THE
Journal of Obstetrics & Gynaecology of India

VOLUME XXIII, No. 2 APRIL 1973

PULMONARY VENTILATION OF INDIAN PREGNANT WOMEN

by

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Cugell in 1953 noted a 39 per cent rise in tidal volume and 42 per cent rise in resting ventilation at term. This observation further investigated by workers like MacRae and Palavradji (1967) and others has thrown considerable light on the hitherto ill understood complex problem of acid base status of the mother and the foetus.

This hyperventilation during pregnancy with reduction of alveolar carbon dioxide tension (Prowse and Gaensler 1965) has been explained by the action of progesterone on the respiratory centre. According to this concept it is expected that the tidal and minute volumes should increase not only in pregnancy but also in the second half of the menstrual cycle.

With a view to assess the rise in pulmonary ventilation in Indian pregnant women, a study was undertaken at the Tata Main Hospital, Jamshedpur.

Material and Methods

Thirty-one pregnant patients in the last trimester were selected for study. Patients with complications were excluded. The surface area of each patient was calculated from the height and weight.

Twenty-five healthy nurses volunteered for this study as control subjects. The surface area of each was measured. The menstrual history and the day of the cycle at the time of the study were noted.

Pulmonary ventilation was measured by volumeter (Drager Werk, Lubeck). Each subject was rested in the morning of the examination for one hour before the measurement of respiratory volume. She was asked to breathe through the volumeter in supine position. The readings of the first few breaths were discarded. The minute ventilation and the respiratory rate were noted. The tidal volume was calculated from the minute volume and rate of respiration.

Action of Progesterone

Five postmenopausal cases were similarly asked to breathe through the volumeter before and half an hour after an injection of 10 to 25 mgm. progesterone. The chance of error due to injection itself was eliminated by injecting 2 ml.

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Received for publication on 4-5-1972.

of placebo and recording the ventilation before injecting progesterone.

Results

There were 25 volunteers. 14 of them were in the first half of the menstrual cycle and 11 in the second half.

Minute Volume

The minute ventilation of the fourteen subjects in the first half of the menstrual cycle varied between 2,000 ml and 5,700 ml, the mean being 4151 ml (Table 1). The mean surface area was 1.40 m^2. The minimum respiratory rate was 14 and the

TABLE I

Control Subjects, (Group I)—Pulmonary Ventilation in Follicular Phase

No.	Surface area (m^2)	Minute ventilation (ml.)	Tidal volume (ml.)	Rate of respiration (per minute)
1.	1.28	3,880	176	22
2.	1.30	5,700	237	24
3.	1.41	3,200	228	14
4.	1.43	3,600	257	14
5.	1.46	3,500	233	15
6.	1.38	5,000	263	19
7.	1.18	3,000	150	20
8.	1.35	4,000	154	26
9.	1.50	4,500	214	21
10.	1.21	5,000	263	19
11.	1.36	5,600	266	21
12.	1.50	2,000	125	16
13.	1.58	4,700	174	27
14.	1.66	4,440	317	14
Mean	1.40	4,151	218	19

TABLE II

Control Subjects, (Group 2)—Pulmonary Ventilation in Luteal Phase

No.	Surface area (m^2)	Minute Ventilation (ml.)	Tidal volume (ml.)	Rate of Respiration (per minute)
1.	1.57	6,800	323	21
2.	1.30	3,500	134	26
3.	1.39	5,700	335	17
4.	1.38	4,500	214	21
5.	1.23	4,000	285	14
6.	1.48	4,200	221	19
7.	1.30	5,400	225	24
8.	1.39	5,690	316	18
9.	1.44	4,600	256	18
10.	1.54	5,700	335	17
11.	1.62	7,000	333	21
Mean	1.40	5,171	270	19
Gr. I & Gr. II	1.40			

maximum 27 per minute, the mean being 19 per minute. The tidal volume ranged between 125 ml and 317 ml with a mean of 218 ml.

The mean surface area of the volunteers during the second half of the menstrual cycle was 1.40 m^2 and the rate of respiration 19 per minute (Table II). The minute ventilation varied between 3500 ml and 7000 ml, the mean being 5171 ml. as compared to 4151 in the first half of the cycle. The tidal volume ranged between 134 ml and 385 ml., the mean being 270 ml. as compared to 218 ml. of group I.

Table III shows the findings on pregnant subjects (Group III).

There were thirty-one patients in the last trimester. Twenty-four of them were in 36 to 40 weeks' gestation, 6 between 30

TABLE III

Normal Pregnant Patients, (Group III) Pulmonary Ventilation in Third Trimester

No.	Week of gestation	Surface area (m^2)	Minute volume (ml.)	Tidal volume (ml.)	Rate of respiration (per minute)
1.	36	1.50	7,000	250	28
2.	36	1.36	4,750	296	16
3.	40	1.37	7,600	345	22
4.	36	1.52	4,600	200	23
5.	40	1.25	4,600	191	24
6.	40	1.31	4,000	235	17
7.	40	1.41	3,900	216	18
8.	36	1.43	3,400	178	19
9.	34	1.56	3,100	155	20
10.	40	1.33	5,800	241	24
11.	34	1.43	8,400	381	22
12.	40	1.45	6,280	369	17
13.	36	1.42	5,000	250	20
14.	40	1.49	5,000	250	20
15.	36	1.42	5,610	330	17
16.	36	1.59	6,000	353	17
17.	30	1.40	8,780	627	14
18.	32	1.40	4,650	178	26
19.	40	1.62	8,100	540	15
20.	32	1.40	6,000	375	16
21.	36	1.44	7,000	388	18
22.	34	1.30	7,000	368	19
23.	40	1.48	7,000	304	23
24.	40	1.48	7,200	257	28
25.	40	1.57	7,000	466	15
26.	40	1.50	6,000	285	21
27.	40	1.59	8,600	318	27
28.	40	1.57	5,890	327	18
29.	36	1.32	5,750	230	25
30.	40	1.52	10,000	400	25
31.	42	1.60	9,500	593	16
Mean		1.45	6,532	319	20

to 34 weeks and one was postmature by 2 weeks. Surface area varied between 1.30 and 1.62 m^2, with a mean of 1.45 m^2. The minimum minute ventilation was 3100 ml, maximum 10,000 ml., the mean being 6532 ml. The rate of respiration varied between 15 and 28 per minute, the mean being 20 per minute. The tidal volume ranged between 178 ml. and 593 ml., the mean being 319 ml.

Comparative study of the Tidal and Minute Volumes of the Various subjects. Tidal volume—Table IV.

The mean tidal volume of the 25 control subjects was 241 ml. as compared to 319 ml. of the pregnant subjects showing a rise of 32.3% in tidal volume during pregnancy. Computed t was 2.89 and the difference was statistically significant.

The mean tidal volume of group I was 218 ml. as compared to 319 ml. of group III. The increase was 40.8% and t was 3.05 making the difference significant.

The mean tidal volume of group I, i.e., 218 ml. increased to 270 ml. in group II and the rise was 19.2%., t was 2.12 and found to be statistically significant.

The mean tidal volume of group II which was 270 ml. rose to 319 ml. in Group III. The increase in tidal volume was 18.1%, t was 1.30 and was not significant.

Table V clearly shows that the tidal volume increases in second half of menstrual cycle and is highest during pregnancy near term in spite of the fact that the rate of respiration remains almost same.

TABLE IV

Comparative Study of the Mean Tidal Volume of the Three Groups

Groups		Percentage rise	Significance
1. 241 ml (Gr. I & II)	319 ml. (Gr. III)	32.3	t 2.89 Significant.
2. 218 (Gr. I)	319 (Gr. III)	40.8	t 3.05 Significant.
3. 218 (Gr. I)	270 (Gr. II)	19.2	t 2.12 Significant.
4. 270 (Gr. II)	319 (Gr. III)	18.1	t 1.30 Not significant.

TABLE V

Mean Tidal Volumes of Various Groups of Subjects

Group	Surface area	Rate of respiration	Mean tidal volume
I	1.40 m^2	19/min	218 ml.
II	1.41 m^2	19/min	270 ml.
III	1.45 m^2	20/min.	319 ml.

.TABLE VII

Tidal Volume Before and After Injection of Progesterone

After Placebo injection	Dose of progesterone injected	After injection of progesterone
1. 172 ml.	25 mgm	230 ml.
2. 280 ml.	25 mgm	330 ml.
3. 203 ml.	25 mgm	250 ml.
4. 226 ml.	10 mgm	428 ml.
5. 300 ml.	10 mgm	318 ml.

TABLE VIII

Observations of Various Authors on Mean Minute Ventilation and Tidal Volumes

Author	Mean Surface area	Minute ventilation	Tidal Volume
Cugell et al 1953	1.76 m^2	10.34 litres	678 ml.
Mac Rae & Palavradji 1967	—	—	600 ml.
Present series	1.45 m^2	6.53 litres	319 ml.

though the surface area difference is much less.

Discussion

The present study clearly demonstrates hyperventilation during pregnancy, reaching maximum near term. There was an increase of tidal volume by 32.3% in pregnancy over those of the non-pregnant controls in our series. Cugell (1953) found an increase of tidal volume by 39% above normal at term. Prowse & Gaensler (1965) reported an increase in resting ventilation by 48% above normal when the oxygen uptake increased only by 21%. MacRae & Palavradji (1967) in a longitudinal study showed an increase of mean tidal volume by 47% over the mean tidal volume of the same patients two to five months after pregnancy.

Hasselbach & Gameltoft, quoted by Prowse & Gaensler (1965) reported decrease of alveolar PCO_2 in pregnancy and luteal phase of the menstrual cycle. Heerhaber *et al.* quoted by MacRae & Palavradji (1967) found hyperventilation in the second half of cycles. The same authors quote the findings of Doring *et al.* that indicate biochemical changes in luteal phase of the cycle. All these facts tend to explain the hyperventilation in pregnancy and luteal phase by the action of progesterone on the respiratory centre. In our series of cases, we have found 19% rise of tidal volume in the second half of the cycle. Moreover, in a small

series of 5 postmenopausal patients there is a definite tendency of tidal volume to increase after injection of progesterone. MacRae & Palavradji (1967) found fluctuation of acid base levels consistent with fluctuations of the alveolar carbon dioxide tension and pregnanediol excretion.

The hyperventilation in pregnancy leads to respiratory alkalosis and metabolic acidosis which is of compensatory nature due to reduction of alkaline reserve (MacRae & Palavradji 1967). Many workers have shown a fall of PCO_2 to 30 to 32 mm Hg. level. These changes increase the oxygen uptake and favour placental gaseous exchange.

The outstanding feature of the present study is the low minute and tidal volumes of Indian women even during pregnancy. Compared to about 600 ml. in the series of authors like Cugell, MacRae & Palavradji, the tidal volumes of our Indian women were at the level of 319 ml., Mathur *et al.* (1971) in a study of healthy Indian adults found the minute volume ranging between 3200 and 6000 ml. with tidal volumes between 200 to 300 ml. These observations show that the ventilatory capacity is probably less in Indian women as compared to that of western countries.

In hospitals with limited facilities of hormone assays longitudinal study of pulmonary ventilation on individual patients in various trimesters of pregnancy may give approximate idea as to the progesterone level. MacRae & Palavradji (1967) have even diagnosed fresh pregnancies in a patient 5 months postpartum by the rise of tidal volume. Patients with lung diseases may be submitted to ventilatory studies. If there is no hyperventilation of pregnancy there may be danger to the mother and baby due to the absence of biochemical changes which favour oxygen uptake and placental exchange of gases.

I am grateful to Dr. P. B. Bharucha, Superintendent, Tata Main Hospital for permission to utilise the case records of Tata Main Hospital, Jamshedpur, and also to Dr. Snehlata Gadh for her valuable assistance in this work.

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