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Reciprocal changes in nasal resistance in response to changes in posture*†

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SUMMARY *Unilateral nasal resistance to airflow has been reported to be affected by a change in position of the body. On changing from an erect position to a recumbent one, there is an increase in total nasal resistance to airflow which is thought to be caused by congestion of the nasal venous erectile tissue due to an increase in the jugular venous pressure. Changing from the erect or the supine position to the lateral recumbent position is known also to result in congestion of the ipsilateral or dependent nasal passage. Application of unilateral pressure to the axillary region results in congestion ipsilaterally and decongestion contralaterally. The effect of the lateral recumbent position has been investigated both in the dependent nasal passage and the contralateral nasal passage. Also examined is the effect on the total nasal resistance and the normal nasal cyclic activity.*

Key words: Reciprocal, nasal resistance, airflow, posture

INTRODUCTION

Unilateral nasal resistance to airflow has been reported to be affected by a change in position of the body. On changing from an erect position to a recumbent one, there is an increase in total nasal resistance to airflow which is thought to be caused by congestion of the nasal venous erectile tissue due to an increase in the jugular venous pressure (Rundcrantz, 1969; Rao and Potdar, 1970).

Changing from the erect or the supine position to the lateral recumbent position is known also to result in the congestion of the ipsilateral or dependent nasal passage. This was proposed to be due to an increase in the pressure in the ipsilateral jugular vein draining the dependent nasal passage (Jonson and Rundcrantz, 1969). Davies and Eccles (1985) have shown that by the application of unilateral pressure to the axillary region by means of a crutch device in the sitting position, not only is congestion obtained ipsilaterally, but there is also decongestion contralaterally. This reciprocal response has not been demonstrated in the lateral recumbent position because previously attention has been drawn mainly to the dependent nasal passage (Heetderks, 1927; Rundcrantz, 1969; Rao and Potdar, 1970; Kayser, 1895).

In this presentation, the effect of the lateral recumbent position has been investigated not only in the dependent nasal passage but also in the contralateral nasal passage and the effect on the total nasal resistance as well as the normal nasal cyclic activity is also examined.

The mode of investigation has also been quantitative using standardised experimental procedures.

METHOD

Twenty-six experiments were performed on 6 normal adult Caucasians. They were volunteers comprising mainly of students and staff of the University. The experimental procedures were explained to them and their consent was obtained. There were three males and three females aged between 21-37.

For the purpose of identification, the nasal passage with the higher resistance under control conditions, in the supine position, at the onset of the experiment was designated HC (High resistance control). The nasal passage with the lower resistance under control conditions, in the supine position, at the onset of the experiment, was designated LC (Low resistance control). The respective nasal passages maintained this nomenclature irrespective of the subsequent levels of nasal resistance values obtained from each.

Unilateral nasal pressure values were obtained at a sample flow rate of 0.2 litre.sec-1 using the NR1 rhinomanometer (Mercury Electronics, Glasgow, UK). The active anterior rhinomanometric method was adopted in these procedures (Babatola, 1985; Babatola and Eccles, 1987).

Each subject was examined clinically in a supine position on an examination couch. They were then allowed to acclimatise to

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the laboratory environment for 10 minutes. Nasal pressure values were recorded for each nasal passage (HC; LC) at five-minute intervals for a period of 15 minutes with the subject in the supine position. The subject was then instructed to lie down on the side ipsilateral to the nasal passage with the lower resistance (LC). The nasal pressure values were then recorded for each nasal passage (HC and LC) at five-minute intervals for another twenty minutes in this first lateral recumbent position. The experimental procedure was then repeated with the patient lying on the other side of the body (i.e. ipsilateral to the nasal passage HC). Subsequently the procedure was repeated on the first lateral recumbent position. Finally, the subject was required to return to the supine position and the corresponding nasal pressure values determined.

Nasal resistance values were then computed for each nasal passage in the different positions investigated using the relationship:

$R_N = P/V$ (Hamilton, 1979)

The corresponding graph was then plotted. Total nasal resistance values were also calculated from the relationship:

$1/R_{TNR} = 1/R_{HC} + 1/R_{LC}$ (Hamilton, 1979)

Statistical significance of changes observed was assessed using a t-test, (Bahn, 1972).

RESULTS

Figure 1 illustrates a typical example of the results obtained in the experiments. In each subject, there was a typical asymmetry between the two nasal passages at the onset of the experiments. This asymmetry was quantified in the ratio HC/LC which was obtained by comparing the value from LC with the value from HC in each subject in each position. The changes in the ratio HC/LC that occurred in each of the positions are shown in Table 1.

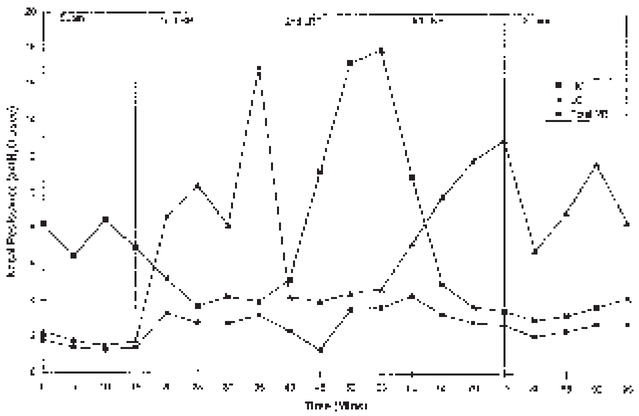

Figure 1. Graph showing changes in unilateral and total nasal resistance to airflow in response to changes in posture

Table 2 shows the mean values of changes in unilateral nasal resistance to airflow that occurred as a result of adopting the various lateral recumbent positions. The changes were statistically significant. There was a complete reversal of the asymmetry between the two nasal passages with an increase in nasal resistance in the dependent nasal passage LC and a simultaneous decrease in nasal resistance in the contralateral nasal passage HC. The changes were statistically significant with $p < 0.01$ (LC) and $p < 0.001$ (HC). The ratio HC/LC obtained in the first lateral recumbent position was a mean value of 0.47 ± 0.04 (n=26, Table 1). The ratio in the supine position had been a mean value of 3.53 ± 0.17 (n=26, Table 1). In the second lateral recumbent position (LRP), another reversal was obtained with nasal passage LC now becoming decongested while nasal passage HC became congested. Nasal passage HC was now in the dependent position. The changes obtained in both nasal passages were statistically significant (with LC, $p < 0.01$; with HC, $p < 0.001$; Table 2). The ratio HC/LC obtained also defines this reversal of asymmetry with a mean value of 2.91 ± 0.19 (n=26,Table 1). In the third LRP, again the dependent nasal pas-

Table 1. Mean values of the ratio HC/LC in the different positions investigated.

	Position				
	Supine	1st LRP	2nd LRP	3rd LRP	Supine
HC / LC	3.53+/-0.17	0.47+/-0.04	2.91+/-0.19	0.44+/-0.06	0.35+/-0.02

Table 2. Mean values of unilateral nasal resistance to airflow in the supine and lateral recumbent position.

	Position				
	Supine	1st LRP	2nd LRP	3rd LRP	Supine
LC	4.07	15.42	6.55	16.16	13.97
	+/-0.23	+/-2.18	+/-0.85	+/-1.69	+/-1.27
△ LC, p=		< 0.01	< 0.01	< 0.001	< 0.1
HC	14.4	7.18	19.05	7.08	4.92
	+/-0.96	+/-0.69	+/-1.77	+/-0.93	+/-1.15
△ HC, p=		< 0.001	< 0.001	< 0.001	< 0.001

Table 3. Mean values of total nasal resistance to airflow in the supine and lateral recumbent positions.

	Position				
	Supine	1st LRP	2nd LRP	3rd LRP	Supine
TNR	3.17	4.71	4.53	4.63	3.42
	+/-0.17	+/-0.55	+/-0.56	+/-0.76	+/-1.08
△ TNR, p=		= 0.02	> 0.5	> 0.5	< 0.01

sage (LC) became congested while a simultaneous decongestion occurred in the contralateral nasal passage. The changes obtained were statistically significant (in LC, $p < 0.001$; in HC, $p < 0.001$; Table 2). The ratio HC/LC in the third LRP was a mean value of 0.44 ± 0.06 (n=26, Table 1). On assumption of the supine position, at the end of the experiments, mean values of the ratio HC/LC were 0.35 ± 0.02 (n=26, Table 1) showing that the asymmetry existing during the third LRP was maintained through to the supine position (Table 2). The asymmetry attained in the third lateral recumbent position was maintained into the supine position.

Total Nasal Resistance

The pooled results for total nasal resistance (TNR) values are shown in Table 3. Changing from the supine position to the first lateral recumbent position , mean TNR value increased by a mean value of 1.54 ± 0.14 $cmH_2O.L^{-1}.sec$. This change was statistically significant with $p = 0.02$. In the second LRP, mean value of TNR showed a decrease of 0.18 ± 0.25 $cmH_2O.\ L^{-1}.\ sec$ from the first LRP. In the third LRP, the mean value of TNR showed an increase of 0.10 ± 0.10 $cmH_2O.L^{-1}.sec$ from the second LRP. These changes were not statistically significant with $p > 0.5$ in both cases (Table 3). On adoption of the supine position, mean total nasal resistance showed a decrease of 1.21 ± 0.48 $cmH_2O.L^{-1}sec$ from a mean value of 4.63 ± 0.76 $cmH_2O.L^{-1}sec$ (n=26) in the third LRP. This change was statistically significant with $p < 0.01$. (Table 3).

DISCUSSION

In the supine position, an asymmetry in the nasal resistance to airflow between the two nasal passages was always observed. This asymmetry indicated that there is an imbalance between the two nasal passages with respect to the filling of the nasal mucosa and this has been attributed to the regular cyclic alternation in the sympathetic tone to the venous erectile tissue in the nasal mucosa (Stocksted and Thomsen, 1953; Eccles, 1978 and 1983). This cyclic alternation has been referred to as the nasal cycle (Heetderks, 1927; Kayser, 1895; Eccles, 1977).

Assumption of the lateral recumbent position normally resulted in a reciprocal change in nasal resistance to airflow. This response occurred within 20 seconds of attaining the position and was consistent. It could therefore not be attributed to the spontaneous nasal cyclic activity mentioned above. This cyclic activity appears to have been overridden by the assumption of the lateral recumbent position. The nasal cyclic activity normally has a period of 4-6 hours (Eccles, 1977). The mechanism by which this reciprocal change in nasal resistance occurs when the lateral recumbent position is assumed is not known. Rundcrantz (1969) suggested that the ipsilateral response could-be due to the effect of gravity and increased jugular venous pressure but this does not necessarily explain the reciprocity except if it was to be assumed that vascular anastomosis between the two nasal passages allowed blood to flow from the higher nasal passage to the more dependent one. There has been no such anastomosis demonstrated between the two nasal erectile tissues (Romanes, 1981). Moreover, the nasal erectile tissues are located on the conchae which are found on the lateral aspects of the nasal passages.

It is more likely that the reciprocal responses obtained are reflex in nature as it can be explained by a reciprocal change in the sympathetic tone to the nasal mucosa. Such a reciprocal change has been seen in the Harlequin colour syndrome, (Nelligan and Strang, 1952; Birdsong and Edmunds, 1956), the hemi-hidrotic reflex (Kuno,1956), and the unilateral pressure reflex (Ferres, 1956; 1958). Pressure stimulus on one side of the body has been shown to result in ipsilateral cutaneous vasodilatation and a simultaneous contralateral cutaneous vasoconstriction in the harlequin colour syndrome. In the hemi-hidrotic and unilateral pressure reflexes, ipsilateral inhibition of sweating has also accompanied contralateral increase in sweating when the unilateral pressure has been exerted. Burrow et al (1984) and then Davies and Eccles (1985) have also shown that in a sitting position, axillary pressure may initiate such a reciprocal change.

The blood vessels and sweat glands are innervated by the sympathetic nervous system fibres. Davies and Eccles (1985) proposed that there are sensory receptors in the skin acting as the afferent side of a reflex arc which induces changes in sympathetic activity when pressure is exerted. The possible mechanism by which this operates has been documented (Bamford and Eccles, 1982).

The changes in total nasal resistance were significant only in changing from the supine to the lateral recumbent position and back to the supine position. The increase in total nasal resistance may cause an increase in the work effort required for breathing. An inverse relationship has also been shown to exist between the level of the nasal mucosal congestion and its rate of secretion. Heetderks (1927) and Lillie (1923) demonstrated that there is increased fluid secretion in the decongested mucosa while the congested mucosa has very little secretion. In infants, this may pose a problem if in the lateral recumbent position, the decongested nasal passage secretes more fluid resulting in the blockage of the nasal passage. Since the dependent passage is congested already, bilateral nasal blockage may occur leading to asphyxia as infants are obligatory nasal breathers. It is possible that this could be one of the mechanisms involved in the cot-death syndrome.

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