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Virtual histology of coronary arteries using intravascular ultrasound (IVUS) - local experience.

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Abstract

Background: In the occurrence of coronary events, atherosclerotic plaque characteristics have been demonstrated to play a pivotal role. Based on histological studies of victims of sudden cardiac death, lesions containing a large amount of necrotic core with an overlying thin fibrous cap (referred to as thin cap fibroatheroma TCFA) have been linked to plaque rupture. In vivo detection of potentially vulnerable plaques may improve the prevention of cardiovascular events.
The aim of the study was to find out the pattern of plaque morphology using VH-IVUs in our population.
Methodology: This descriptive study was conducted in Lady Reading Hospital, Peshawar. We enrolled patients with a history of coronary artery disease admitted for coronary angiography from 2007 to 2011. Virtual histology was obtained for the fibrofatty, fibrous, calcified, and necrotic plaques. The sizes of the vessels and lumen were measured. The results of the study were mentioned in mean, standard deviation, and percentage of different variables.
Results: A total of 41 patients were studied. The mean age was 56.3 years (+ 9.9 SD). Males were 29 (70.7%). Chest pain was almost reported by all patients (100%). Acute coronary syndrome (ACS) diagnosis was present in 23 patients (56.1%), while patients with chronic coronary syndrome (CCS) were 18 (43.9%). The Minimum plaque burden was 58.5%, while the maximum was 89.6%, with a mean value of 73.1%. The most common plaque type was fibrous (77.3% SD +6.4), followed by fibro¬fatty plaque (13.02% SD +3.5). The necrotic type was 7.09 % SD +6.2, while calcified plaque was 2.2% SD + 1.4.
Conclusion: Fibrous type plaque was the most common type of VH IVUS in both CCS patients and the ACS group; However, necrotic core was comparatively more in the ACS group.

Keywords

Intravascular Ultrasound, Virtual Histology, Coronary Artery Disease

Introduction

Ischemic heart disease is the leading cause of death worldwide. The rupture of an atheromatous coronary plaque, which causes thrombosis and myocardial infarction, causes the bulk of these clinical occurrences[1]. Atherosclerotic plaque features are crucial to the occurrence of coronary events. Lesions with a significant proportion of necrotic cores and an overlaying thin fibrous cap (known as thin-cap fibroatheroma TCFA) have been associated with plaque rupture based on histological examinations of victims of sudden cardiac death. The ability to identify potentially vulnerable plaques in vivo may enhance the prevention of cardiovascular events[2]. To evaluate the makeup of coronary artery plaques, a method known as virtual histological intravascular ultrasonography (IVUS) combines high-resolution IVUS imaging with sophisticated signal processing[3]. As atherosclerosis is the root cause of most cases of coronary artery disease (CAD) worldwide, IVUS has become a useful tool for examining the pathophysiology of atherosclerosis[4]. It uses mechanical or dynamic array catheters ranging in size from 2.6 to 3.5F, which are compatible with 6- or 7-F guiding catheters. It provides a 25–45 MHz image frequency for tissue characterization and a 3-dimensional picture of the coronary arteries[5]. Computer software can reconstruct the images using automated or manual pull-back devices[6]. This method provides the detailed morphology of the normal coronary arterial wall, major components of atherosclerotic plaque, and changes that occur during and after percutaneous coronary intervention. This can be performed in vivo in an otherwise possible way.

Virtual histology is a novel technique that uses sophisticated computer algorithms to analyze IVUS images and classify the composition of coronary artery plaques. This analysis is based on the principle that different types of tissues have unique acoustic properties that can be identified by their characteristic backscattering patterns. Using advanced signal processing techniques, virtual histology software can differentiate between four major types of plaques: fibrous, fibrofatty¬, calcified, and necrotic, which are color-coded as green, yellow, white, and red, respectively. Virtual histology provides detailed information about the composition of the plaque, as well as the total plaque burden[12]. Recently, Nasu et al. demonstrated that VH IVUS, when compared to histology, enabled the diagnosis of a necrotic core with an accuracy of 88.3% and the detection of dense calcium with an accuracy of up to 96.5%[13]. A large volume of international data is rapidly emerging regarding the use of IVUS and virtual histology in various aspects of cardiology; however, local data are limited.

Our study aimed to examine the pattern of plaque morphology in coronary arteries using virtual histology (intravascular ultrasound) in the local population. This study provides insight into our patients' plaque morphology and will help plan treatment strategies in appropriate clinical settings.

Methodology

This cross-sectional descriptive study was conducted from 2007 to 2011 in the Cardiology Department of the Lady Reading Hospital, Peshawar. After approval from the hospital's ethical committee, symptomatic patients with a history of coronary artery disease who were admitted for coronary angiography were enrolled in the study after obtaining informed consent. All patients provided written consent after being informed of the study protocol. The inclusion criterion was age > 16 years with a history of ischemic heart disease. Patients with lesions suggestive of chronic total occlusion (CTO) were excluded from the study. Each patient had a proforma filled out with information on their age, sex, previous history of hypertension, diabetes, hypercholesterolemia, and myocardial infarction. Virtual histology was obtained for the fibrofatty, fibrous, calcified, and necrotic plaques. The sizes of the vessels and lumen were measured. An index of remodeling was also established. The IVUS equipment automatically computed the plaque burden using built-in software. Due to the computerized processing of all characteristics, bias in the study was minimized. SPSS version 14.0 was used to analyze the data. The confidentiality of the data was preserved.

For categorical data such as gender and demographics, frequency and percentage were utilized, whereas mean and standard deviation were used for numerical variables such as age and plaque burden.

Results

The present study involved 41 patients, with a mean age of 56.3 (+SD 9.9). Among study participants, 29 were male, accounting for 70.7% of the total, while the remaining 12 were female (29.3 %). All the patients included in the study reported experiencing chest pain. Based on the diagnosis, 23 patients (56.1%) were diagnosed with acute coronary syndrome (ACS), while the remaining 18 patients (43.9%) were diagnosed with chronic coronary syndrome (CCS). Regarding risk profile, 20 (48.7%) patients were diabetic, 12 (29.26%) were hypertensive, 28 (68.2%) had dyslipidemia and 29 (70.7%) were smokers.

In addition, 11 (26.8%) patients had positive remodeling while 30 (73.2%) had negative remodeling indexes. The minimum plaque burden calculated in the study was 58.5%, whereas the maximum was 89.6%, with a mean plaque burden of 73.1%.

Furthermore, the study examined plaque type, which was identified as fibrous in the majority of patients (77.3% SD + 6.4), followed by fibro-fatty plaque (13.02% SD + 3.5). The necrotic type was observed in 7.09% of the patients (SD + 6.2), while calcified plaques were found in 2.2% of the patients (SD + 1.4)

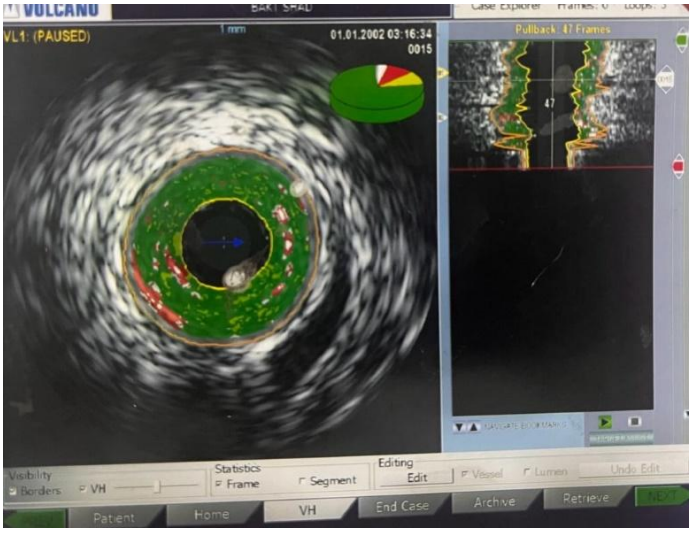

Figure 1: Intravascular Ultrasound Virtual Histology

Table 1: Baseline Characteristics of Study Participants.

Variables		**N(%)**
Total population		41(100)
Male		29(70.7)
Female		12(29.3)
Chest Pain		41(100)
Acute Coronary Syndrome		23(56.1)
Chronic Coronary Syndrome		18(43.9)
Dyspnoea		16(39)
	Diabetes Mellitus	20(48.7)

Risk Factors	Hypertension	12(29.26)
	Dyslipidaemia	28(68.2)
	Smoking	29(70.7)

Table 2: Characteristics of Plaque.

Type of plaque	**Mean ± SD**
Fibrous Plaque	77.3±6.4
Fibro-fatty plaque	13.02±3.5
Necrotic plaque	7.09±6.2
Calcified plaque	2.2±1.4
	Percentage %(N)
Remodeling Index	
Positive remodeling (RI > 1.0)	26.8(11)
Negative remodeling (RI<1.0)	73.2(30)
Plaque Burden	
Maximum Plaque Burden	89.6(+5.3)
Minimum Plaque Burden	58.5(+4.3)
Mean Plaque Burden	73.1(+6.2)

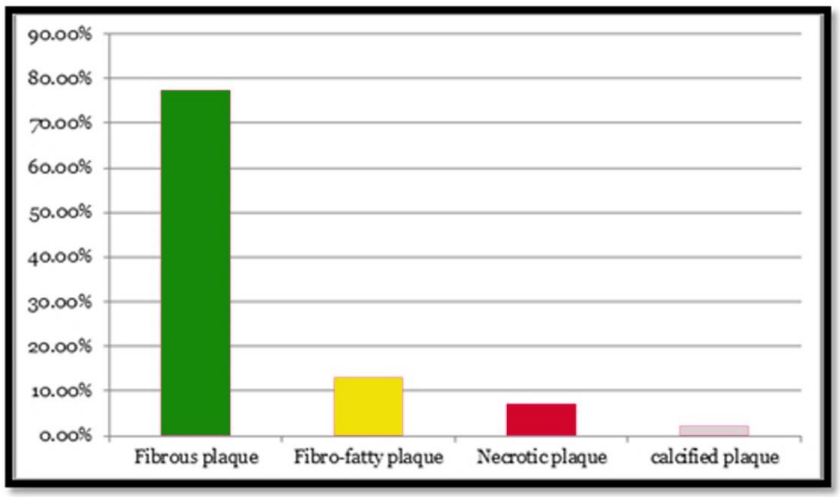

Figure 2: Type of Plaque

Discussion

IVUS employs ultrasound to obtain an intrusive image of the coronary arteries inside. The method is based on ultrasonography, in which the tissue is penetrated by high-energy sound waves, which are then reflected to the transducer and transformed into images[14]. Virtual histology is a novel technique that uses sophisticated computer algorithms to analyze IVUS images and classify the composition of coronary artery plaques. Virtual histology software can differentiate between four major types of plaques: fibrous, fibrofatty¬, calcified, and

necrotic, which are color-coded as green, yellow, white, and red, respectively[12].

Many variables, including age, sex, and cardiovascular risk factors, can affect the occurrence of various plaque types. The average age of the participants in our study was 56.3 years, and most were male. The prevalence of various plaque forms in our study is in line with the results of earlier studies that examined plaque morphology in related populations. For instance , a study published in the Egyptian Heart Journal had comparable results with the maximum prevalence of fibrotic plaques[16]. In our study, we used intravascular ultrasonography and virtual histology to examine the plaque morphology pattern in the coronary arteries of local individuals.

According to a different study by Nasu et al., fibrous plaques accounted for 52% of the overall plaque volume, whereas necrotic and calcified plaques accounted for 17% and 14% of the total plaque volume[13]. Plaque stiffness correlates with plaque morphology, which ultimately affects the success of the procedure. Plaque stiffness tends to be higher as coronary atherosclerosis advances; among the four categorized groups, calcified plaques had the highest stiffness while healthy segments had the lowest, according to a study[19].

According to our research, the vast majority of patients had fibrous plaques (77.3%), followed by fibrofatty plaques (13.02%). The least frequent type of plaque was calcified (2.2%), whereas the necrotic type was observed in a lesser (7.09%) proportion of individuals.

Knowing the plaque burden is important because a similar study showed that IVUS-guided evaluation of coronary plaque burden led to a higher frequency of detection of CAD, and in turn was followed by higher utilization of prevention therapies, and ultimately improved long-term prognosis[17]. In our study, the mean plaque burden was 73.1%, which means that in a significant number of patients, primary prevention of cardiac events was possible by aggressive modification of risk factors.

Several studies have evaluated plaque morphology by combining virtual histology with intravascular ultrasonography. For instance, a study by Stone et al. found that calcified and necrotic plaques were uncommon and that fibrous and fibro-fatty plaques were the two most prevalent type[18].

Schoenhagen P et al. described remodeling as compensatory enlargement of coronary arteries in response to an increase in plaque area[15]. In our study, negative remodeling was more common (73.2%). The remodeling index is calculated as a ratio of EEM (external elastic membrane) divided by that of the reference site. The threshold of the remodeling index for positive remodeling in our study was RI >1.0. The remodelling index was calculated and divided into groups. RI >1.0 was categorized as positive remodelling, while RI <1.0 was considered a negative RI.

Limitations

Various limitations of our study must be considered. First, the sample size was modest, which restricts the wide applicability of our results. Second, our study only included individuals who were referred for coronary angiography because they were thought to have coronary artery disease, which may have resulted in selection bias. Third, we did not examine the connection between plaque form and clinical outcomes, such as myocardial infarction or mortality. This is important as a study conducted in Germany showed that utilization of IVUS was associated with a 36% reduction in all-cause mortality during longitudinal follow-up (17). Similar findings were observed in 3 years follow-up in an ULTIMATE TRIAL that IVUS-guided DES implantation was associated with significantly lower rates of target vessel failure and stent thrombosis (20). Additional research examining the association between plaque shape and clinical outcomes in our community is required, along with studies with larger sample sizes and longer follow-up periods.

Conclusion

In our study, virtual histology intravascular ultrasonography was used to elucidate plaque

morphology patterns in the local population. According to our research, fibrous plaques predominated in both ACS and CSA groups; however, necrotic type was more common in ACS. Negative remodeling was the predominant type of remodeling in our patients. Our study contributes to the expanding body of research that supports the use of intravascular ultrasonography and virtual histology for the evaluation of plaque morphology and formulation of treatment plans in catheterization laboratories.

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