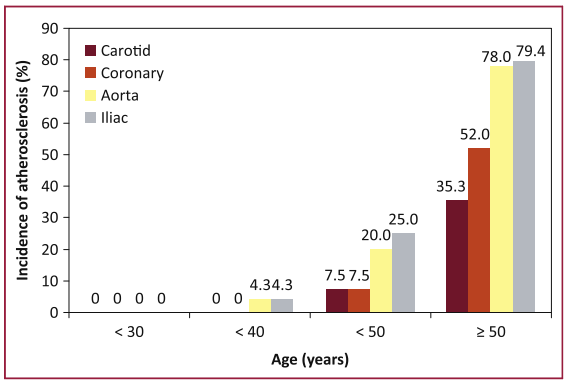

FIGURE 5. Vascular bed distribution of calcification in modern Egyptian group in relation to age.

beds examined included carotid, coronary, aortic, and iliofemoral.

Imaging of ancient Egyptian mummies was done using whole-body, 6-slice Siemens Emotion 6 (Florsheim, Germany), specifically searching for cardiac and vascular calcification. Technical details are described elsewhere [1]. Mummies were selected for scanning based on a good state of preservation and were not randomly selected. Examined vascular beds included carotid, coronary, aortic, iliofemoral, and peripheral beds.

Severity and extent of vascular calcification

Based on the number of vascular beds affected, the severity and extent of the disease was classified into the following: no disease, no evidence of vascular calcification = 0 vascular beds affected; mild disease = 1 to 2 vascular beds affected; and severe disease ≥3 vascular beds affected. Images were interpreted by consensus of 5 experienced cardiovascular imaging physicians.

Statistical analysis

Normally distributed continuous variables were described by means ± SD, and categorical variables were described as frequencies (percentages). Statistical significance was defined as a probability value <0.05. To compare between modern and ancient groups, *t* tests and chi-square tests were used for continuous and dichotomous variables, respectively. Analyses were conducted using SPSS (version 17, SPSS Inc., Chicago, Illinois).

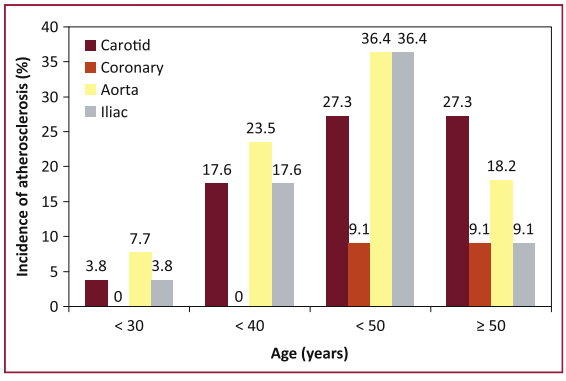

FIGURE 6. Vascular bed distribution of calcifications among ancient Egyptian group.

RESULTS

Modern Egyptian group characteristics are presented in Table 1. Fifty-eight percent of these patients were men and the average age was 52.3 ± 14.9 years. The number of men in the modern Egyptian group was 104 (58.4%), whereas the number of male mummies in the ancient Egyptian group was 48 (64.9%), p = 0.209. The mean age of the modern Egyptians involved in this study was 52.3 ± 15 years (range 14 to 84) versus the estimated age at death of

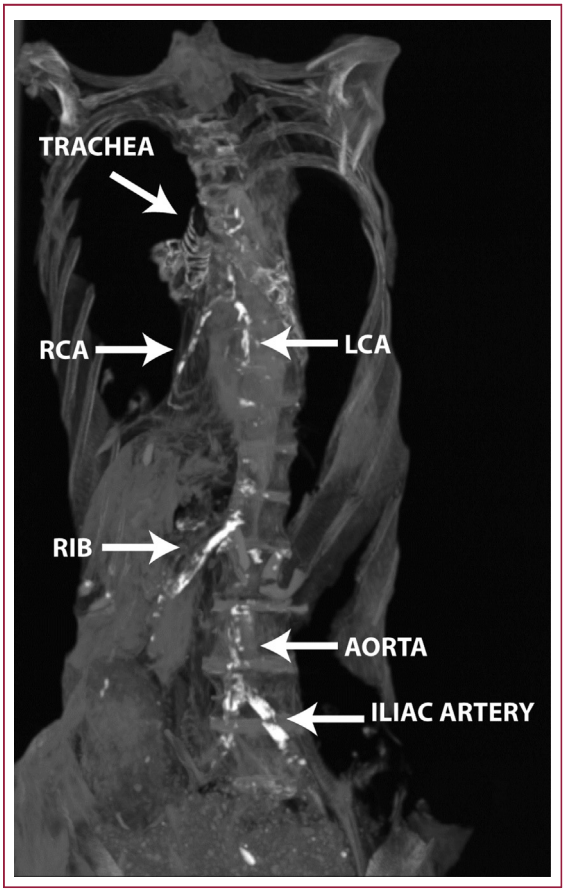

FIGURE 7. Reoriented coronal thick slab 3-dimensional, multiplanar reconstruction window adjusted for vascular calcification, computed tomography image of the mummy of a princess who lived during the Second Intermediate Period of ancient Egypt shows calcifications in the coronary and iliac arteries. This person had diffuse atherosclerosis. Reprinted, with permission, from Allam et al. [4].

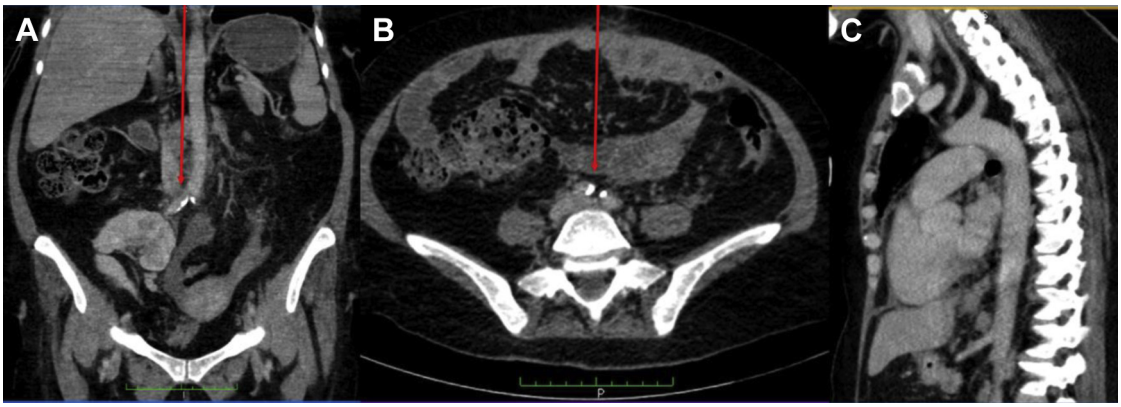

FIGURE 8. Coronal, axial and sagittal computed tomographic multiplanar reformatted images from a 47-year-old modern Egyptian woman with hypertension, but no other risk factors for atherosclerosis. There is mild aortoiliac disease (*arrows* in A and B) but no coronary or carotid calcium (C).

the mummies was 36.5 ± 13 years (range 4 to 60 years); $p < 0.0001$.

Vascular calcification was detected in 108 of 178 (60.7%) modern Egyptian patients versus 26 of 76 (38.2%) ancient Egyptian mummies, $p < 0.001$. Incidence of vascular calcification was strongly related to age irrespective of sex differences as shown in Figure 1. In addition, the extent of the disease assessed by the number of vascular beds affected was directly related to age.

The mean age for the modern Egyptian group with evidence of vascular calcification was 61 ± 10.5 years compared with 39 ± 10.1 years for those without evidence of vascular calcifications ($p < 0.0001$), 56 ± 9.5 years for those with mild disease, and 65.7 ± 9.2 years for those with severe disease ($p < 0.0001$). The same finding was detected among the Egyptian mummies group. Mean age of mummies at time of death was 42.7 ± 10.2 years for those with atherosclerosis versus 32.7 ± 12.4 years for those without evidence of vascular calcification ($p < 0.0001$). For mummies with evidence of mild disease, the mean age was 41.4 ± 10.9 years and 45.9 ± 7.9 years for those with severe disease (Figs. 2 and 3).

None of the ancient Egyptian mummies had an estimated age exceeding 60 years at the time of death. When modern Egyptian patients exceeding 60 years of age were excluded in a subsequent analysis, atherosclerosis prevalence and severity were comparable among both modern and ancient Egyptian groups (Fig. 4).

When a subanalysis was done showing the pattern of atherosclerotic vascular disease among both groups with relation to age, it was quite striking to note that the pattern of progression of vascular atherosclerosis was the same among modern and ancient Egyptians. Moreover, the disease pattern was the same across different age groups. Figure 5 shows that

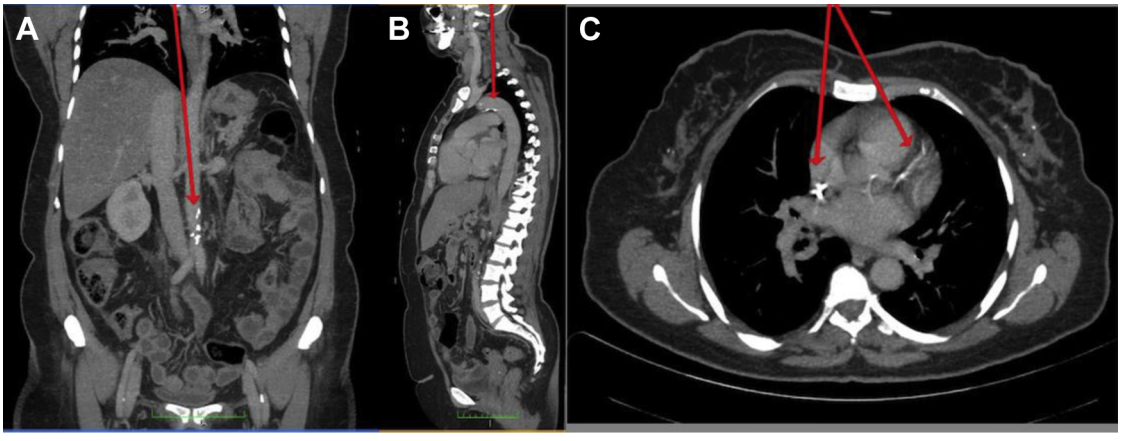

FIGURE 9. Coronal, sagittal, and axial computed tomographic multiplanar reformatted images from a 58-year-old modern Egyptian woman with hypertension. Calcifications are seen in the abdominal aorta (A), the aortic arch (B), and the coronary arteries (C).

vascular calcification starts at the peripheral vascular bed (iliofemoral then aortic beds), then spreads to the target vessels (coronary and carotid beds) around a decade later than the onset of aortoiliac calcification. This finding was noticed in both ancient and modern populations (Fig. 6). This finding could have relevance for vascular screening protocols (Figs. 7 to 11).

Another important finding illustrated in Figure 12 is the trend toward a higher incidence of vascular calcifications among female mummies versus modern Egyptians. One possible explanation could be the higher exposure to household smoke among ancient Egyptian women.

DISCUSSION

The use of CT to detect vascular calcification as a characteristic feature of atherosclerosis is well documented in previous studies [1–3]. This noninvasive, nondestructive method has been validated by comparison with other imaging modalities and with histologic evidence of atherosclerosis. Studying atherosclerosis in ancient populations from different cultures and geographic regions has evolved to be the major area of research addressed by the Horus Team [4–6].

The fact that atherosclerosis, as evidenced by vascular calcification, was seen on whole-body CT examination of ancient Egyptian mummies has changed our belief that vascular atherosclerosis is a disease related to a modern lifestyle and has demonstrated that our understanding of the causative risk factors of this disease are less than perfect. This has deepened our interest to better study demographics and patterns of this disease in both ancient and modern Egyptians.

Thompson et al. [5] reported that CT evidence of atherosclerosis was prevalent in mummies from multiple cultures across 4 disparate geographical regions over several time epochs. CT scanning has also shown atherosclerosis in the body of an ancient European. Previous autopsy studies have also shown atherosclerosis in ancient Egyptians and pre-historic Native North Americans and ancient Peruvians as well as Aleutian Island hunter-gatherers [7–11].

In the current study, comparison of the demographic characteristics and the pattern of atherosclerosis between modern and ancient Egyptian populations reveal that age was the most consistent factor related to development of atherosclerosis in both groups irrespective of sex. Severity of the disease—in terms of the number of vascular beds affected—also correlated strongly to aging.

In a previous study of 650 asymptomatic modern individuals, Allison et al. [12] showed that atherosclerosis with calcification was ubiquitous in men by age 60 years and in women by 70 years, as indicated by the presence of calcification in at least 1 of 5 beds assessed: carotid; coronary; proximal aorta; distal aorta; and iliac vessels. By the age of 50 years, atherosclerosis was present in all 5 beds in 82% of men and 68% of women.

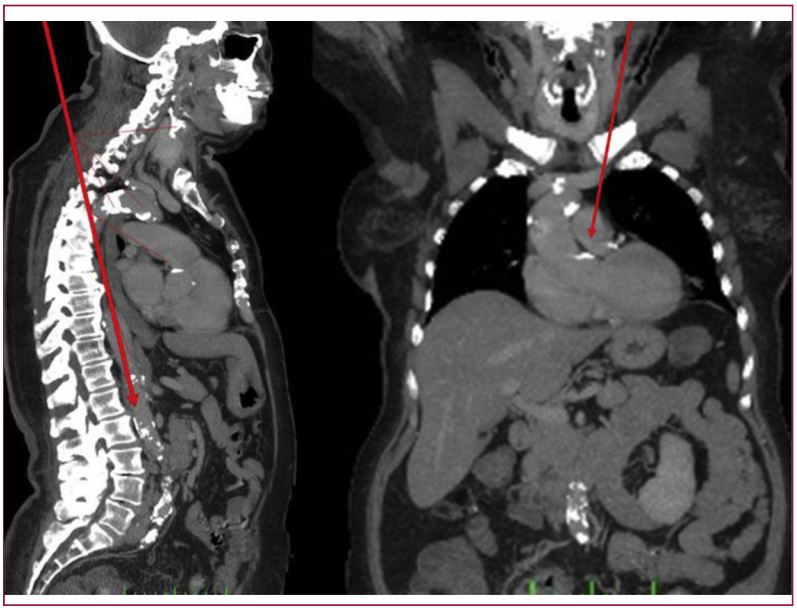

FIGURE 10. Sagittal and coronal computed tomographic multiplanar reformatted images from a 69-year-old woman with diabetes and a previous stroke. There are extensive calcifications in the aortoiliac and proximal aorta as well as in the coronary and carotid arteries.

As none of the mummies' ages at the time of death was more than 60 years, we excluded modern patients more than 60 years of age from subsequent analysis. When age range was matched, both the incidence and severity of the atherosclerotic disease were not significantly different between ancient and modern Egyptians.

Subsequent analysis of patterns of atherosclerosis and its relationship to age showed that atherosclerotic changes in both ancient and modern Egyptians usually start first at

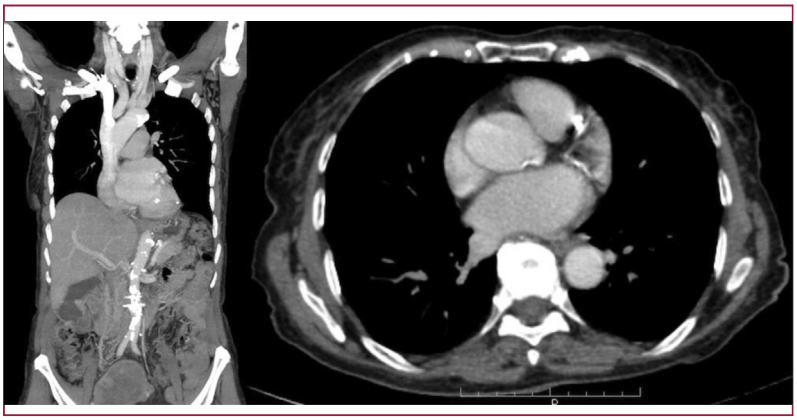

FIGURE 11. Coronal and axial computed tomographic multiplanar reformatted images from an 81-year-old woman with hypertension. There are extensive calcifications in the aortoiliac, proximal aorta, coronary, and carotid arteries.

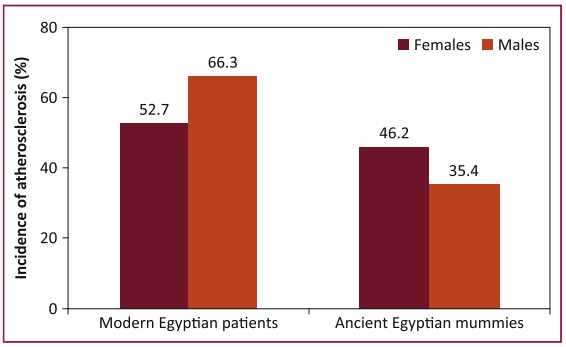

FIGURE 12. Incidence of vascular calcification in relation to sex in both groups.

the peripheral vascular beds (iliofemoral and aortic) usually a decade earlier than the target vessels (coronary and carotid beds) are affected.

Wong et al. [13,14] reported in the MESA (Multi-Ethnic Study of Atherosclerosis) study that abdominal aortic calcification is strongly associated with subclinical cardiovascular disease in other vascular beds, including the coronary, carotid, and leg arteries. They concluded that the high prevalence of abdominal aortic calcification, even in the absence of coronary or carotid disease, may suggest earlier occurrence of atherosclerosis in the abdominal aorta than the other event-related vascular beds [13,14]. Occurrence of aortoiliac calcification a few years earlier than coronary and carotid calcification could be used as an important screening tool for effective preventive cardiovascular strategies.

Elucidation of risk factors underlying the development and progression of atherosclerosis helps identify effective strategies for the prevention and treatment of this common human disease. Our knowledge on risk factor patterns among ancient Egyptians, including associated conditions such as diabetes mellitus, dyslipidemia, and hypertension, is incomplete. Further studies comparing varying environmental and genetic predispositions to the development of atherosclerosis between ancient and modern Egyptians are warranted.

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