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Effect of Antenatal Breathing Exercises on Maternal Blood Gases and Foetal Heart Patterns – A Pilot Study

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Summary

Breathing exercises are an integral part of the antenatal exercise program for preparation for labour to have better control over breathing during labour, generalized relaxation and to increase the vital capacity. Their beneficial effects however have been questioned time and again. The literature does not comment on the duration for which these exercises can be done in one session. The present study was planned to know the changes in maternal blood gases in pregnant women of more than 30 weeks gestation during and after conventionally advocated slow deep breathing exercises and to determine their effect on the fetal heart patterns, if any.

It was observed that none of the blood gas or C.T.G. parameters increase or decrease to levels harmful to the fetus, though maternal blood gas parameters recover faster as compared to fetal CTG after exercise.

Results therefore imply that, deep breathing exercises, if recommended, may be done with caution, as the changes may be persistant in some patients.

Introduction

Breathing exercises after first trimester of pregnancy till term are considered to be an important part of the antenatal exercise program (ANEP) (Van and William, 1971) for preparation for labour. Their beneficial effects (Yahia and Uling, 1965; Hughey et al, 1978) and controversies (Beck and Hall, 1978) have been studied by various authors.

The aim of teaching these exercise to the patients is to have better control over breathing during labour to achieve generalized relaxation and to increase the vital capacity. Slow deep breathing exercises have been said to give better alveolar ventilation resulting in better oxygen absorption and carbon dioxide release as compared to fast shallow respiration (Starring, 1984; Polden and Mantle, 1990). However, literature does not mention about the duration for which these breathing exercises should be advocated in one session, and also their effect on foetal wellbeing during or after the exercises.

Polden and Mantle (1990) have discussed the breathing exercises conventionally advocated and argue out that slow, 'deep' calm 'abdominal' breathing exercises are better as compared to rigid patterns of breathing which reduce the oxygen supply to the mother and fetus. Hyperventilation associated with exercise and low carbon dioxide levels give rise to distressing maternal side effects of panic, anxiety, wooziness, paraesthesia. This will further affect the rate and depth of respiration, intensifying the symptoms. They further hypothesize, that the maternal apnea that follows periods of hyperventilation might affect the fetus. Noble (1981) states that it is difficult to understand the justification for altering something as fundamental as normal breathing, especially during the increased metabolic demands that occur in labour. However no systematic study has been done to support these hypothesis.

While advocating the breathing exercises to the pregnant women in our hospital, we observed that many of them complained of inability to continue slow deep breathing exercises even for a short period of time, though they were not having any associated medical disease. This was specifically seen in women after 24 weeks of gestation period. Most of them complained of respiratory distress in the form of breathlessness and some had vague lower abdominal pain also. Based on these pilot findings, the present study was planned to know the changes in maternal blood gases in pregnant women of more than 30 weeks gestation during and after conventionally advocated antenatal slow deep breathing exercises and to determine their effect on the fetal heart patterns, if any.

Material & Method

After taking the institutional ethical committee's approval, non-obese primigravidas with gestational age of thirty weeks or more were randomly selected for the study. All subjects were having medium physical work capacity and were habitually doing routine Indian house-hold work. Those having anaemia, cardiac, respiratory, neurological, musculoskeletal or any other associated disease which can lead to breathlessness, were excluded from the study. The procedure was explained in detail and an informed consent taken from the 16 who agreed to be subjects for the study.

Modified Allen's test (Sakes and Vickes, 1991) was performed and satisfactory ulnar collateral blood flow to either of the hands was confirmed. The radial artery of the selected hand was cannulated with 20 G arterial cannula (Romsons) after infiltrating 0.5% lignocaine at the site of puncture and around the artery. The patient's were then placed comfortably in supine position with 15° lateral tilt using a specific wedge under the right hip to prevent aortocaval compression.

The patients were instructed to do slow deep breathing exercises as advocated by Polden and Mantle (1990). They were asked to take a deep breath, holding it for approximately three seconds (Van and William, 1971) and then exhaling slowly. This maneuver was done for a maximum of thirty minutes or till the time the patients were not able to continue the exercise or till the maternal heart rate exceeded 140 bpm (Artal and Wisel, 1986).

Fetal monitor (Corometric® Model : 115) was used to record fetal heart rate (FHR) patterns and the graph speed was set at 1cm/min. The recordings were started 10 minutes prior to the exercise (baseline) and were continued till 30 minutes after stopping the exercise. Patients were also instructed to press the hand switch provided with the cardiotocograph (CTG) on feeling of the fetal movements to mark it on the tracing.

The blood gas analysis was done using AVI automatic Blood gas analyser model AVL 995-S™. Samples for maternal blood gas analysis were taken and pulse rate and BP were recorded on the following occasions:

1. Before starting exercises (Baseline)
2. Completion of exercises at 30 minutes or before if exercises were interrupted due to any indication of respiratory discomfort, lower abdominal pain etc.
3. FHR of less than 100 bpm or more than or equal to 160 bpm.
4. Every 5 minutes for 30 minutes, after stopping the exercise.

Data Analysis

Cardiotocographs were evaluated for fetal heart rate (FHR), beat to beat variability (BBV), accelerations

Table – 1: Cardiotocography Scoring

Parameter	Score 0	1	2
Baseline Fetal Heart Rate (Beats/min)	<100>180	100-119 or 161-180	120-160
Variability			
Oscillatory Amplitude	<5	5-9or >25	10-25
Oscillatory Frequency (Oscillations/min)	<3	3-6	>6
Accelerations	0	Periodic or 1-4 sporadic	>4 sporadic
Decelerations	0	1-4	>4

and decelerations as per grading shown in Table 1. A total score of 10 was given.

A midrange value for FHR and BBV was determined for each minute segment of the FHR tracings and an average was taken out for baseline, during exercise, 0-10 minutes and 10-20 minutes after exercise (Collings and Cruet, 1985).

Recovery time was defined as time taken by the fetal heart to show recovery in terms of BBV, accelerations and decelerations to the baseline values, after stopping the exercise (exs).

Statistical analysis was done by using Tukey test with hierarchical Anova, paired and unpaired t-test, wherever applicable. Results were classified as statistically significant when p-value <0.05.

Results

The mean age of the 16 subjects selected was 21.87 ± 2.99 yrs. (range 18-28 yrs.), mean gestation period 34.81 ± 2.56 weeks range (30-38 wks). The mean duration of exercise tolerated was 10.81 ± 8.51 minutes. Fourteen out of 16 patients (87.5%) could not complete the exercise for 30 minutes as advised and 2 of them could not do it even beyond 4 minutes.

Cardiotocography at different time intervals from baseline till the end of procedure revealed that mean CTG scores at the end of exercise and upto 2.5 minutes there after were statistically different from the basal scores (p<0.05) (Table II). The scores started to recover immediately after the end of exercise and the difference from Basal level was not found to be statistically significant beyond 2.5 min. after end of exercise. During the time of significant falls of the scores, 5 patients showed a decrease in FHR below 120 bpm (later on termed as dip). However, this persisted not more than 1 sec. None of these patients complained of any breathing discomfort or any other symptoms at this time and continued the exercises.

No significant difference was found between the FHR and BBV at different time intervals while comparing different periods of gestation (Table III & IV). It was observed that FHR decreased during exercise from baseline (was as low as 120 bpm in 5 patients but only for a second after end of exercise) and started to recover at around 10-20 min. returning to normal by 30 min (Table III). During the entire observation at no point of time FHR deteriorated to levels dangerous to the fetus. BBV also showed similar variations (Table IV). Of the 16 subjects studied. BBV improved in 2, showed no change in 3 and deteriorated in 11 subjects. The mean time after start of exercise, when the BBV started to change was 9.37min. This change however was irrespective of the stopping of exercise. In 5 patients the BBV decreased after the exercise had been stopped. In the two patients who showed improvement in BBV, the change started while exercising only. The mean recovery time was 18.75min (range :0-30 min).

Arterial blood samples were taken at different time intervals and the various indices were statistically examined. pH measured at 0 hrs was significantly different from the end exercise (p<0.01) whereas there was significant difference between pH values at the end of exercises from 5 min, 10min, 15 min, 30 min (Table V).

Table II
Comparison of CTG Scoring at different time Intervals

Time	NST Score (mean ± SD, n=16)
Before Exercise	8.31 ± 1.99
During Exercise	6.88 ± 2.33
End of Exercise	5.88 ± 2.00
0-2.5 min (after exercise)	6.44 ± 1.59
2.5-5 min	6.94 ± 1.77
5-10 min	6.94 ± 1.84
10-15 min.	7.19 ± 2.40
15-20 min.	7.38 ± 2.33
20-25 min.	7.31 ± 2.47
25-30 min.	7.94 ± 2.32

p-value (F-test) 0.001
Significance
(Tukey test at 5%)
Before exercise is significantly different from end of exercise and 0-2.5 minutes. End of exercise is significantly different from 25-30 min.

Table – III
Comparison of FHR at Different Time Intervals

Time (in min.)	I (30-32 wks) n=3	II (33-35 wks) n=5	III (36-38 wks) n=8
Before Exs	144.00 ± 8.54	143.40 ± 8.96	137.50 ± 7.56
During Exs	143.33 ± 10.41	143.00 ± 10.95	137.63 ± 15.05
0-10′ (after exs)	140.00 ± 13.23	135.00 ± 10.00	131.75 + 12.79
10-20′	136.67 ± 11.55	136.20 + 8.93	132.75 ± 10.63
20-30′	139.00 ± 09.64	137.60 ± 6.66	137.13 ± 12.09
P – value (F test)	0.314	0.314	0.314
Significance (Tukey test at 5%)	NS	NS	NS

Table – IV
Comparison of BBV at Different Time Intervals*

Time (in min.)	I (30-32 wks) n=3	II (33-35 wks) n=5	III (36-38 wks) n=8
Before Exs	2.00 ± 1.36	3.00 ± 1.00	3.50 ± 0.76
During Exs	1.67 ± 1.53	3.00 ± 1.00	2.50 ± 1.07
0-10 (after exs)	1.67 ± 1.53	2.80 ± 0.84	2.50 ± 0.93
10-20	2.00 ± 2.00	2.80 ± 0.84	2.63 ± 0.92
20-30	2.67 ± 1.53	3.20 ± 0.45	3.13 ± 0.99
P-value (F-test)	0.23	0.23	0.23
Significance (Tukey Test at 5%)	NS	NS	NS

*Tukey test is an inexact test that is not able to detect the difference between gestation periods.

The pCO2 showed a decrease in the mean value at the end of exercise which was statistically significant. The pCO2 levels returned to basal levels starting 5 min. after end of exercise.

The fall and subsequent rise of pO2 levels though not found to be statistically significant at various time intervals were lowest i.e. 69.66 torr at the end of exercise as compared to basal level of 79.344 torr and at other time intervals.

The O2 saturation was lowest 91.80 torr at the end of exercise and was found to be statistically significant ($p<0.001$) from the basal reading. O2 saturation showed a constant increase up to 30 min interval after end exercise. The AaDO2 was highest at the end of exercise 37.644 torr and was significantly different from 0 hrs., 5 min., 10 min., 15min., 30 min. Both O2 saturation and AaDO2 levels returned to near basal levels 30 min after end of exercise.

In 5 patients where FHR dropped to < 120 bpm though for not more than one second, blood samples taken at that time showed a mean pH of 7.42, PCO2 of 26.60 torr, a pO2 of 76.76 torr, O2 saturation of 95.10 and AaDO2 33.96 torr.

Discussion

Maternal and fetal response to various intensities of exercise have been studied (Artal and Wisel, 1986) by various authors both in vitro & vivo. The major shift in blood distribution to the various organs is part of the normal changes associated with pregnancy. The demands of exercises require a major redistribution of blood away from the splanchnic organs towards the working muscle. The possible effect of the shunting of blood away from the reproductive organs is of major

Table V

Showing the Statistical Difference Between the Various Blood Gas Parameters

Variables	0'hrs.		End Exercise		5 mins After end of exs.		10 mins After end of exs.		15 mins After end of exs.		20 mins After end of exs.		25 mins After end of exs.		30 mins After end of exs		P Value	Significance
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	(F-test)	(Tukey test at 5% level)
pH	7.374	0.044	7.416	0.05	7.371	0.051	7.369	0.044	7.376	0.034	7.375	0.038	7.379	0.03	7.37	0.025	0.000 (P<0.001)	0 HRS is sig. Different from end ex end exs is sign. Diff. From 5 mins. 10 mins. 15 mins. 20 mins. 25 mins. 30 mins
pCO_2	34.175	3.13	29.35	5.108	33.569	4.536	33.988	4.132	32.876	3.242	33.367	3.642	32.287	4.9	33.107	3.256	0.000 (P<0.001)	0 Hrs is sign. Different from end ex end exs is sign. Diff from 5 mins, 10 mins. 15 mins, 20 mins, 25 mins, 30 mins
pO_2	79.344	11.145	69.669	17.153	73.644	11.271	73.475	9.573	77.014	9.247	78.579	7.545	74.313	22.141	80.86	10.718	0.108	Not Significant
BE	-4.456	1.1698	-4.294	1.425	-4.831	1.74	-4.913	1.587	-4.853	1.124	-4.76	1.509	-4.687	1.153	-5.107	1.304	0.336	Not Significant
HCO_2	19.328	1.196	18	1.598	18.763	1.541	18.838	1.437	18.107	2.443	18.813	1.435	18.827	1.365	18.54	1.389	0.006 (P<0.001)	Not Significant
O_2Sat	94.25	2.958	91.8	4.938	92.994	3.004	93.675	2.838	94.157	2.291	93.807	4.199	94.72	2.286	94.747	2.035	0.003 (P<0.001)	End exs. is sig. Diff from 25 mins. 30 mins
$NaDO_2$	22.731	8.253	37.644	14.343	28.331	10.068	27.6	9.084	26.2	8.099	24.153	6.661	24.343	6.864	21.727	9.842	0.000 (P<0.001)	0 Hrs is sig. Different from end ex End exs is sig. Diff from 5 mins. 10 mins. 15 mins, 20 mins, 25 mins, 30 mins.

concern during exercise in pregnancy. Though several studies have been conducted to investigate this problem, there is no conclusive evidence as to whether or not the human fetus is actually affected as a result of this apparent deprivation.

The physiological changes occurring during middle pregnancy are such that it results in increased delivery of O_2 to the fetus and at the same time removal of CO_2 from the fetus. The double Haldane effect facilitates the passage of CO_2 from the fetus to mother and the Double Bohr effect describes increased delivery of O_2 to the fetus as a result of shifting of acids from fetus to mother. Other significant pulmonary changes in pregnancy which have a bearing on the fetus's well being are increase in the inspiratory capacity and a decrease in the FRC. This, combined with an increase in the O_2 consumption by about 10-20% results in low maternal O_2 reserves. pCO_2 is decreased as a result of increase in minute ventilation which is compensated by metabolic acidosis and therefore low HCO_3 (maternal).

Studies conducted in pregnant females during mild to moderate exercises have shown an increase in respiratory frequency and increase in minute ventilation (Knuttgen and Emerson, 1974). The state of hyperventilation that is there in pregnancy during rest increases during exercise and results in lower pCO_2, low HCO_3, a modest increase in pH (Mitter et al, 1974). The maternal CO_2 consumption shows an increase both at rest and during exercise because of increased work of respiratory muscles associated with hyperventilation and also because of increase in myocardial VO_2 to increase the COP (Pernoll et al, 1975).

The placental O_2 exchange is a function of maternal and fetal blood flows, placental blood haemoglobin concentrations, arterial O_2 tensions, and a number of maternal and fetal factors. In a study by Lotgering et al (1983) on the effect of exercise on pregnant ewes, it was shown that during exercise the mean maternal pO_2 increased by 8% and maternal Hb concerntration rose by 25%. The uterine blood flow decreased 21% but despite this fall, uteroplacental O_2 delivery remained unchanged. Other changes observed were an increase in maternal and fetal pH values as a result of maternal hyperventilation and an increase in the temperature of both mother and fetus (Lotgering et al, 1983). Maternal exercises induce certain physiological changes, some of which augment fetal O_2 whereas others depress it. Favourable factor is the hemoconcentration of maternal blood leading to increased O_2 carrying capacity and adverse factors are decreased uterine blood flow and increased pH of maternal and fetal blood.

Hyperventilation associated with maternal exercises results in dizziness, wooziness, numbness, parasthesia, muscle spasm, pallor, sweating, feeling of panic which could be attributed to decrease in maternal pCO_2, increased pH and decreased level of ionized Ca^{+2} (Hughey et al, 1978).

In our study, we selected subjects with gestational age of 30 weeks or more because no significant changes occur in FHR patterns as recorded by cardiotocography between 30 weeks and term (Gagon et al, 1987) thus minimizing the chances of variation and controversy.

In our study of pregnant women undertaking deep breathing exercises as a part of ANEP, it was found that the pH values were highest at the end of the exercise because of hyperventilation and the resultant wash out of the CO_2. pCO_2 was recorded to be lowest at a value of 29.35 torr at end exercise which was significant compared to the basal level. The pH value at end of exercise though within the normal range was highest at 7.416 and corresponded to the lowest value of pCO_2 of 29.35 torr at this time. Both the values were found to be statistically significant from basal reading and the readings taken subsequently. This observation can be explained by the fact that deep breathing exercises akin to moderate form of exercises result in hyperventilation (Lotgering et al, 1983) and the resultant washout of CO_2 from the maternal blood.

Some interesting features regarding the maternal O_2 levels were observed which were more pronounced at the time of end of exercise and gradually returning to normal levels over a period of time. The pO_2 levels at the end of exercise, though not statistically significant, were the lowest at 69.66 torr and so was the O_2 Saturation which was lowest at 91.80 at end exercise and was statistically significant ($p<0.001$) from basal levels. The $AaDO_2$ was recorded as highest at 37.644 and was found to be satistically significant from basal, 5 min, 10 min, 15 min, 20 min, 25 min and 30 min.

The above results though difficult to explain can be attributed to the fact that after a period of hyperventilation following exercises, there is brief apnea due to washing out of CO_2 and the low levels of O_2 can be explained due to increase in O_2 consumption which increases significantly on exercising. This fall in maternal pO_2 following deep breathing exercises could explain the low value of CTG scores at end exercise (5.88 ± 2.0) which were significantly different from basal. The finding assumes significance as in 5 patients there was a dip in the FHR for a small period. The pCO_2 level was at the lowest at 26.6 compared to all other readings at different times. The pH was also recorded at 7.429 at this point next only to the reading at end of exercise. These findings can explain the reduced availability of O2 (as explained earlier due to double Bohr effect) for fetus and therefore fetal bradycardia or fall in FHR. These 5 patients who had a dip in FHR did not show the lowest readings for pO2, SpO2 at that time as corroborative findings to explain fetal apnea. As the dip period was of very brief duration, it would be difficult to attribute this to fetal asphyxia and its contribution to future fetal wellbeing. As the patients were also not followed up during delivery and post natally, it would be difficult to comment upon the significance of this finding for the fetal wellbeing subsequently.

As one looks at the CTG and blood gas data, it appears that whatever changes that occur, the changes in maternal blood gases recover faster and at 20 min, values are equivalent to baseline (Table V) whereas the fetal heart takes time to recover, mean score is still not upto baseline value at 25-30 min post exercise (Table II). However, none of the parameters increase or decrease to levels harmful to the fetus.

In conclusion, deep breathing exercise if recommended, may be done with caution, as the changes may be persistant in some patients.

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