Original research article

Pulmonary function test in patients with coronary artery disease

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Abstract

Background: CORONARY ARTERY DISEASE (CAD**)** is a condition in which there is an inadequate supply of blood and oxygen to a portion of myocardium; it typically occurs when there is an imbalance between myocardium oxygen supply and demand. Coronary artery disease (CAD) (atherosclerotic heart disease/ischemic heart disease (IHD) results from the accumulation of atheromatous plaques within the walls of the coronary arteries hampering the supply of oxygen and nutrients to the myocardium.
Objectives and Aims: To compare pulmonary function test in coronary artery disease patients with healthy controls. To compare the following parameters in coronary artery disease patients with healthy controls by spirometry-

1. Forced expiratory volume-1 second (FEV1) (L)
2. Forced vital capacity (FVC)
3. FEV1/FVC (%)
4. Peak expiratory flow rate (PEFR) (L/s)

Materials and Methods: The present study was an analytical epidemiological study with case control design with the sample size of 200 cases the present study was conducted at the department of Medicine, Swami Dayan and Hospital, Delhi. Study period was of 18 months, from March 2018 to august 2019. The patients were recruited from outpatient and inpatient department of general medicine at Swami Dayan and Hospital, Delhi. Age group 30-70 years. Presence of coronary artery disease which was proven by 2D Echocardiography. Any patient with a documented history of myocardial infarction or past history of acute coronary syndrome were recruited for the study, irrespective of whether angiogram was done.
Observations and Results: Study subjects were 200 cases based on matched ages. The highest proportion of patients in the cases and the control groups were 55-64 years old (40% and 39% respectively). The lowest proportion of patients belonged to the <45 year age group in both cases and controls (8%). there was no statistically significant difference between the cases and controls in terms of the age groups (p=0.998). the present study. Statistically significantly higher levels were haemoglobin (p=0.007) and HDL cholesterol (p=0.00) levels among the cases while the total leucocyte counts (p=0.00), ALT (p=0.00), AST (p=0.001), and FBS (p=0.00) were statistically significantly higher in the cases group.
Conclusion: In conclusion, the present study showed a higher proportion of Obstructive Airway Disease (OAD) in patients with Coronary Artery Disease (CAD) than in patients without CAD. All spirometric parameters like FEV1, FVC, FEV1/FVC, and PEFR, except FEF25-75were statistically significantly lower in patients with CAD than in patients without CAD.
Keywords: Pulmonary function test (PFT), obstructive airway disease (OAD), Coronary artery disease (CAD), Chronic obstructive pulmonary disease (COPD), BMI, diabetes mellitus

Introduction

Coronary Artery Disease (CAD) is a condition in which there is an inadequate supply of blood and oxygen to a portion of myocardium; it typically occurs when there is an imbalance between myocardium oxygen supply and demand [1]. Coronary artery disease (CAD) (atherosclerotic heart disease/ischemic heart disease (IHD) results from the accumulation of atheromatous plaques within the walls of the coronary arteries hampering the supply of oxygen and nutrients to the myocardium [2]. It is a major worldwide killer [3]. It is the most common cause of sudden death and is also the most common reason for death of men and women over 20 years of age [4].
In India, studies have reported increasing CHD prevalence over the last 60 years, from 1% to 9%-10% in

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urban populations and <1% to 4%-6% in rural populations. Using more stringent criteria (clinical ± Q waves), the prevalence varies from 1%-2% in rural populations and 2%-4% in urban populations. This may be a more realistic prevalence of CHD in India [5].

Chronic Obstructive Pulmonary Disease is the fourth most common disease in the world. With increases in COPD prevalence throughout the world it is expected to become the third most common cause of death worldwide by 2020 [6, 7]. According to the World Health Organization Global Burden of Disease Update chronic obstructive pulmonary disease (COPD) was among the leading causes of worldwide years of life lost in 2013, accounting 2,931,000 deaths [8]. The prevalence of COPD in the general adult population 40 years or older ranges from 4% to 20% depending on the setting method employed for the detection of the disease [9, 10].

Cardiovascular disease (CVD) and COPD share similar risk factors such as ageing, history of cigarette smoking (or other exposures) and a sedentary lifestyle, and frequently coexist [11, 12, 13]. COPD may be causally related to the occurrence of CAD [14, 15]. In addition, the prevalence of airflow limitation seems to be higher in patients with cardiovascular disease (CVD) [16] than within the general adult population [10]. Studies have demonstrated that COPD is an important risk factor for atherosclerosis, and even modest reductions in expiratory flow volumes elevate the risk of ischemic heart diseases, strokes, and sudden cardiac deaths 2-to 3-fold, independent of other risk factors, such as hypertension, dyslipidemia, and smoking [17, 18]. There is evidence for greater recurrence of adverse cardiovascular events in those patients with coronary artery disease who have impaired lung function, in comparison with those with normal pulmonary function [19]. Population-based studies and a systematic review including over 80,000 patients showed that reduced FEV1 is a predictor of cardiovascular mortality [20, 21, 22]. In clinical practice, patients suspected of having coronary artery disease (CAD) commonly undergo extensive and expensive testing for their cardiovascular disease. However, despite the coexistence of CAD and respiratory disease, pulmonary function tests are rarely performed in patients with heart disease [23, 24, 25]. Spirometry is performed in less than 30% of patients examined for dyspnea by a cardiologist [26] Less symptomatic patients and those with milder lung function impairment tend to remain undiagnosed [16]. Even patients with moderate and severe airflow limitation (AL) remain untreated [16]. It is likely that the similarity of symptoms (dyspnea, cough) for both CVD and COPD can explain this unfortunate clinical situation. Proper diagnosis and treatment of obstructive air way diseases in patients with coronary artery disease will improve the cardiac performance and exercise tolerance of those patients. Forced expiratory volume in one second (FEV1) as assessed by spirometry has been termed not just a lung function test but a marker of premature death from coronary artery disease. This subnormal pulmonary function may in turn predispose to increased mortality in these coronary artery disease patients [21]. For the present study we hypothesized that the prevalence of airflow limitation compatible with COPD would be particularly high in patients with CVD. To test this hypothesis, we planned the present research.

Material and Methods

The present study was an analytical epidemiological study with case control design. The present study was conducted at the department of Medicine, Swami Dayan and Hospital, Delhi. Study period, 18 months, from March 2018 to august 2019.

Study population

The patients were recruited from outpatient and inpatient department of general medicine at Swami Dayan and Hospital, Delhi.

Cases: The patients fulfilling the following inclusion and exclusion criteria were recruited for the study.

Inclusion criteria

1. Age group 30-70 years.
2. Presence of coronary artery disease which was proven by 2D Echocardiography. Any patient with a documented history of myocardial infarction or past history of acute coronary syndrome were recruited for the study, irrespective of whether angiogram was done.

Exclusion criteria

1. Smokers (current smokers is defined as who has smoked >100 cigarettes in their lifetime and has smoked in last 28 days.) (PACK YEARS - average number of packs of cigarettes smoked per day multiplied by the total number of years of smoking.)
2. Person with current respiratory complaints and chronic respiratory disease.
3. Recent MI (< 1 month)
4. Recent stroke, eye surgery, thoracic/ abdominal surgery (< 6weeks).
5. Known thoracic, aortic or cerebral aneurysm.
6. Recent pneumothorax (< 6weeks)
7. Hypertensive emergency (SBP>180mmHg or DBP >120mmHg with target organ damage)

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8. Pulmonary embolism
9. Physical disabilities such as kyphoscoliosis, pectuscarinatum, pectusexcavatum.
10. Obesity (BMI ≥ 25kg/m^2)
11. Unwilling and uncooperative patients and patients with psychiatric disorder

Controls: Age and gender matched otherwise healthy controls were recruited from the Medicine and other departments of Swami Dayan and Hospital, Delhi who were willing to participate in the study.

Sample size and sampling techniques
Formula used-

$$n = \frac{\{Z_{(1-\alpha/2)} + Z_{1-\beta}\}^2 [p_1 (1-p_1) + p_2 (1-p_2)]}{(p_1-p_2)^2}$$

p_1 = Proportion of controls with FEV_1 90%
p_2 = Proportion of cases with FEV_1 75%
α = Level of significance (5%)
$1-\beta$ = Power of study (80%)

By using the formula, the total sample size was 97 subjects in each group. So, we took a minimum of 100 patients in each group i.e. a total of 200 patients.

Statistical analysis
All data were entered into Microsoft Excel (Microsoft Inc.) and was checked for correct entries. Data were analyzed using the statistical software package for social sciences (SPSS)version 21.0 (SPSS Inc., Chicago, IL, USA). Data were presented using the principles of descriptive and analytical statistics.
Descriptive statistics were used to analyze the demographic data and to compare the case and control groups. T-test of means was used to detect any significant difference between continuous variables and chi square test was used to detect any significant difference between categorical variables.

Results

Table 1: Distribution of cases and controls based on age groups (n=200)

Age group (years)	Controls	Cases	Total
≤ 44	8 (8%)	8 (8%)	16 (8%)
45 -54	35 (35%)	35 (35%)	70 (35%)
55 - 64	40 (40%)	39 (39%)	79 (39.5%)
≥ 65	17 (17%)	18 (18%)	35 (17.5%)
Total	100 (100%)	100 (100%)	200 (100%)

Pearson Chi-Square= 0.041, p=0.998

Table shows the distribution of study subjects based on matched ages. The highest proportion of patients in the cases and the control groups were 55-64 years old (40% and 39% respectively). The lowest proportion of patients belonged to the <45 year age group in both cases and controls (8%). there was no statistically significant difference between the cases and controls in terms of the age groups (p=0.998).

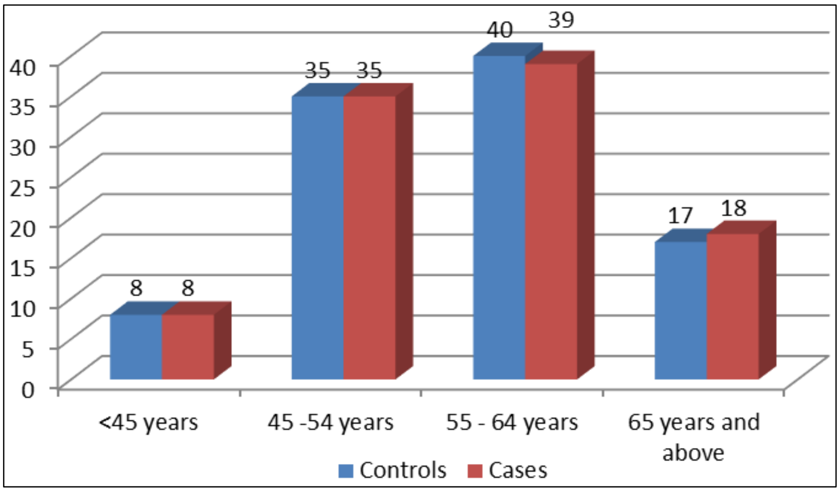


Fig 1: Bar diagram showing the distribution of the cases and controls based on age groups

Table 2: Distribution of cases and controls based on the sex (n=200)

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 01, 2023

Sex	Controls	Cases	Total
Female	25 (25%)	21(21%)	46 (23%)
Male	75 (75%)	79 (79%)	154 (77%)
Total	100 (100%)	100 (100%)	200 (100%)

Pearson Chi-Square= 0.452, p=0.502

Table shows the distribution of study subjects based on sex. The proportion of males were higher compared to female in both the cases (75%) and control (71%) groups, However, there was no statistically significant difference between the cases and controls in terms of the sex (p=0.502).

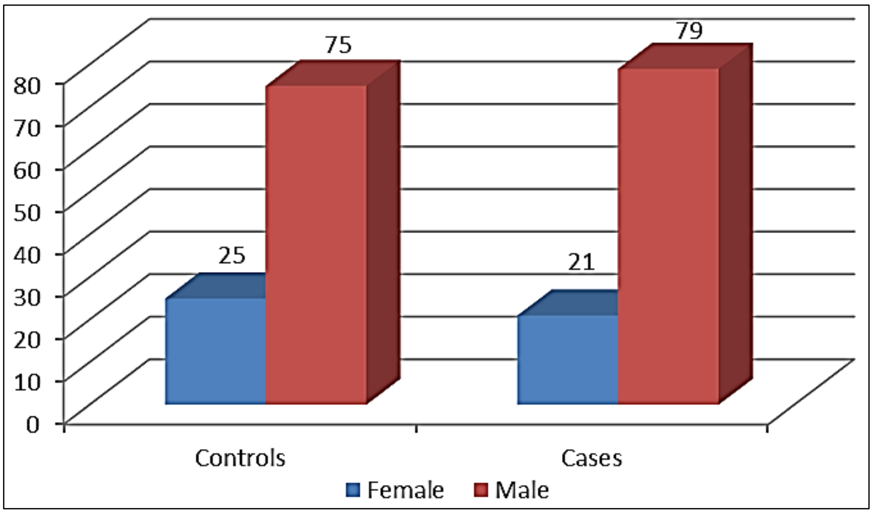


Fig 2: Bar diagram showing the distribution of sex among cases and controls in the study population (n=200)

Table 3: Distribution of cases and controls based on the BMI (n=200)

BMI (kg/m^2)	Controls	Cases	Total
< 18.0	4(4%)	0 (0%)	4 (2%)
18.0-22.9	34 (34%)	33 (33%)	67 (33.5%)
23.0-24.9	62 (62%)	67 (67%)	129 (64.5%)
Total	100 (100%)	100 (100%)	200 (100%)

Pearson Chi-Square= 4.21, p=0. 121

Table shows the distribution of study subjects based on the BMI. The maximum proportion of patients in both the controls and cases group had BMI between 23.0-24.9kg/m^2(62% and 67% respectively), while the least proportion of patients in the control group had BMI< 18.0 kg/m^2(4%). There were no patient with BMI < 18.0 kg/m^2 in the cases group. There was no statistically significant difference between the cases and controls in terms of the BMI (p=0.121).

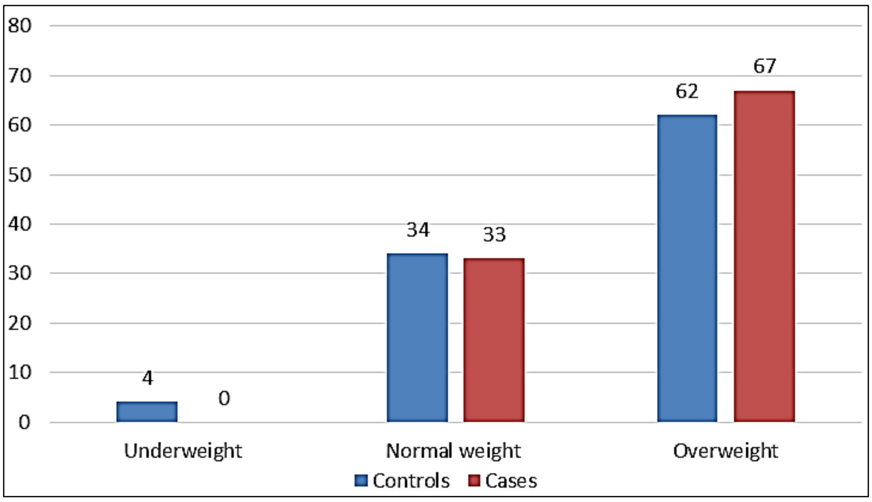


Fig 3: Bar diagram showing the distribution of cases and controls based on the BMI (n=200)

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 01, 2023

Table 4: Distribution of cases and controls based on frequency of alcohol consumption (n=200)

Alcohol	Controls	Cases	Total
Never	51 (51%)	46 (46%)	97 (48.5%)
Occasional	30 (30%)	34 (34%)	64 (32%)
Regular	19 (19%)	20 (20%)	39 (19.5%)
Total	100 (100%)	100 (100%)	200 (100%)

Pearson Chi-Square= 0.533, p=0.766

Table shows the distribution of study subjects based on the frequency of alcohol consumption. The maximum proportion of patients in both the controls (51%) and cases (46%) never had alcohol. One-fifth of patients in both the control (19%) and cases (20%) groups were regular users of alcohol. A third of all controls (30%) and cases (34%) were occasional consumers of alcohol. Statistical analysis shows that there was no statistically significant difference between the cases and controls in terms of alcohol use. (p=0.766).

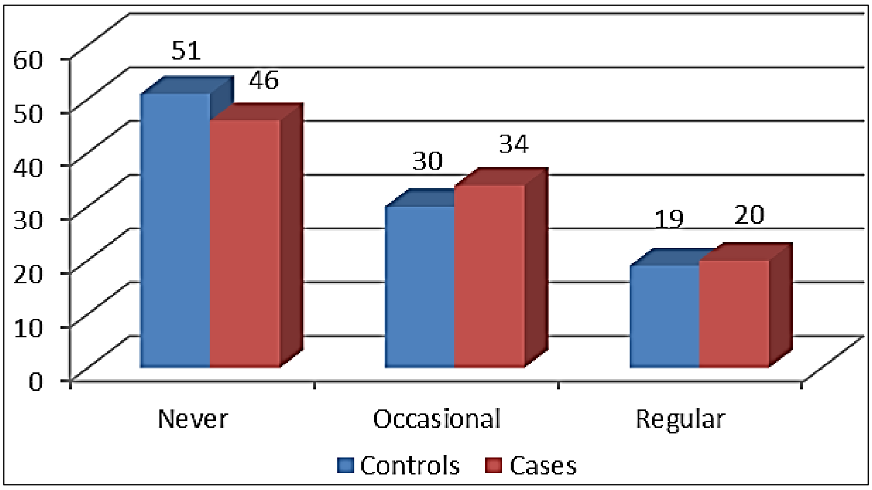


Fig 4: Bar diagram showing the distribution of cases and controls based on frequency of alcohol consumption (n=200)

Table 5: Distribution of cases and controls based on the presence of diabetes (n=200)

Diabetes	Controls	Cases	Total
No	86 (86%)	82 (82%)	168 (84%)
Yes	14 (14%)	18 (18%)	32 (16%)
Total	100 (100%)	100 (100%)	200 (100%)

Pearson Chi-Square= 0.595, p=0.44

Table shows the distribution of study subjects based on the presence of diabetes. The proportion of participants with diabetes was slightly higher in the cases group (18%) than the control group (14%). However, the differences were not statistically significant (p=0.44).

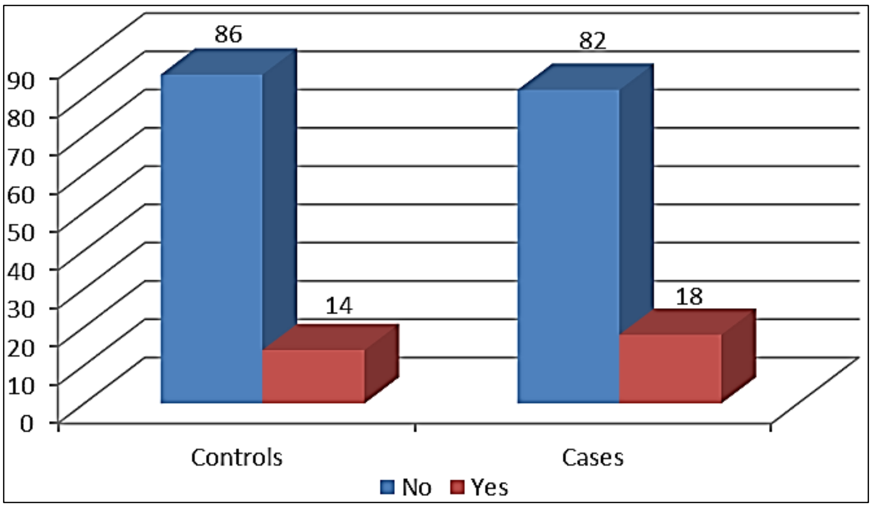


Fig 5: Bar diagram showing the cases and controls based on the presence of diabetes (n=200)

Table 6: Distribution of cases and controls based on the presence of hypertension (n=200)

Hypertension	Controls	Cases	Total
No	67 (67%)	64 (64%)	131(65.5%)
Yes	33 (33%)	36 (36%)	69 (34.5%)
Total	100 (100%)	100 (100%)	200 (100%)

Pearson Chi-Square= 0.199, p=0.655

Table shows the distribution of study subjects based on the presence of hypertension. The proportion of participants with hypertension was higher in the cases group (36%) than the control group (33%). However, the differences were not statistically significant (p=0.655).

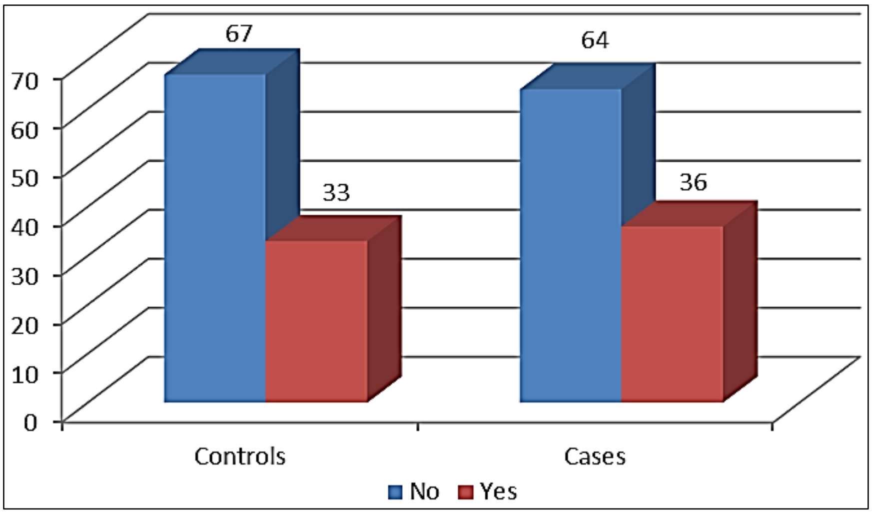


Fig 6: Bar diagram showing the distribution of cases and controls based on the presence of hypertension (n=200)

Table 7: Comparison of means of age between cases and controls (n=200)

Variable	Controls	Cases	t-test, p value
	Mean ± SD	Mean ± SD	
Age	56.03 ± 8.14	56.04 ± 8.11	0.00, 0.993

Table shows the means ± standard deviation of the age of the cases and controls. There was no significant difference between the means of age between cases and controls.

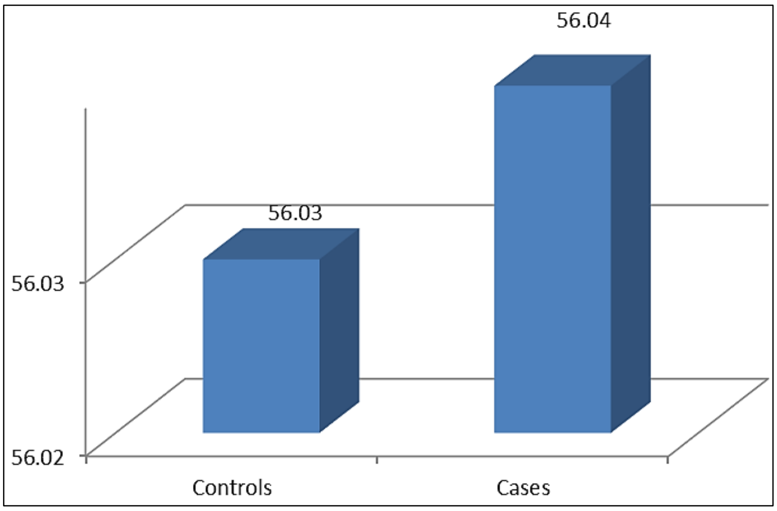


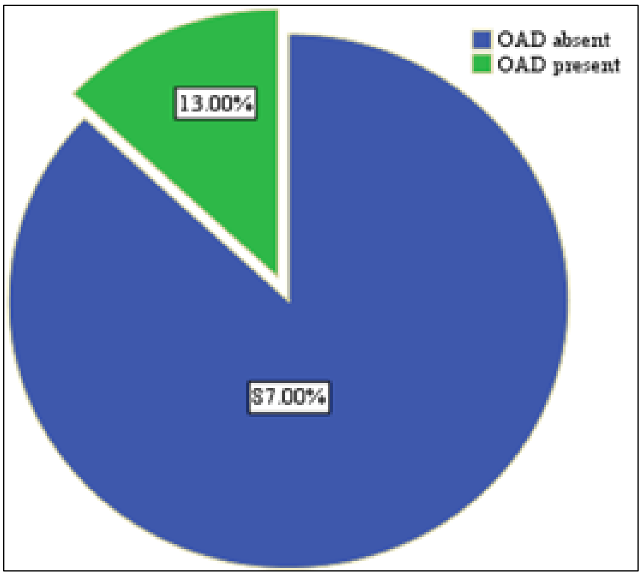
Fig 7: Bar diagram showing the mean age between cases and controls

Table 8: Comparison of means of laboratory parameters between cases and controls (n=200)

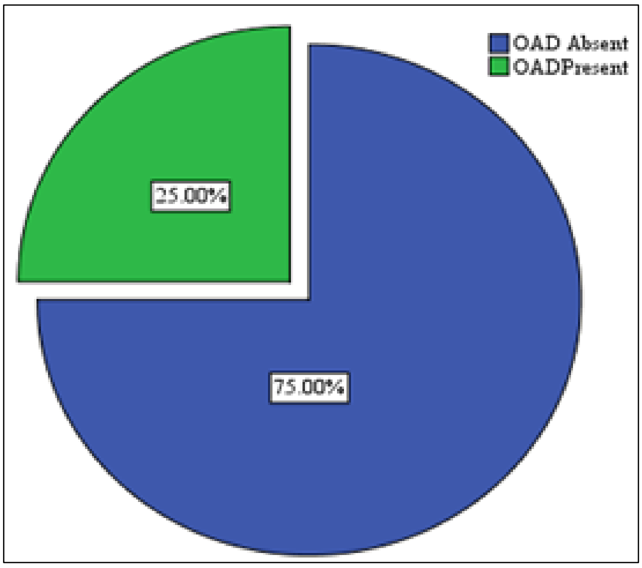
Laboratory parameters	Controls Mean ± SD	Cases Mean ± SD	t-test, p value
Hb	12.1 ± 2.0	11.2 ± 2.3	0.596, 0.007*
TLC	7208.9 ± 2610.9	10500.4 ± 5147.8	21.39, 0.00*
Total Bilirubin	0.7 ± 0.3	0.7 ± 0.4	0.015, 0.791
ALT	32.7 ± 13.5	56.7 ± 39.2	5.79, 0.00*
AST	34.8 ± 13.0	61.7 ± 81.3	3.27, 0.001*
Urea	29.0 ± 8.9	31.6 ± 11.4	2.765, 0.071
Creatinine	0.9 ± 0.2	1.0 ± 0.3	0.136, 0.273
FBS	94.7 ± 9.1	124.3 ± 46.9	33.814, 0.00*
Cholesterol	184.6 ± 23.5	185.2 ± 23.6	0.01, 0.862
HDL	54.0 ± 7.7	49.5 ± 7.0	0.251, 0.00*
LDL	125.5 ± 16.2	127.8 ± 16.4	0.018, 0.334

*statistically significant

Table shows the differences in the laboratory parameters among controls and cases included in the present study. Statistically significantly higher levels were haemoglobin (p=0.007) and HDL cholesterol (p=0.00) levels among the cases while the total leucocyte counts (p=0.00), ALT (p=0.00), AST (p=0.001), and FBS (p=0.00) were statistically significantly higher in the cases group.



Patients without Coronary Artery Disease (CAD)



Patients with Coronary Artery Disease (CAD)

Fig 8: Figures show the prevalence of Obstructive Airway Disease in patients with and without Coronary Artery Disease

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Table 9: Comparison of means of Spirometeric parameters between cases and controls (n=200)

Spirometric parameters	Controls	Cases	t-test, p value
FVC obtained	2.8 ± 0.7	2.5 ± 0.7	0.342, 0.002*
FEV1 obtained	2.2 ± 0.7	1.9 ± 0.7	0.021, 0.000*
FEV1/FVC obtained	77.5 ± 11.7	74.0 ± 11.6	0.45, 0.035*
FEF25-75 obtained	2.0 ± 0.8	1.7 ± 0.9	1.119, 0.085
PEF obtained	5.8 ± 1.8	5.3 ± 1.6	0.586, 0.03*

*statistically significant

Comparison of the spirometric parameters between cases and controls reveal a lower Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 sec (FEV1), FEVI/FVC, Forced Expiratory Flow 25-75 and Peak Expiratory Flow (PEF) among cases as compared to controls. Statistical comparison shows that all of these, except FEF25-75 were statistically significant (*p*<0.05).

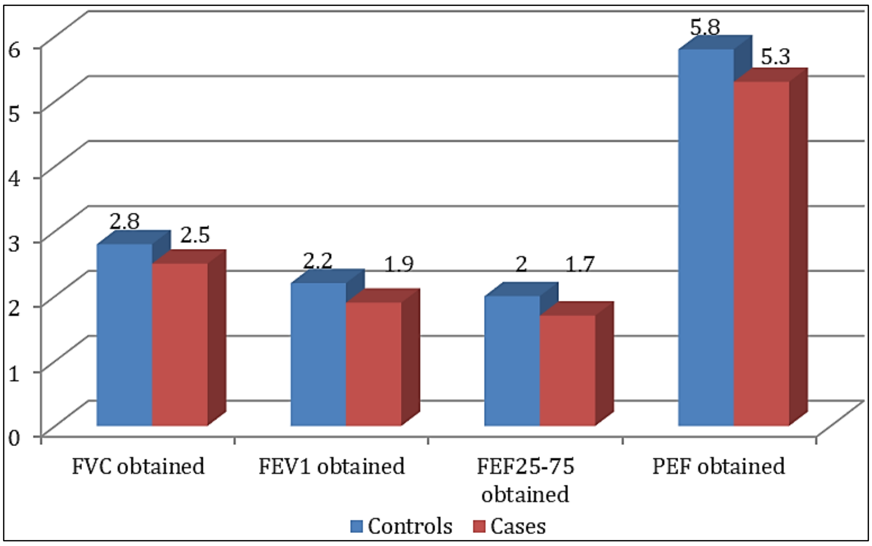
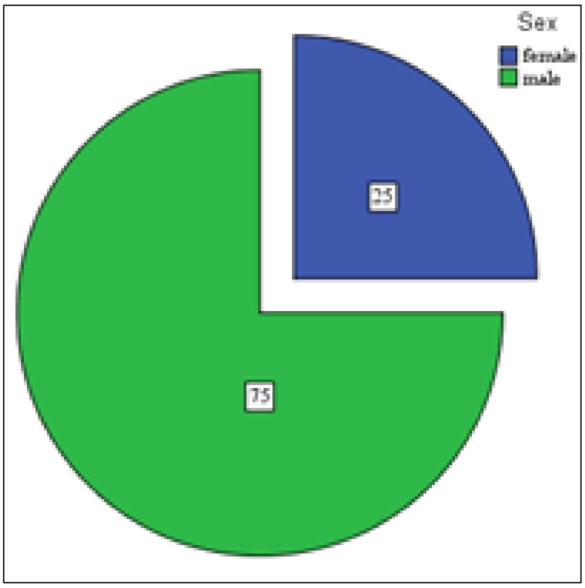


Fig 9: Comparison of means of Spirometeric parameters between cases and controls (n=200)

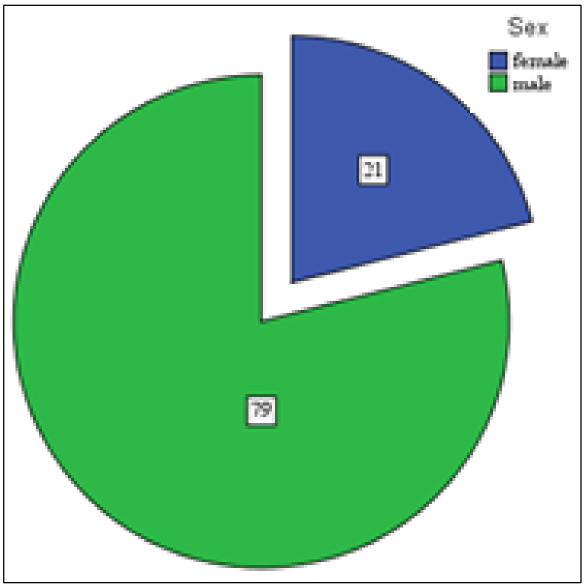
Table 10: Sex wise distribution of Patients with and without CAD

Sex	CAD	
	Yes	No
Male	79	75
Female	21	25
Total	100	100



Patients without CAD

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 01, 2023



Patients without CAD

Fig 10: Pie charts show Sex wise distribution of Patients with and without CAD

Table 11: Association of microalbuminuria with obstructive airway disease among patients with CAD (n=100)

Micro-albuminuria	Obstructive Airway Disease		Total
	Present	**Absent**	
Present	12 (48%)	48 (64%)	60 (60%)
Absent	13 (52%)	27 (36%)	40(40%)
Total	25 (100%)	75 (100%)	100 (100%)

Pearson Chi-Square= 2.000, p=0.157

The above table shows the association of micro-albuminuria with obstructive airway disease in patients with coronary artery disease. Although micro-albuminuria was present in 60% of the coronary artery disease patients their association with obstructive airway diseases was not statistically significant (p=0.157).

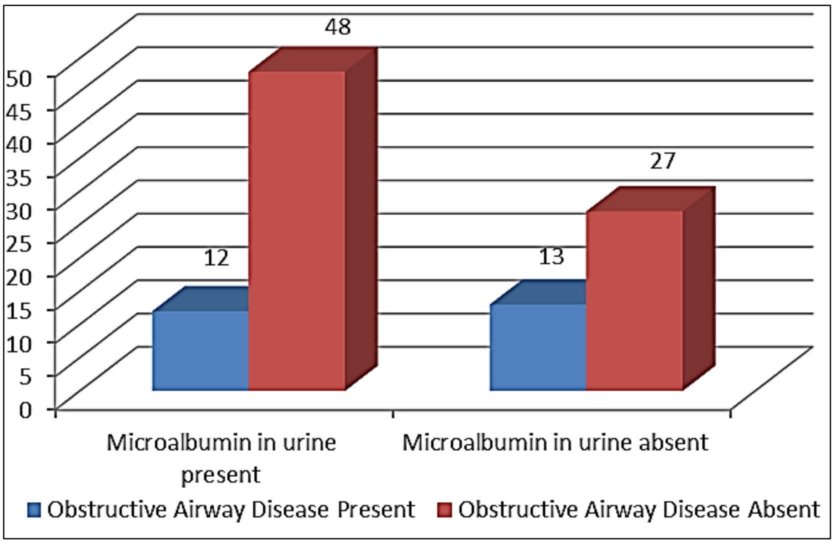


Fig 11: Bar diagram showing the distribution of micro-albuminuria with obstructive airway disease among patients with CAD (n=100)

Table 12: Association of HbA1c with obstructive airway disease among patients with CAD (n=100)

Parameter		**Obstructive Airway Disease**		**Total**
		Present	**Absent**	
HbA1C	>7%	6 (24%)	29 (38.7%)	35 (35%)
	≤ 7 %	19 (76%)	46 (61.3%)	65 (65%)
Total		25 (100%)	75 (100%)	100 (100%)

Pearson Chi-Square= 1.773, p=0.183

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The above table shows the association of HbA1C with obstructive airway disease in patients with coronary artery disease. HbA1C was higher than the recommended level (≤ 7 %) in 24% of the patients with coronary artery disease and obstructive airway disease. HbA1c more than 7mg/dl were seen in 38.7% of patients with coronary artery disease without obstructive airway diseases. Although differences in proportions were noted in the cases in regards to CAD and OAD, the differences were not statistically significant indicating no significant association between the two (p=0.183).

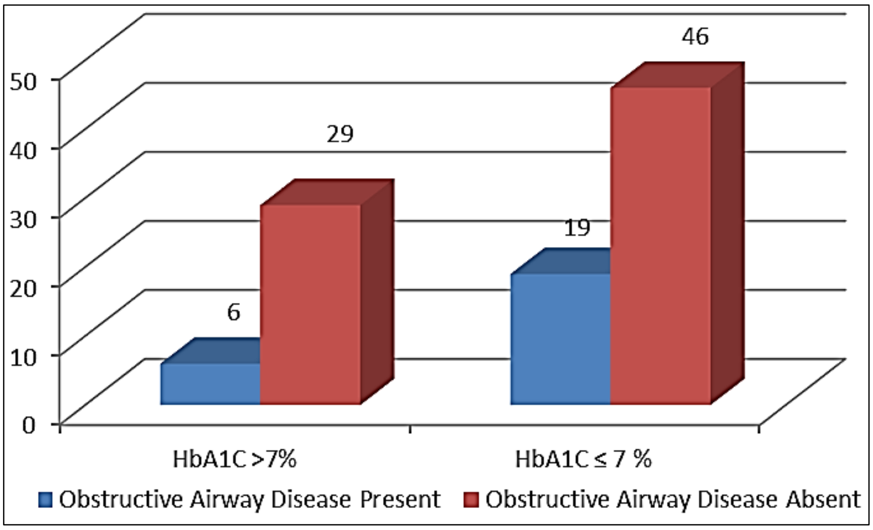

Fig 12: Bar diagram showing the distribution of obstructive airway disease among patients with CAD based on HbA1C (n=100)

Table 13: Comparison between the presence of obstructive airway disease and Left Ventricular Ejection Fraction in patients with CAD (n=100)

Obstructive Airway Disease	Left Ventricular Ejection Fraction		Total	P value
	<40%	≥40%		
Absent	39 (69.3%)	36 (92.3%)	75 (75%)	0.002*
Present	22 (30.7%)	3 (7.7%)	25 (25%)	
Total	61 (100%)	39 (100%)	100 (100%)	

*statistically significant

Table shows that a higher proportion of patients with CAD and ejection fraction less than 40% had OAD than in patients with CAD with LVEF more than or equal to 40%. Statistical analysis shows that the difference was statistically significant. (p=0.002).

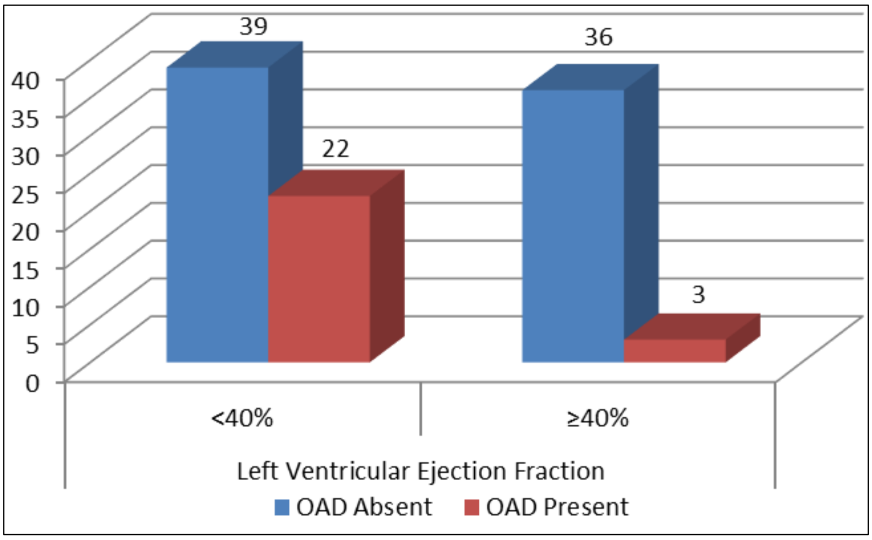

Fig 13: Bar diagram showing the comparison between the presence of obstructive airway disease and LVEF on Echocardiography (n=100)

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 01, 2023

Table 14: Comparison between the presence of obstructive airway disease and the presence of regional wall motion abnormality on Echocardiography (n=100)

Obstructive Airway Disease	Regional wall motion abnormality on Echocardiography		Total	p value
	Absent	Present		
Absent	31(81.6%)	44 (71%)	75 (75%)	0.234
Present	7 (18.4%)	18 (29%)	25 (25%)	
Total	38 (100%)	72 (100%)	100 (100%)	

Table shows that among cases with regional wall motion abnormalities on echocardiography the prevalence of obstructive disease was higher at 29% compared to the prevalence of 18.4% among patients with Coronary Artery Disease without RWMA on echocardiography. However, the differences between the prevalence were statistically not significant.

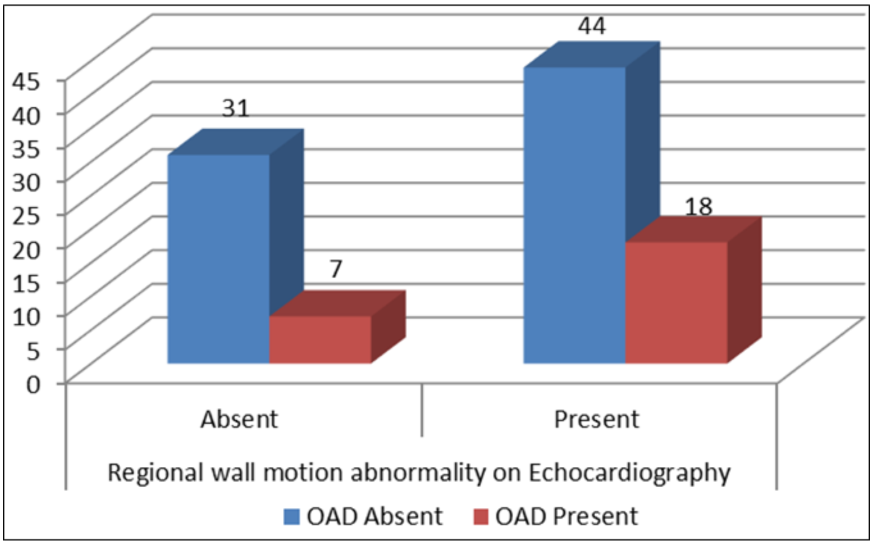

Fig 14: Bar diagram showing the comparison between the presence of obstructive airway disease and Regional wall motion abnormalities in cases (n=100)

Table 15: Comparison of means of spirometric parameters with LVEF of <40% and ≥40% among patients with CAD (n=100)

Spirometric parameters	Left ventricular ejection fraction		t-test, p value
	<40%	≥40%	
FVC obtained	2.36 ± 0.69	2.70 ± 0.73	0.131, 0.020*
FEV1 obtained	1.70 ± 0.63	2.12 ± 0.63	0.136, 0.001*
FEV1/FVC obtained	71.42 ± 13.15	78.14 ± 6.82	9.515, 0.004*
FEF25-75 obtained	1.54 ± 0.87	2.07 ± 0.85	0.050, 0.003*
PEF obtained	5.08 ± 1.72	5.66 ± 1.39	1.106, 0.078

*statistically significant

Table shows comparison of the spirometric parameters in patients with CAD with LVEF of <40% and ≥40% groups. All spirometric parameters included in the study was higher in patients with an ejection fraction of greater than 40%. The differences in the measured parameters except PEF were statistically significant.

Table 16: Comparison between the presence of obstructive airway disease and the number of vessels involved as detected by coronary angiography (n=100)

Obstructive Airway Disease	Vessels involved			Total	P value
	SVD	DVD	TVD		
Absent	28 (73.7%)	26 (89.7%)	21 (63.6%)	75 (75%)	0.009*
Present	10 (26.3%)	3 (10.3%)	12 (36.4%)	25 (25%)	
Total	38 (100%)	29 (100%)	33 (100%)	100 (100%)	

*statistically significant

Table shows an increase in the proportion of Obstructive airway disease cases with triple vessel involvement. The highest proportion of patients with OAD had triple vessel disease (36.4%), while 10.3% of people with double vessel disease had OAD. Statistical analysis of the data showed that these differences were statistically significant (p=0.009).

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 01, 2023

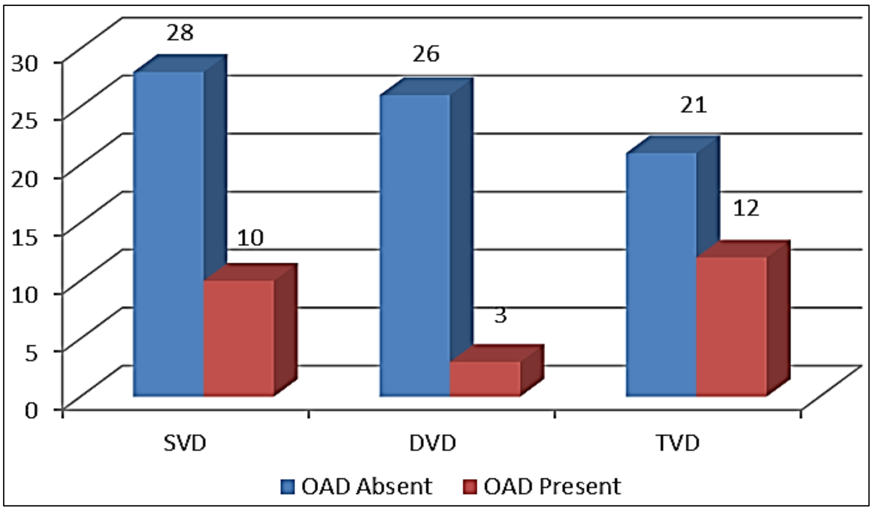

Fig 15: Comparison between the presence of OAD and the number of vessels involved as detected by coronary angiography

Discussion

The present study compared the prevalence of Airflow Limitation (AL) or Obstructive airway Disease (OAD) in 100 patients with Coronary Artery Disease (CAD) at the Swami Dayan and hospital with 100 age and sex matched subjects recruited from the medicine and other department of the hospital. None of the recruited controls had any respiratory symptoms. Coronary artery disease is a major worldwide killer [3]. It is the most common cause of sudden death and is also the most common reason for death of men and women over 20 years of age [4]. Risk factors for development of coronary artery disease include hypercholesterolemia, hypertension, diabetes mellitus and cigarette smoking [31]. Cardiovascular diseases, especially coronary heart disease (CHD), are epidemic in India. The Registrar General of India reported that CHD led to 17% of total deaths and 26% of adult deaths in 2001-2003, which increased to 23% of total and 32% of adult deaths in 2010-2013 [27].

The prevalence of COPD in Indian males and females has been found to be 5% and 2.7% respectively with a median male-to-female ratio of 1.6:1 [36]. A recent systematic review from major studies in India, has reported a prevalence range between 6.5% and 7.7% in rural and up to 9.9% in urban India [35].

Cigarette smoking is the major independent risk factor for CAD and OAD [28, 29]. However, additional risk factors, which remain largely unclear, maybe involved in the interrelationship between these two chronic conditions. The risk of CAD may increase further in smokers who have developed OAD, and OAD may be causally related to the occurrence of CAD [14, 15]. In addition, the prevalence of airflow limitation seems to be higher in patients with cardiovascular disease (CVD) [16] than within the general adult population [10]. Although several small studies have investigated the prevalence of COPD in patients with CVD, their interpretation is hampered by heterogeneity in smoking status [16] and the nature of CVD as well as the lack of guideline-based lung function testing [30].

The precise prevalence of obstructive air way diseases in patients with coronary artery disease is still unknown [25]. It has been reported to be from 4.7% to as high as 60%, and that airflow limitation was an independent risk factor for cardiovascular disease, in various studies from India and abroad [31, 32, 33, 34]. The large differences in the prevalence is due to the differential recruitment of patients in terms of smoking status and whether the patient was a already diagnosed with COPD. A Japanese multicenter study by **Onishi *et al.*** conducted in 995 (ex-)smoking patients aged greater than 40 years, diagnosed and treated for CVD (mainly hypertension), also reported a similar prevalence of airflow limitation (27%), despite differences in the criteria defining airflow limitation (FEV1/FEV6 , 0.73) and in the severity of underlying CVDs [44]. A study done by **Almagro *et al***. in 133 patients of IHD confirmed with percutaneous coronary intervention, concluded that the prevalence of COPD was 24.8% [35]. In their study on 80 angiographically proven patients of CAD, **Agarwal *et al***. found that 22.5% had OAD, similar to the findings of the present study.

Increased inflammation caused by cigarette smoking has been considered as the reason for both Coronary Artery Disease and Chronic Obstructive Pulmonary Disease [48]. However, since none of the patients with or without CAD had a history of exposure to the first-hand tobacco smoke or to the environmental tobacco smoke, it was effectively excluded the possible confounding factor. Even then the proportion of patients with OAD was significantly higher in patients with CAD than in patients without CAD; the proportion of CAD being similar to the proportion found by **Agarwal *et al***. in a group of non-smokers with CAD in their study from Gwalior, Madhya Pradesh [45]. In a study on 100 patients with Coronary Artery Disease admitted in the medicine department of a tertiary care hospital by **Patil *et al*.**, the mean values of all spirometric variables (FEV_1, FEV_1/FVC %, FVC, FEF 25-75, PEFR) were significantly lower than healthy controls [74].

Several inflammatory makers like leucocytes, CRP, fibrinogen, tumour necrosis factor-α, (TNF-α), interleukin 6 (IL-6) and interleukin 8 (IL-8), have been shown to be increased in the serum of COPD patients. Of them the best studied is the CRP [36]. The number of studies published concerning CRP is rapidly increasing and there is considerable interest concerning the role inflammation may play in the pathogenesis of COPD and associated morbidity [37]. Elevated CRP has been associated with CHD. Several landmark large prospective clinical case-control studies on middle-aged men (Physician's Health Study, Monitoring Trends and Determinants in Cardiovascular Disease) [38], postmenopausal women (Women Health Study) [39] and elderly men and women (Cardiovascular Health Study Rural Health Promotion Project) [40] have identified CRP as a strong, independent risk factor for CHD. In some recent studies Arroyo Espliguero *et al*. [30] and Raposeiras Roubın [41] concluded that CRP is an independent predictor of adverse cardiac events.

In recent years, it has become clear that pollution from ambient particulate matter also significantly contributes to the disease burden magnitude of IHD and airflow limitation. Furthermore, patients with IHD and airflow limitation are often characterized by physical inactivity. Reduced physical activity is recognized as a consequence of and a prognostic factor in these diseases, and also predisposes patients to a greater incidence of CVD, airflow limitation, and development of co-morbidities in COPD. Accelerated ageing also seems to underlie many non-communicable chronic diseases, including IHD and airflow limitation. In addition, chronic airflow limitation may be an independent risk factor.

The present study shows a statistically significant increase in the proportion of Obstructive airway disease cases with increasing vessel involvement. This is in contrast to a study by Agarwal *et al*. from India where although the prevalence of OAD was high, no association with a number of coronary vessel involvement was seen, despite the fact that both the studies were conducted in non-smokers. A study among patients admitted at the hemodynamic unit of the Mutua de Terrassa University Hospital due to IHD who underwent a PCI revealing stenosis above 50% in primary arteries, reported that patients with CAD and OAD were older and had more number of coronary vessels involved than in patients with CAD alone. Similarly, in another study from China also showed that COPD was associated with multi-vessel involvement [48].

Spirometry is recognized as the most reproducible, widely available test to diagnose airflow limitation compatible with COPD. Accurate diagnosis of chronic airflow limitation is important to initiate early modification of risk factors and start therapeutic interventions aimed at symptom relief, improvement in health status, and risk reduction among those with the disease. Since spirometry is not done routinely on patients with CAD, these are largely undiagnosed and untreated. Presence of obstructive lung diseases in these patients increase symptom burden, reduce functional status and increase the chances of morbidity.

Conclusions

In conclusion, the present study showed a higher proportion of Obstructive Airway Disease (OAD) in patients with Coronary Artery Disease (CAD) than in patients without CAD. All spirometric parameters like FEV1, FVC, FEV1/FVC, and PEFR, except FEF25-75were statistically significantly lower in patients with CAD than in patients without CAD. Among patients with CAD, OAD was seen in significantly higher proportion of patients with Triple Vessel Disease and with Left Ventricular Ejection Fraction of less than 40%.

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