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Research Article

PRELIMINARY REPORT ON NON-INVASIVE CORONARY DILATATION AND ITS FOLLOW-UP

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ABSTRACT
Authors tried a non-invasive procedure in modulation of coronary artery on them and arrived at the conclusion that deep coughing and respiratory modulation can dilate coronary arteries. They are now presenting a three year follow up which shows some amount of permanent dilatation along with further scope of improvement of blood flow immediately after fresh attempts of modulation.

Key Words: *Non-Invasive Coronary Dilatation, Preventive Cardiology*

INTRODUCTION
In a previous paper (Saha and Adhikari, 2011) authors experimented on themselves (due to non-availability of other human volunteers). They tried a method of non-invasive coronary dilatation. The follow up results after three years is encouraging.
Planned exercise schedule led to dilatation of coronary arteries (CAs). It was practiced for three years to find if there was any permanent effect of dilatation or any other effect on the persons under consideration.

MATERIALS AND METHODS
The authors experimented on themselves: deep coughing every 2-3 seconds, then deep inspiration and *kumbhaka* (holding respiration, something like *valsalva*) which was followed by deep expiration with PEEP effect (Persistent end expiratory pressure exerted by pursed lips). This manoeuvre was then repeated three to ten times depending on the comfort level and tolerance of the subject. The person was then examined for girth of his coronary artery (CA) by echocardiography, initially at rest and thereafter deep coughing and further, after long expiration with PEEP-like effect. The same procedure without any imaging was practiced as daily exercise with the hope of generating a permanent good effect on CAs in the long run. The non-invasive technique of echocardiography was chosen for its advantage of being repeatable at short intervalsasit is not possible in any other method. In echocardiography picture diameters will be indicated as length as it present pictures orthogonally.

RESULTS
Case 1: On First author

Table 1: Comparison of change in diameters of LMCA, LAD, LCX& RCAat resting stageof Case-1: First Author himself

Diameter of (mm)	Initially at resting on 20.12.2008	Follow up at restingon 17.04.2012	Increase of diameter in %
Diameter of left main coronary artery (LMCA)	3.52	4.81	36.65
Left anterior descending (LAD)	2.75	3.70	34.54
Left circumflex (LCX)	2.03	3.77	85.71
Diameter of right coronary artery (RCA)	3.17	5.03	58.67
Average	2.87	4.33	53.89

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Figure 1A: Diameter of left main coronary artery (LMCA) = 3.52 mm at the starting of programme

Figure 1B: Diameter of left anterior descending (LAD) = 2.75 mm at the starting of programme

Figure 1C: Diameter of left circumflex (LCX) = 2.03 mm at the starting programme

Figure 1D: Diameter of right coronary artery (RCA) = 3.17 mm at starting of programme

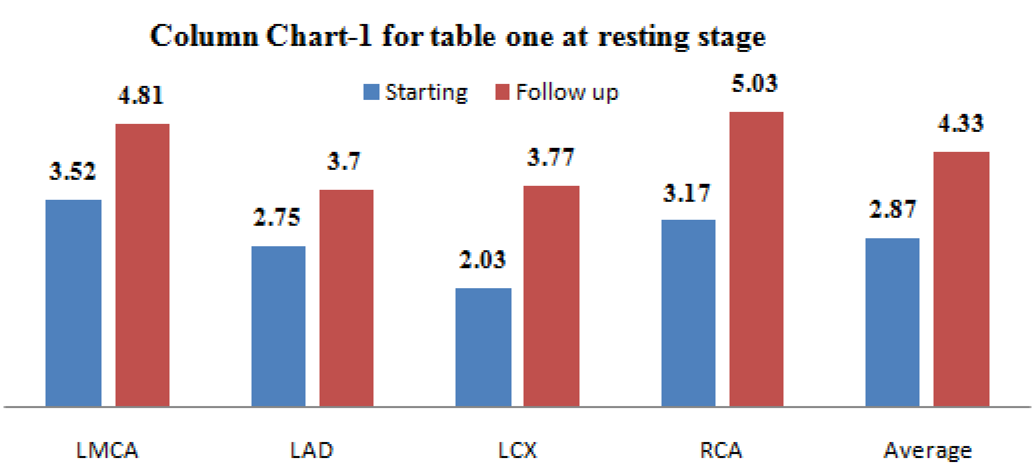

Figure 2A: Diameter of left main coronary artery (LMCA) = 4.81 mm at the follow up

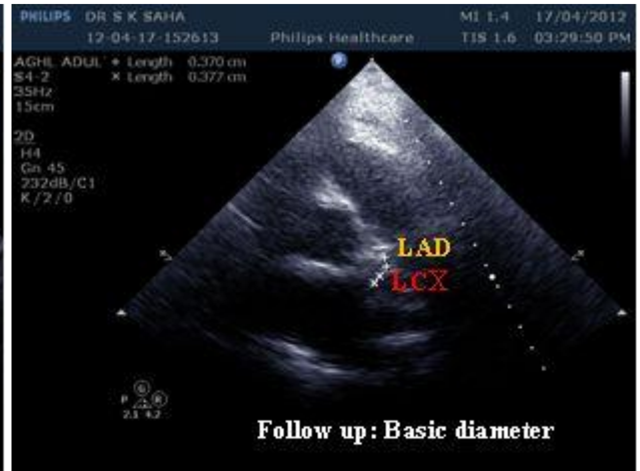

Figure 2B: Diameter of left anterior descending (LAD) = 3.70 mm & left circumflex (LCX) = 3.77 mm after follow up

Figure 2C: Diameter of right coronary artery (RCA) = 5.03 mm at the follow up

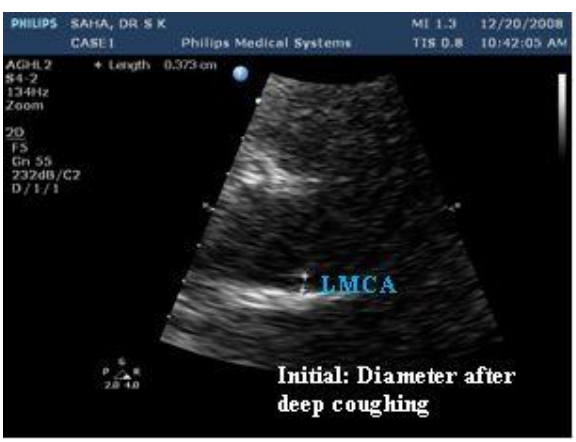

Figure 1E: Diameter of left main coronary artery (LMCA) = 3.73 mm after deep coughing (initial)

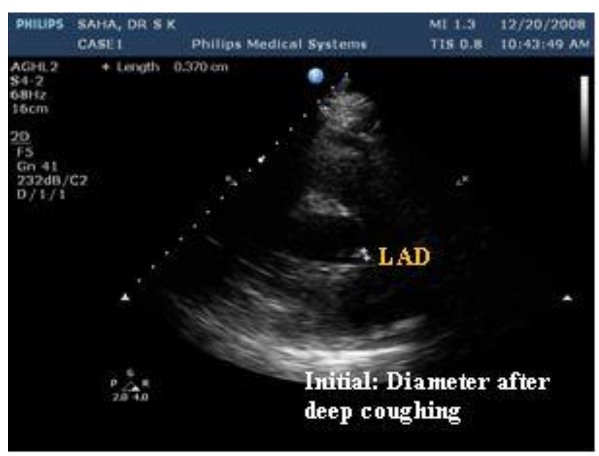

Figure 1F: Diameter of left anterior descending (LAD) = 3.70 mm after deep coughing (initial)

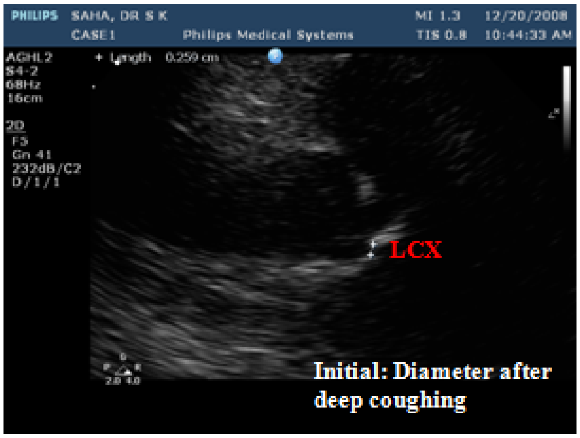

Figure 1G: Diameter of left circumflex (LCX) = 2.59 mm after deep coughing (initial)

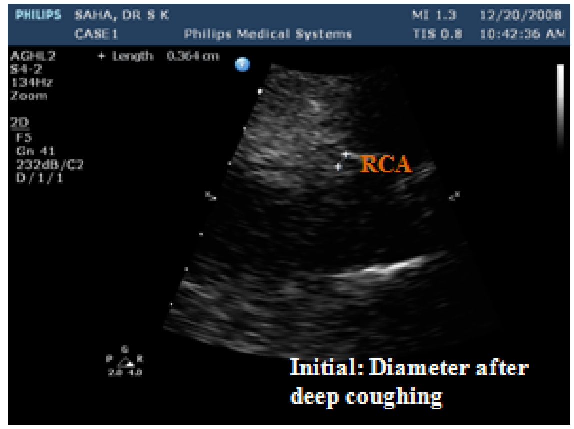

Figure 1H: Diameter of right coronary artery (RCA) = 3.64 mm after deep coughing (initial)

Figure 2D: Diameter of left main coronary artery (LMCA) = 6.03 mm after deep coughing in follow up

Figure 2E: Diameter of left anterior descending (LAD) = 4.81 mm and left circumflex = 4.30 mm after deep coughing in follow up

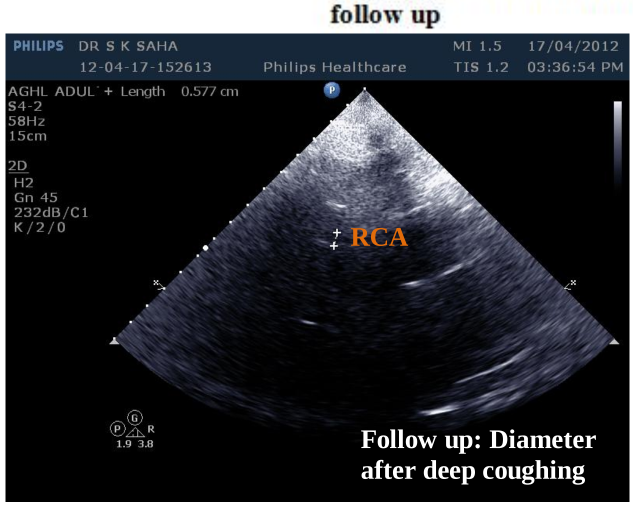

Figure 2F: Diameter of right coronary artery (RCA) = 5.77 mm after deep coughing in follow up

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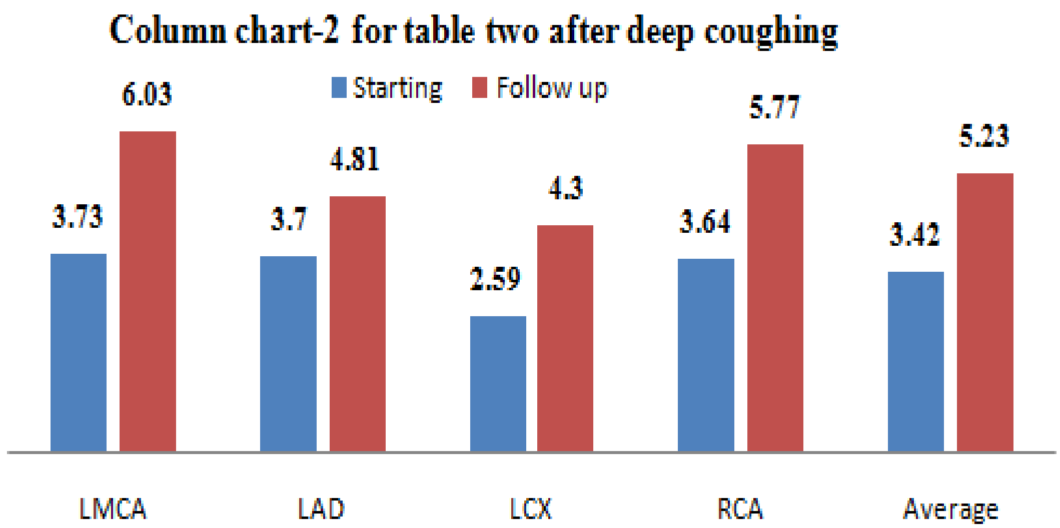
Table 2: Comparison of diameters of LMCA, LAD, LCX& RCA after deep coughingof Case-1: First Author

Diameter of (mm)	Initiallyon 20.12.2008	follow up on 17.04.2012	Increase of diameter in %
Diameter of left main coronary artery (LMCA)	3.73	6.03	61.66
Left anterior descending (LAD)	3.70	4.81	30.00
Left circumflex (LCX)	2.59	4.30	66.02
Diameter of right coronary artery (RCA)	3.64	5.77	58.52
Average	3.42	5.23	54.05



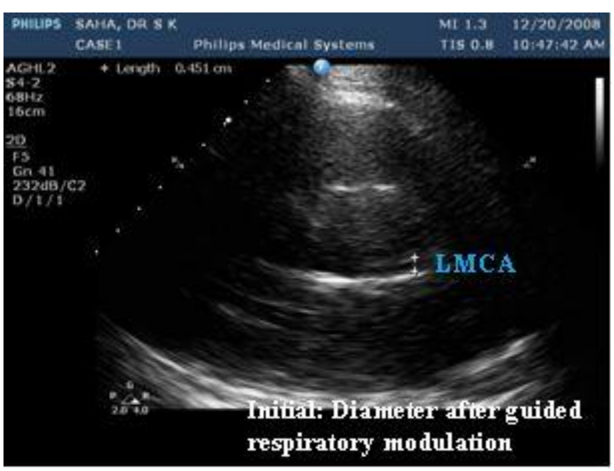


Figure 1I: Diameter of left main coronary artery (LMCA) = 4.51 mm after guided respiratory modulation (initial)

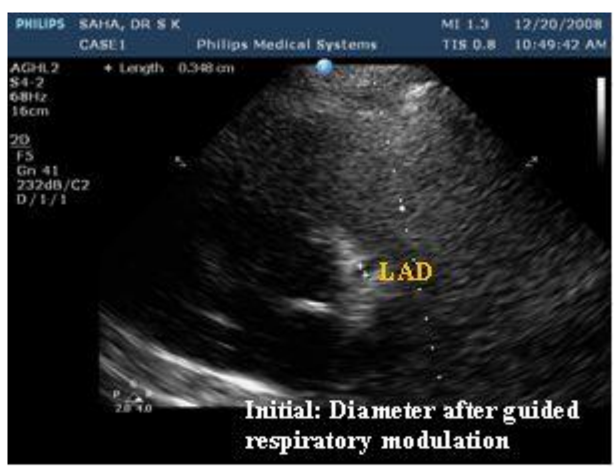


Figure 1J: Diameter of left main coronary artery (LAD) = 3.48 mm after guided respiratory modulation (initial)

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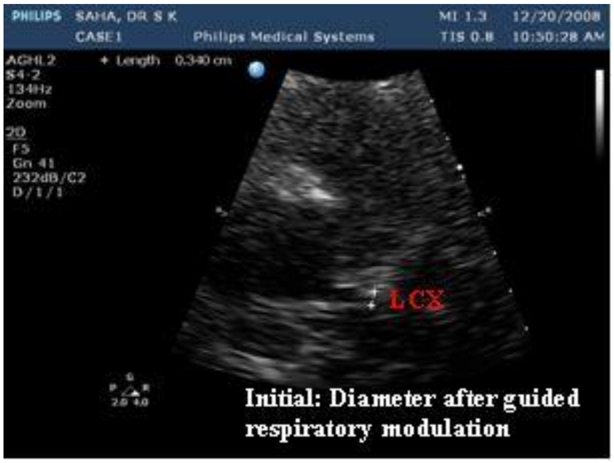


Figure 1K: Diameter of left circumflex (LCX) = 3.40 mm after guided respiratory modulation (initial)

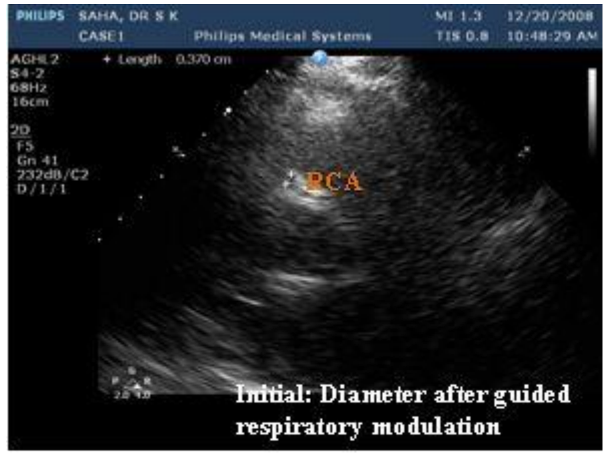


Figure 1L: Diameter of right coronary artery (RCA) = 3.70 mm after guided respiratory modulation (initial)

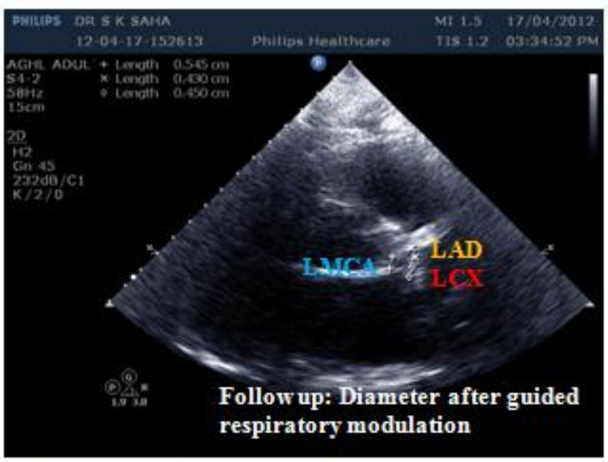
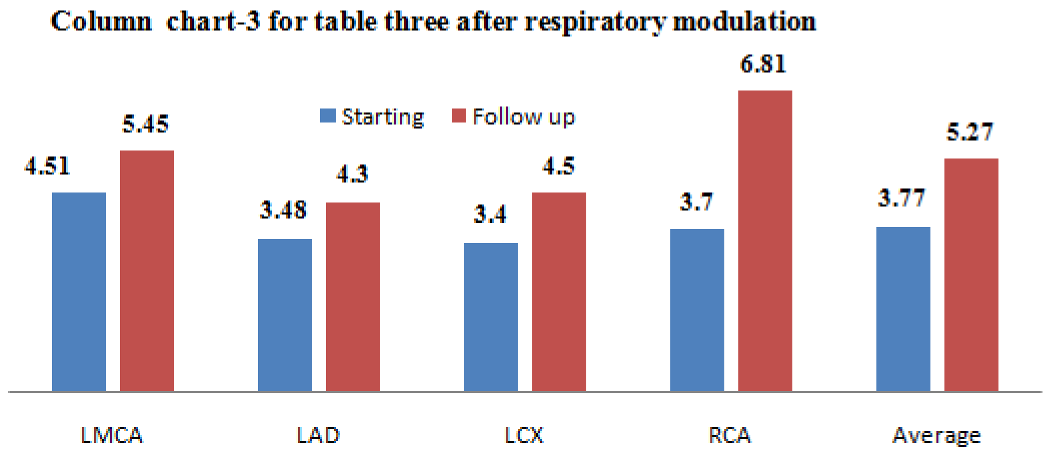


Figure 2G: Diameters of left main coronary artery (LMCA) = 5.45 mm; left anterior descending (LAD) = 4.30 mm and left circumflex (LCX) = 4.50 mm after guided respiratory modulation in follow up

Figure 2H: Diameters of right coronary artery (RCA) = 6.81 mm after guided respiratory modulation in follow up

Table 3: Comparison of diameters of LMCA, LAD, LCX& RCA after guided respiratory modulation of Case-1: First Author

Diameter of (mm)	Initially on 20.12.2008	Follow up on 17.04.2012	Increase of diameter in %
Left main coronary artery (LMCA)	4.51	5.45	20.84
Left anterior descending (LAD)	3.48	4.30	23.56
Left circumflex (LCX)	3.40	4.50	32.35
Diameter of right coronary artery (RCA)	3.70	6.81	84.05
Average	3.77	5.27	40.20



Case 2 Similar experiment has been done on the co-author

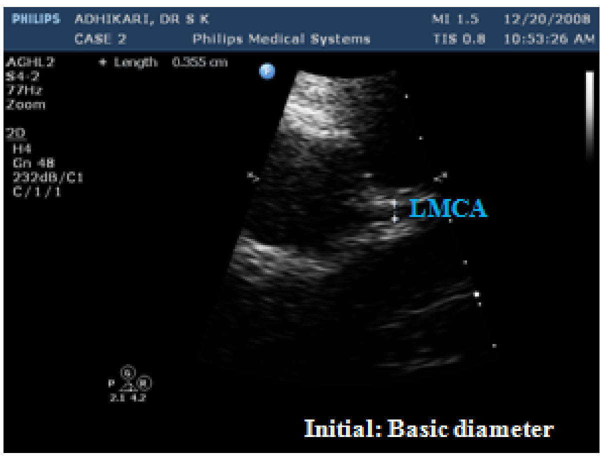


Figure.3A: Diameter of left main coronary artery (LMCA) = 3.55 mm (initial) resting

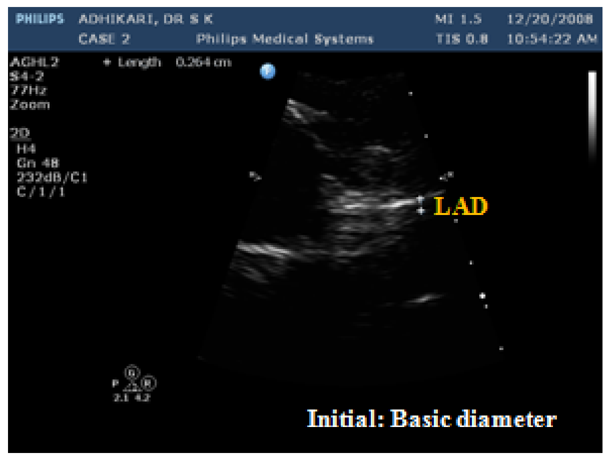


Figure.3B: Diameter of left anterior descending (LAD) = 2.64 mm (initial) at rest

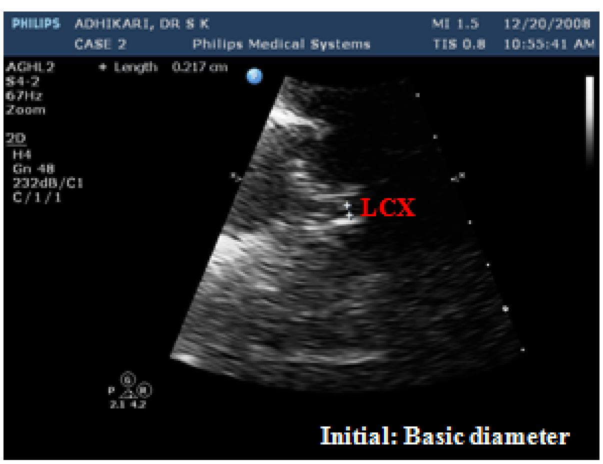


Figure.3C: Diameter of left circumflex (LCX) = 2.17 mm (initial) at rest

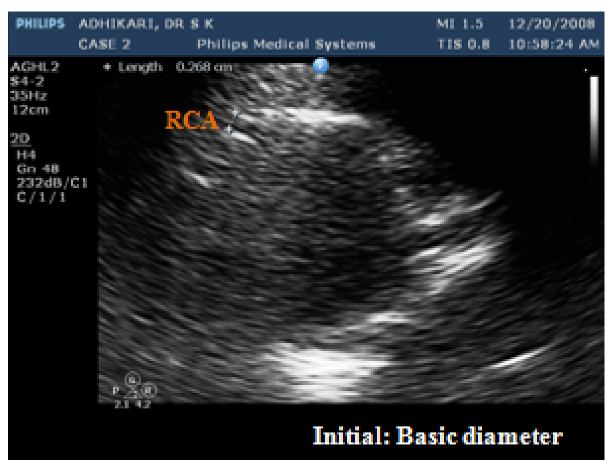


Figure 3D: Diameter of right coronary artery (RCA) = 2.68 mm initial at rest

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Figure 4A: Diameters of left main coronary artery (LMCA) = 5.73 mm; left anterior descending (LAD) = 3.09 mm; left circumflex (LCX) = 3.39 mm in follow up at rest

Figure 4B: Diameter of right coronary artery (RCA) = 3.75 mm at rest on follow up

Table 4: Comparison of change in diameters of LMCA, LAD, LCX &RCA at rest of Case-2: Co-author

Diameter	**At start in mm on 20.12.2008**	**At follow up in mm on 17.04.2012**	**Increase of diameter in %**
Left main coronary artery(LMCA)	3.55	5.73	61.41
Left anterior descending (LAD)	2.64	3.09	17.05
Left circumflex (LCX)	2.17	3.39	56.22
Right coronary artery(RCA)	2.68	3.75	39.93
Average	2.76	3.99	43.65

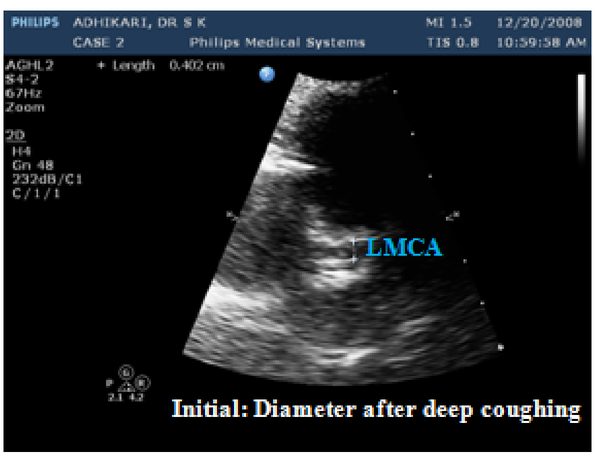

Figure 3E: Diameter of left main coronary artery (LMCA) = 4.02 mm after deep coughing (initial)

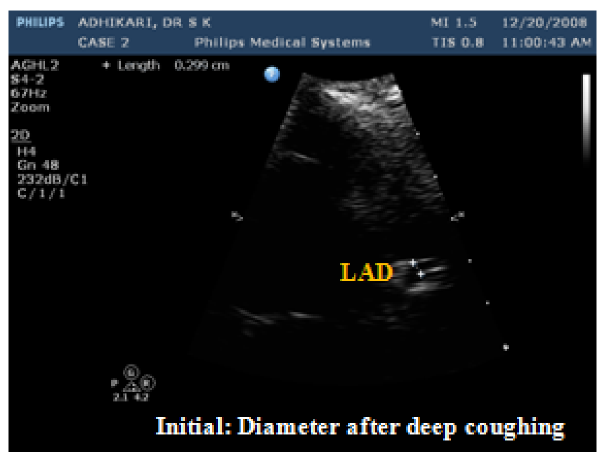

Figure 3F: Diameter of left anterior descending (LAD) = 2.99 mm after deep coughing (initial)

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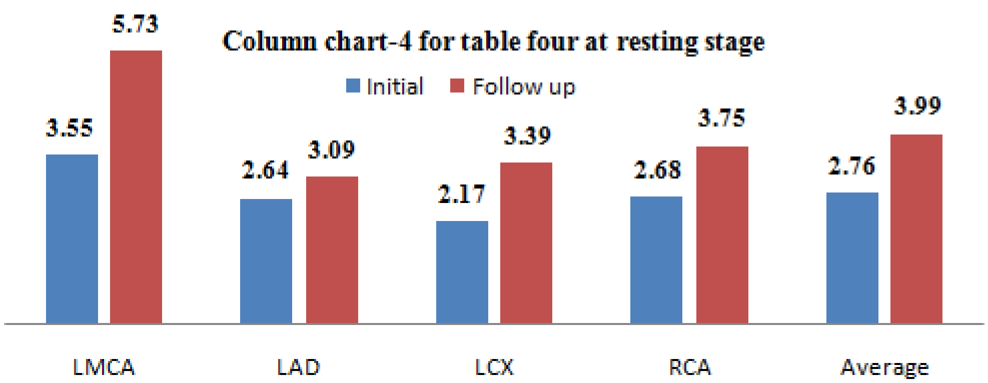

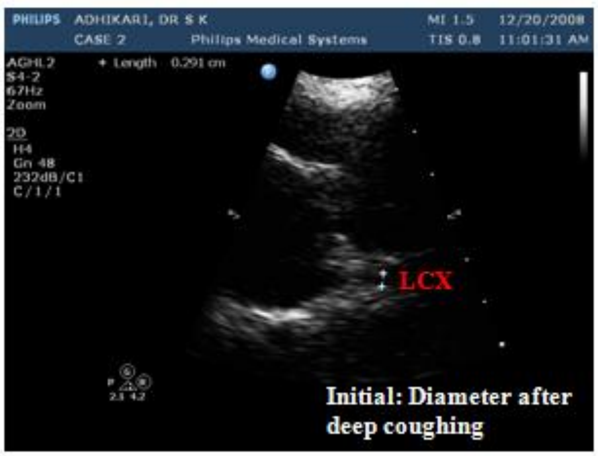

Figure 3G: Diameter of left circumflex (LCX) = 2.91 mm initially after deep cough

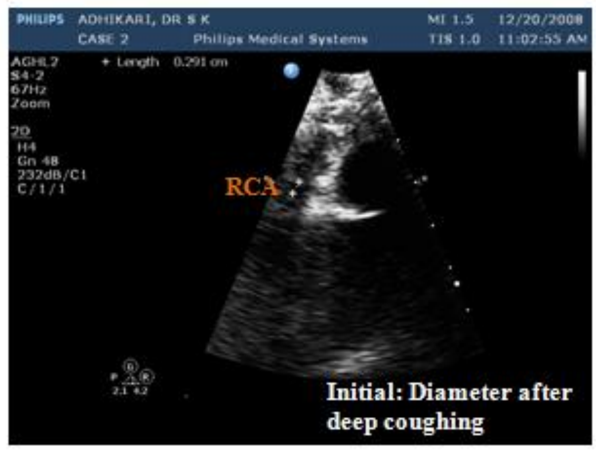

Figure 3H: Diameter of right coronary artery (RCA) = 2.91 mm after deep coughing (initial)

Figure 4C: Diameters of left main coronary artery (LMCA) = 6.64 mm; left anterior descending (LAD) = 3.53 mm; left circumflex (LCX) = 3.82 mm after deep coughing (follow up)

Figure 4D: Diameters of Right coronary artery (RCA) = 6.28 mm after deep coughing (follow up)

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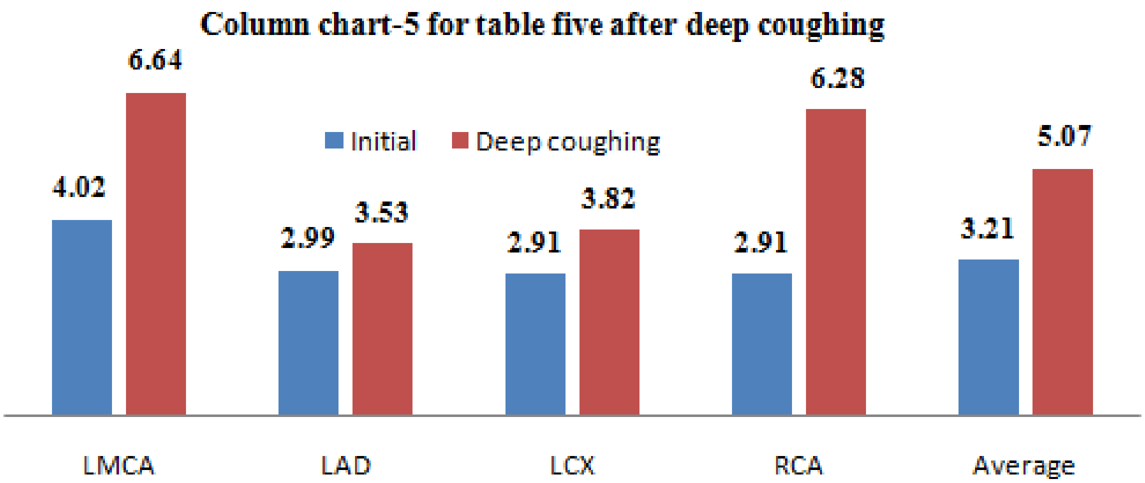

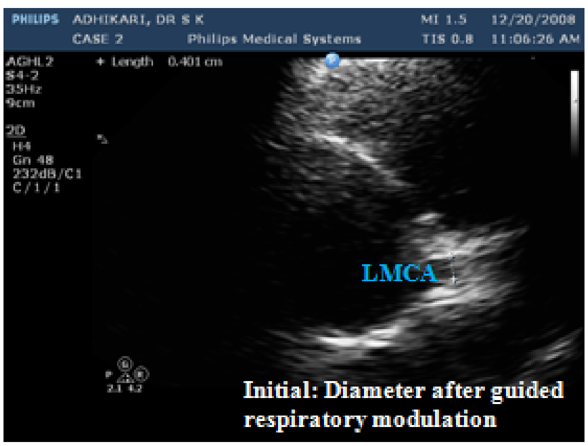

Figure 3I: Diameter of left main coronary artery (LMCA) = 4.01 mm after guided respiratory modulation (initial)

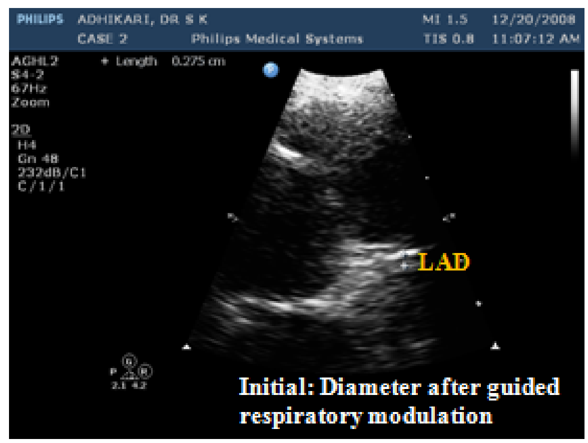

Figure 3J: Diameter of left anterior descending (LAD) = 2.75 mm after guided respiratory modulation (initial)

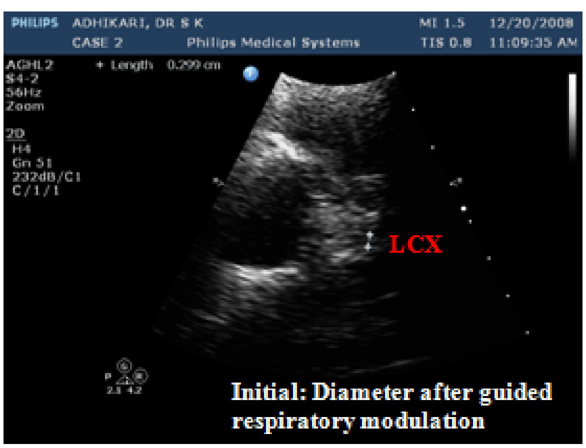

Figure 3K: Diameter of left circumflex (LCX) = 2.99 mm after guided respiratory modulation (initial)

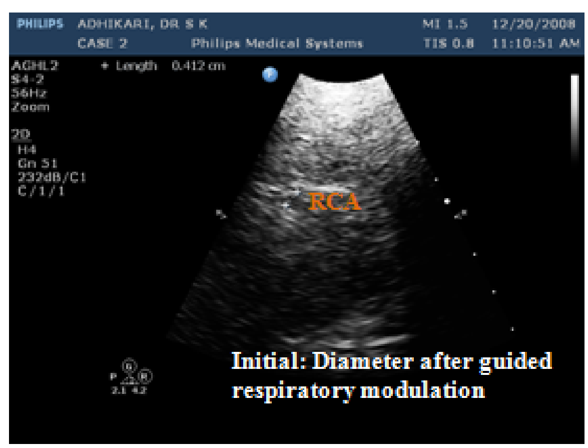

Figure 3L: Diameter of right coronary artery (RAC) = 4.12 mm after guided respiratory modulation (initial)

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Table 5: Comparison of change in diameters of LMCA, LAD, LCX& RCA after deep coughing of Case-2: Co-author

Diameter of(in mm)	Initially on 20.12.2008	follow up on 17.04.2012	Increase of diameter in %
Left main coronary artery(LMCA)	4.02	6.64	65.17
Left anterior descending (LAD)	2.99	3.53	18.06
Left circumflex (LCX)	2.91	3.82	31.27
Right coronary artery(RCA)	2.91	6.28	115.81
Average	3.21	5.07	57.58

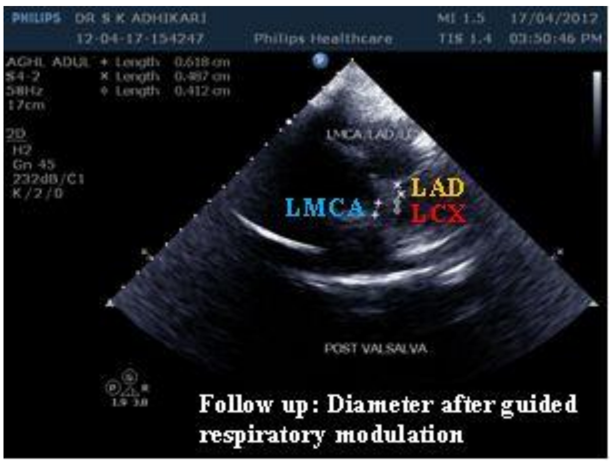

Figure 4E: Diameters of left main coronary artery (LMCA) = 6.18 mm; left anterior descending (LAD) = 4.87 mm; left circumflex (LCX) = 4.12 mm after guided respiratory modulation (follow up)

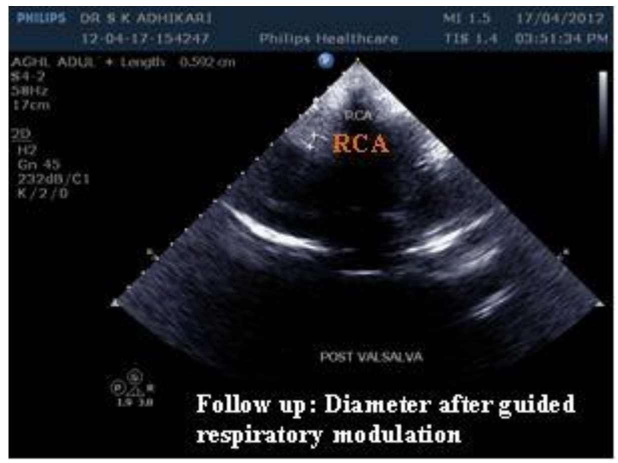

Figure 4F: Diameter of right coronary artery (RCA) = 5.92 mm after guided respiratory modulation (follow up)

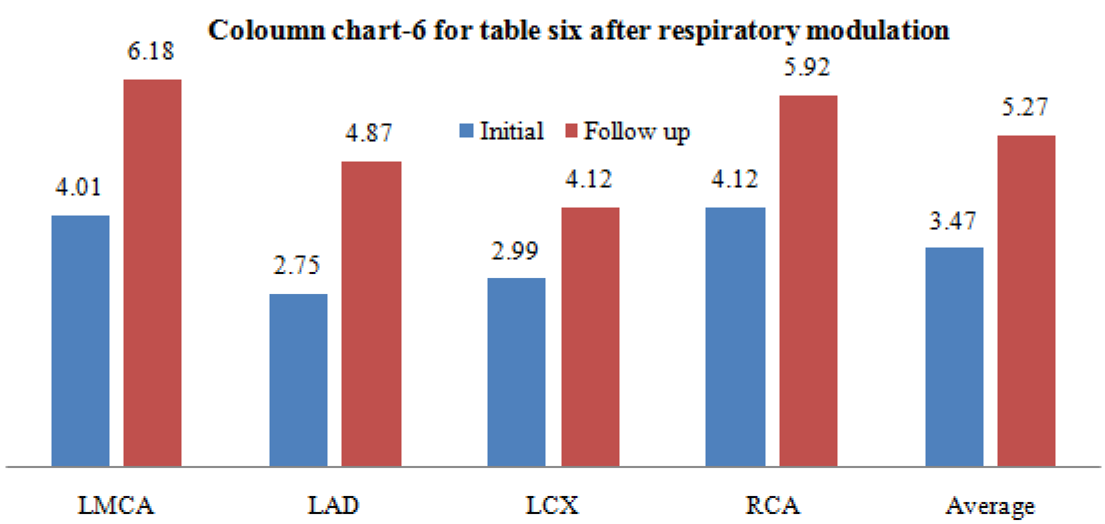

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Table 6: Comparison of change in diameters of LMCA, LAD, LCX& RCA after guided respiratory modulation, of Dr. S. K. Adhikari

Diameter of (mm)	Initially on 20.12.2008	Follow up on 17.04.2012	Increase of diameter in %
Left main coronary artery(LMCA)	4.01	6.18	54.11
Left anterior descending (LAD)	2.75	4.87	77.09
Left circumflex (LCX)	2.99	4.12	37.79
Right coronary artery(RCA)	4.12	5.92	43.69
Average	3.47	5.27	53.17

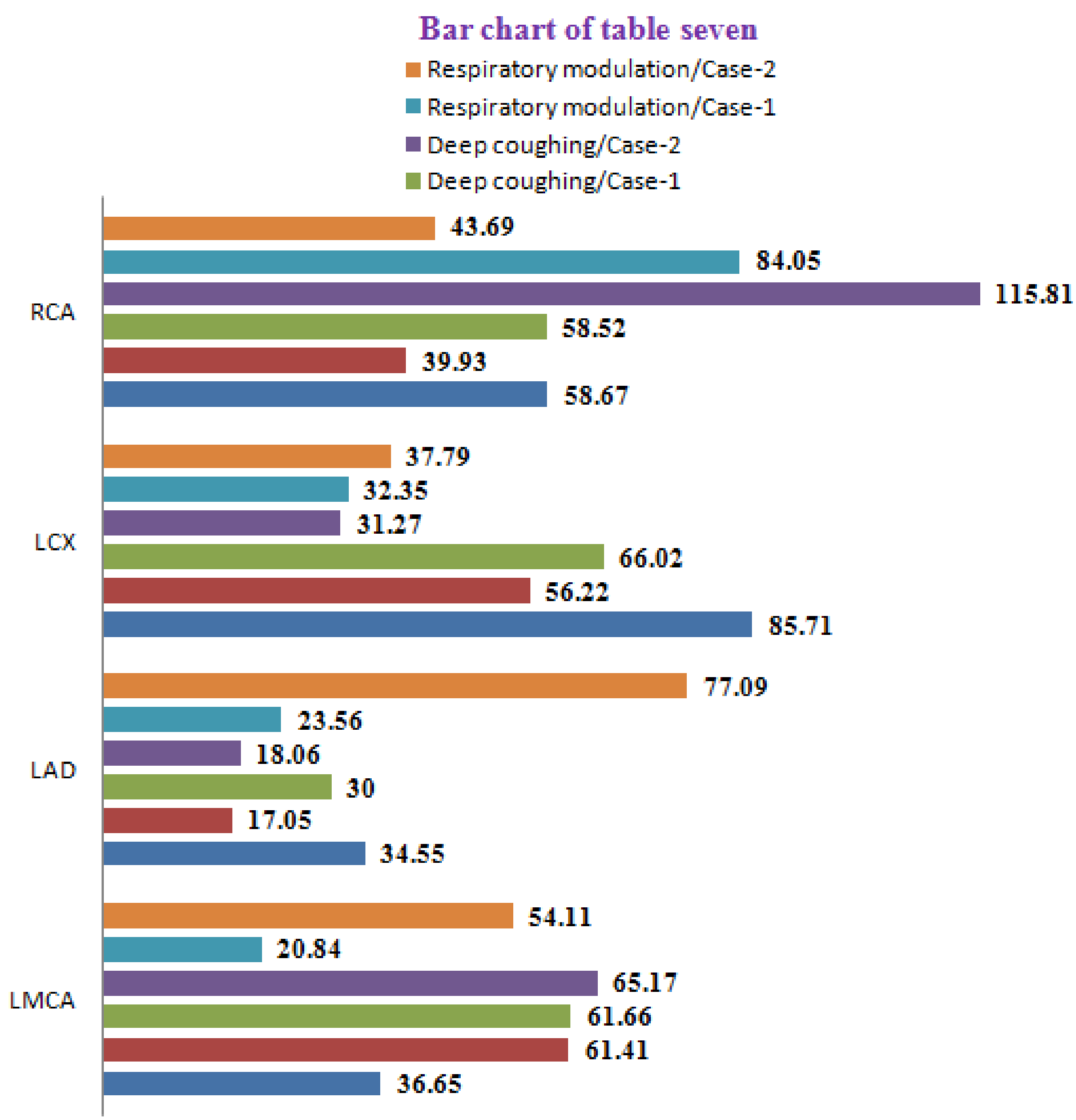

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Table 7: Comparison ofaverage change in % between case-1 & case-2 in follow up

Coronary arteries	**% increase in diameter on 2012 in resting stage in comparison with 2008**		**% increase in diameter on 2012 after deep coughing in comparison with 2008**		**% increase in diameter on2012 after guided respiratory modulation in comparison with 2008**	
	For Case-1	For Case-2	For Case-1	For Case-2	For Case-1	For Case-2
LMCA	36.65	61.41	61.66	65.17	20.84	54.11
LAD	34.55	17.05	30.00	18.06	23.56	77.09
LCX	85.71	56.22	66.02	31.27	32.35	37.79
RCA	58.67	39.93	58.52	115.81	84.05	43.69
Average	53.90	43.65	54.05	57.58	40.20	53.17

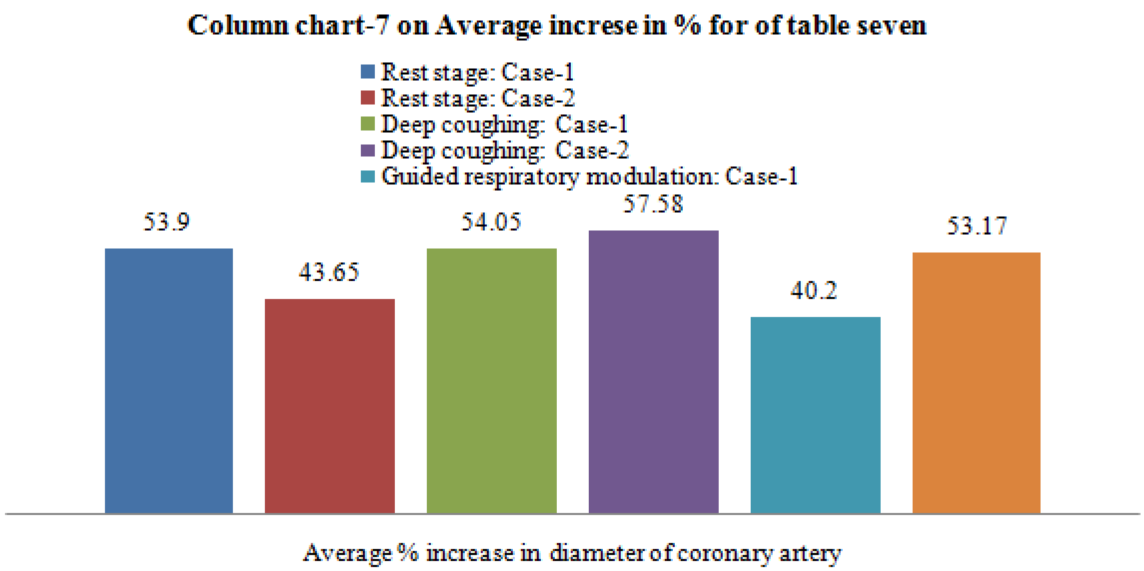

Table 8: Girth at resting state (Comparison with the standard girth in another published paper)

Arteries	**Normal standard From Godge et al**	**Resting girth of Case-1**		**Case-2**	
		2008	**2012**	**2008**	**2012**
LMCA	4.50 mm ± 0.50 mm	3.52 mm	4.81 mm	3.55 mm	5.73 mm
LAD	3.70 mm ± 0.40 mm	2.75 mm	3.70 mm	2.64 mm	3.09 mm
LCX	3.40 mm ± 0.50 mm	2.03 mm	3.77 mm	2.17 mm	3.39 mm
RCA	3.90 mm ± 0.60 mm	3.17 mm	5.03 mm	2.68 mm	3.75 mm
Total	15.50 mm ± 2.00 mm	11.47 mm	17.31 mm	11.04 mm	15.96 mm

NB. It appears that the resting girth in 2008 was rather on the lower side in comparison with the standard.*Saikrishna et al*[14] attempted to document the coronary artery size in the normal living Indian population free of coronary artery disease. Their data show that the coronary artery dimensions for left coronaries are similar to that reported in the West but the dimensions of the right coronary were comparably greater. But our findings support the general perception that Indians probably have smaller coronary arteries but the size of RCA does not appear larger than the standard.

Table 9: Maximum girth dilation with modulation (lumen + wall thickness) in follow up period

Arteries	Case-1		Case-2	
	Diameter	**Comments**	**Diameter**	**Comments**
LMCA	6.03 mm	Deep coughing, 2012	6.64 mm	Deep coughing, 2012
LAD	4.81 mm		3.53 mm	
LCX	4.50 mm		4.12 mm	
RCA	6.81 mm		6.28 mm	Deep coughing, 2012
Sum	22.15 mm		20.57 mm	

NB: Sum of the maximum diameter of 4 vessels was 22.15mm in case 1 & 20.57mm maximum in case 2: both exceeds thenormal standard figures

Table 10: Coronary Artery diameter in Pakistani, Caucasians and Asians in general: (Z Kaimkhani et al) vis-à-vis our present observation (in mm)

Arteries	Pakistani	Caucasias	Asians	Dodge et al	Case-1 (Resting)		Case-2 (Resting)	
					2008	**2012**	**2008**	**2012**
LMCA	4.28+0.82	4.00	4.00	4.50+0.50	3.52	4.81	3.55	5.73
LAD	3.22+0.74	3.40	3.12	3.70+0.40	2.75	3.70	2.64	3.09
LCX	3.02+0.75	3.00	3.10	3.40+0.50	2.03	3.77	2.17	3.39
RCA	3.08+0.78	3.20	2.70	3.90+0.60	3.17	5.03	2.68	3.75
Total Diameter	13.60+2.60	13.60	12.90	15.50+2.00	11.47	17.31	11.04	15.96

Table 11: (all measurements are in mm)

*** figures showing outer diameter of LAD = Lumen + Wall**

S. K. Saha Atherosclerosed		S. K. Adhikari Near normal		The American Journal of Cardiology	Circulation	Journal ofThe Pakistan Medical Association	Radiology	Journal ofAmerican College of Cardiology	The American Journal of Cardiology Wall thickness
2008	2012	2008	2012	2008	1992	2004	1972	1999	2003
2.75	3.70	2.64	3.09	3.30	3.30	3.22	3.40	3.12	1.60 in Diseased / 0.90 in Normal
– 1.60	– 1.60	– 0.90	– 0.90	– 1.60	– 1.60	– 1.60	– 1.60	– 1.60	Deduction of wall thickness
1.15	2.10	1.74	2.19	1.70	1.70	1.62	1.80	1.52	Lumen diameter

DISCUSSION

We are trying to say in this article that coronary arteries undergo relaxation / dilatation changes with certain sets of exercises. We can probably compare it with the warm up phenomenon of physical exercise. This was done for three years by two old volunteers living with HBP (High blood pressure), DM (Diabetes Mellitus) and other comorbid conditions.

Our model of respiratory modulation with deep coughing and then deep inspiration, hold and deep expiration with PEEP was scheduled to be practiced in the morning, before starting the day's work. This was regularly practiced by case-1, before embarking on his semi-sedentary daily work schedule. He suffers from Ischemic Heart Disease (IHD) and felt some relief with repetition of these procedures whenever there was mild discomfort in chest (during routine work or mild strain), even at other times of the day. He is not on stent and has not yet undergone bypass surgery. He is on permanent pace maker for bi-fascicular block since Feb. 2008.

The same procedures were irregularly practiced by the second case. He is type-2 diabetic without any feature of complication. He would often forget about this project as there was no reminder of physical discomfort in his case. He practiced only when he was reminded or became mindful.

It appears from our previous observations[1]that the coronary arteries dilate without any side effect immediately after modulating procedures. In this article, we are searching for an answer to the question as to how much of it is sustained even after a few years. Our results show that there is significant dilatation in the follow up of all the four coronary arteries after three years as compared with the initial images in both cases 1 and 2[Table 7].

On comparing the resting figures of 2008 with those of 2012 we find that the average improvement was better in case-1 (53.9%), who followed the exercises regularly than in case-2 (43.65%), who was irregular in practice. We can ignore instrumental/observer dependant variation in such comparison by considering the difference of average reading between two cases. The errors due to variations of machine reading will be cancelled mutually as the readings were from the same machine. The two sets of readings show statistically significant difference of10.25%.

The average results after deep coughing, in case-1, (54.05%) was worse than in case-2 (57.58%) and after respiratory modulation (40.20% and 53.17% respectively). The differences were in favour of case -2 after deep coughing (3.53%) and after deep breathing and hold (12.97%), though he was in a worse position as per resting figures. These figures are also significant.

Atherosclerosis in IHD of case -1 has probably restricted the amount of immediate dilatation even after practicing the modulation regularly. It appears that body could adjust itself in the longrun due to the repeated endeavours of modulation. Absence of IHD in case-2, has allowed better dilatation immediately after modulation procedures which was only a transient effect. He has not practiced regularly to get the sustained effect adequately. Another significant point is that there is no side effect for the procedures in either case.

The increase in lumen in various readings can also be appreciated by deducting wall thickness obtained from some standard reference papers (Table 11). This also indicates dilation of lumen in our cases.

Thus it seems that case 2 has allowed better dilatation immediately after modulation procedures, which was only a transient effect probably due to Diabetes Mellituscausing a situation like pre autonomic neuropathy. He has not practiced regularly to get the sustained dilation effects in a better way.

Symptomatic improvement (from chest discomfort) after modulation exercises in case-1, indirectly point towards immediate improvement in coronary flow. But not much dilatation was observed in the follow up results after deep coughing and respiratory modulation. It could be assumed that deep coughing does the job of squeezing and massaging heart which gives some symptomatic relief immediately.

The technique of deep breathing and hold probably helps in better oxygenation immediately. It probably helps in subsequent dilatation of the coronary arteries which are normally fed during diastole[3]. Physiologically speaking, prolonged expiration causes slowing of heart rate which may mean more time for cardiac cycle (and better oxygenation in diastole). But this result does not appear good in an atherosclerotic subject. Regular practice of the set technique of respiratory modulation by case -2, could give us more insight.Even then, the mean percentage increase in CAs between 2008 and 2012 of both the cases is appreciable (Table 7).

Conclusion

Coronary arteries are the supply lines of heart which sustain life. Atheromatous plaques in coronary arteries of hypertensive and dyslipidæmicpersons with or without other co-morbid conditions may be the fore runner of major cardiac attack by blocking the coronary flow. It seems that the supply line could be moulded favourably by following our non-invasive procedures. The presence of IHD due to associated atherosclerosis probably hinders full effect of modulation but can show some amount of sustained dilatation at rest in the long run, as observed in our follow up results. Supervised (without discontinuing the maintenance doses of medicines) results in two old persons with various co-morbid conditions is

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presented here. This raises some hope of obtaining good results with these modulation techniques. These observations need further long term follow up in many more cases and many more centres.

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