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The pattern of resting breathing in patients with upper airway obstruction

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The pattern of resting breathing in patients with upper airway obstruction. J. Sanchis, J.L. Díez-Betoret, P. Casan, J. Milic-Emili.
ABSTRACT: The flow-time curve of resting breathing was recorded in 14 patients (aged 36±16 yrs) with mild to moderate symptoms of upper airway obstruction (UawO) and compared to that of 28 matched, healthy controls (HC) in order to characterize the breathing pattern of such patients. The inspiratory time over total time (Ti/Ttot) was higher in the patients (0.42; SD 0.04) than in HC (0.37; SD 0.04) ($p<0.001$), and tidal volume (VT) over Ti was lower in patients (0.37; SD 0.07 $l \cdot s^{-1}$) than in HC (0.43; SD 0.09 $l \cdot s^{-1}$) ($p<0.01$). Inspiratory and expiratory peak flows at rest were also lower in the patients ($p<0.001$). In these, the mean to peak flow ratio of inspiration (0.74; SD 0.07) was higher than in HC (0.66; SD 0.04) ($p<0.0005$). This indicates a more rectangular wave of inspiration in the patients. All of these changes may be due to the increased inspiratory load. However, since the patients were breathing at rest with VT and flows far below their values on the maximal flow volume loop, the changes can also be interpreted as adaptive rather than imposed by absolute mechanical limitations.
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Obstructive lesions of the upper airway, from carina to epiglottis, are classified as fixed or variable according to the dynamics of airflow limitation (AFL) [1]. A fixed lesion produces AFL during inspiration and expiration. When the lesion renders the airway more compliant the obstruction is variable and depends on the effect of changes in pressure on the airway wall. Its location determines the phase of breathing, inspiration or expiration, in which AFL occurs [1]. Variable extrathoracic lesions mainly affect inspiration, whilst variable intrathoracic lesions principally limit expiratory flow.

An obstructive lesion of the upper airway increases turbulent flow, thus markedly raising airway resistance as flow increases in a mechanically intact respiratory system. Upper airway obstruction (UawO) can be characterized by two physiological abnormalities: the inspiratory flows are markedly reduced and the peak expiratory flow (PEF) is disproportionately low relative to the forced expiratory volume in one second (FEV_1) [2]. Attention has therefore been focused on the following ratios: maximum mid-expiratory flow to maximum mid-inspiratory flow (FEF_{50}/FIF_{50}) [3]; forced expired volume in one second to the peak expiratory flow rate (FEV_1/PEF) [4]; FEV_1 to forced expired volume in 0.5 s ($FEV_1/FEV_{0.5}$) [5]; and maximal voluntary ventilation (MVV) to FEV_1 [6, 7].

Apart from these indices, the overall shape of the maximal flow-volume loop (MFVL) is in itself informative as indicated by Miller and Hyatt in 1969 [1, 2]. Extensive study has since been done on the MFVL of patients with UawO. However, little attention has been focused on the pattern of resting breathing in UawO. In the present study, we sought to obtain new information on the breathing strategies these patients use in the face of increases in upper airway flow resistance, by comparing the patients' resting breathing pattern with that of healthy controls.

Patients

The studies were performed on 14 patients (9 women) with extrathoracic UawO as confirmed by direct endoscopy and pulmonary function tests. The patients' anthropometric and clinical data, together with individual values for selected pulmonary function indices of UawO, are presented in table 1. All patients reached at least two of the index values used as criteria for extrathoracic UawO. In addition, the contour of the maximal flow-volume loop in patients with fixed narrowing showed nearly equal degrees of flattening of the inspiratory and expiratory loops, whereas in patients with lesions of variable narrowing the MFVL showed

Table 1. – Characteristics of the patients with upper airway obstruction

Patient No.	Sex	Age yr	Height cm	Cause of UawO	Type of	Grade of	Ventilatory/Function indices**				
					UawO	dyspnoea*	FIF_{50}	FEF_{50}/FIF_{50}	FEV_1/PEF	$FEV_1/FEV_{0.5}$	MVV/FEV_1
1	F	34	157	Glottic stenosis, iatrogenic	Fixed	II	1.06	1.25	11.2	1.65	17.8
2	M	56	165	Supra-glottic carcinoma	Fixed	I	2.01	0.85	8.5	1.80	37.8
3	F	56	150	Left vocal cord paralysis, oedema	Fixed	IV	0.35	1.41	13.1	1.89	24.7
4	M	38	163	Carcinoma of larynx	Variable	I	1.86	1.81	11.8	1.69	13.9
5	M	28	175	Vocal cord paralysis, trauma	Variable	I	3.40	1.56	7.7	1.40	25.0
6	F	41	154	Vocal cord paralysis, goitre	Variable	I	2.69	1.50	8.3	1.36	21.3
7	F	48	149	Tracheal adeno-carcinoma	Fixed	II	1.12	1.17	12.6	2.03	19.4
8	F	17	158	Tracheal stenosis, traumatic	Fixed	I	2.54	1.16	13.6	2.30	15.7
9	M	59	171	Tracheal compression, oesophageal carcinoma	Variable	I	1.56	2.61	9.5	-	15.2
10	F	23	153	Supraglottic carcinoma	Fixed	II	1.49	1.30	14.1	2.00	14.9
11	M	21	171	Hemilaryngectomy, thyroid carcinoma	Variable	II	2.42	1.76	12.1	1.70	16.5
12	F	21	152	Vocal cord paralysis, arytenoidectomy	Variable	III	1.36	1.70	10.1	1.70	12.3
13	F	14	160	Vocal cord paralysis tracheal stenosis	Fixed	II	1.39	1.04	11.7	1.91	12.7
14	F	39	160	Tracheal stenosis, iatrogenic	Fixed	II	1.50	1.30	13.8	2.20	11.6

*: according to MRC Classification [8]; **: from refs [5, 7, 9]; UawO: upper airway obstruction; FIF_{50}: maximum mid-inspiratory flow $l \cdot s^{-1}$; FEF_{50}/FIF_{50}: ratio of maximum mid-expiratory flow to maximum mid-inspiratory flow; FEV_1/PEF: ratio of forced expired volume in one second to peak expiratory flow rate; $FEV_1/FEV_{0.5}$: ratio of FEV_1 to forced expired volume in 0.5 s; MVV/FEV_1: ratio of maximal voluntary ventilation to FEV_1.

mainly a flattening of the inspiratory loop. Patients reported no respiratory symptoms prior to development of their UawO. Only patient No. 5 had been a smoker.

The control group consisted of 28 healthy subjects (19 women), selected solely on the basis of similarity to the patients' ages, heights and weights, and to provide a similar male/female ratio. The mean values of physical characteristics and pulmonary function data of both groups can be seen in table 2. The study was approved by the hospital's Ethics Committee. Informed consent was obtained from patients and healthy volunteers.

Table 2. – Physical characteristics and pulmonary function data

	Controls (n=28)		UawO patients (n=14)
Sex	9M/19F		5M/9F
Age yr	33 (9)		36 (16)
Height cm	162 (6)		160 (9)
Weight kg	57 (8)		61 (13)
FVC l	3.8 (0.7)		3.4 (1.1)
FEV_1 l	3.1 (0.6)	*	2.3 (1.0)
FEV_1/FVC %	82 (7)	*	67 (11)
FRC l	2.8 (0.6)		2.8 (0.7)
TLC l	5.3 (0.9)		5.0 (1.4)
RV/TLC %	27 (3)	*	33 (7)
MVV $l \cdot min^{-1}$	126 (32)	*	43 (20)
RawI hPa·l^{-1}·s	1.8 (0.7)	*	6.6 (5.4)
RawE hPa·l^{-1}·s	1.9 (0.7)	*	7.9 (6.7)
Pao_2 kPa	-		12.1 (1.2)
$Paco_2$ kPa	-		5.2 (0.7)

Values are means with SD in parentheses. *: $p<0.005$; M: male; F: female; FVC: forced vital capacity; FEV_1: forced expiratory volume in one second; FRC: functional residual capacity; TLC: total lung capacity; RV: residual volume; MVV: maximum voluntary ventilation; RawI and RawE: inspiratory and expiratory airway resistance, respectively; Pao_2 and $Paco_2$: arterial oxygen and carbon dioxide tension, respectively; UawO: upper airway obstruction.

Methods

Using standard techniques [10], spirometry and 15s MVV were recorded with a Fleisch No. 3 pneumotachograph (Pulmonary System, Hewlett-Packard HP21072B, Palo Alto, Ca., USA) connected to a pressure transducer, analogue-to-digital converter (HP47310A) and desk-top computer (HP9825A) assembly. Apparatus deadspace was 130 ml. Functional residual capacity (FRC) was measured by helium-dilution (Mark V.P.K. Morgan, UK) and inspiratory and expiratory airway resistance (RawI, RawE) were determined with a body plethysmograph (Fenyves & Gut, Basel, Switzerland). All volumes were adjusted for body temperature, atmospheric pressure and saturation. Samples of arterial blood were drawn, in patients only, by puncture from the radial artery and immediately analysed with a blood gas analyser (ABL 30 Radiometer, Copenhagen, Denmark).

Mouth occlusion pressure ($P_{0.1}$) was measured according to the technique of WHITELAW *et al.* [11] with a silent, hand-operated valve and a pressure transducer (Hewlett-Packard HP270) and amplifier (HP8805C) whose signal was displayed graphically by an X-Y recorder (HP07041A). The result reported for each subject is the mean value of the three best of ten recordings as judged by the technician.

Airflow at rest was measured at the mouth by means of the same equipment used for spirometry and MVV; with the computer suitably programmed to record the flow signal at 50 ms intervals, up to a period of 5 min per sample, at least twice for each subject, and then stored on floppy disks for later analysis. Volume was obtained by electronic integration of the flow signal. The various breathing pattern indices were estimated cycle-by-cycle and then averaged for each 5 min sample in each subject. Because of their smaller variability, mean values of the second sample were used for analysis. Minute ventilation ($\dot{V}E$), breathing frequency (f), tidal volume (VTI, VTE), mean flows (VTI/TI, VTE/TE), peak flows ($\dot{V}$Imax, $\dot{V}$Emax), inspiratory and expiratory times (TI, TE) and duty cycle (TI/Ttot) were measured. If present, Ttot included the end-expiratory pause (eeP), *i.e.* a period with no flow at the end of expiration. Possible differences in the overall shape of the flow-time profile were assessed by measuring the ratio of the mean to peak flow in each phase of breathing ((VTI/TI)/$\dot{V}$Imax and (VTE/TE)/$\dot{V}$Emax, respectively).

A frequency distribution analysis of data was performed by the Kolmogorov-Smirnov test for each variable. The test showed no significant difference from the Gaussian distribution for all variables, with the exception of eeP ($p<0.032$). Therefore, t-test comparisons of variables from UawO patients and healthy controls were carried out. A correlation analysis was performed with variables of the resting breathing and the MFVL in the patients. Statistical significance was accepted at $p<0.05$.

Results

Comparison of physical and pulmonary function data of patients and healthy controls (table 2) showed statistically significant differences for FEV_1, FEV_1 as percentage of forced vital capacity (FEV_1/FVC), residual volume as percentage of total lung capacity (RV/TLC), MVV, RawI and RawE. Thus, as a group, patients had a significant degree of AFL during forced expiration and inspiration. In the absence of previous lung disease, all these abnormalities of lung function can be attributed solely to UawO.

The means of the resting breathing pattern variables together with $P_{0.1}$ of patients and controls are shown in table 3. $P_{0.1}$ was significantly higher in the UawO patients. In contrast, their mean inspiratory flow was significantly lower due to lower VT and longer TI. This was associated with a significantly higher TI/Ttot and a shorter end-expiratory pause in the UawO patients. In fact, an eeP >0.2 s was present in only two of the 14 UawO patients, whilst in the control group it was observed in seven of the 28 healthy volunteers. The (VT/TI)/V̇Imax and (VT/TE)/V̇Emax ratios were significantly higher in the UawO patients. This reflects the more rectangular shape of the patients' inspiratory and expiratory flow-time profiles as graphically illustrated by the comparison of the flow-time curve of two representative cases: a UawO patient and a healthy control (fig. 1).

Table 3. – Resting breathing pattern

	Controls		UawO patients
$P_{0.1}$ kPa	1.2 (0.5)	*	2.2 (1.4)
V̇E $l \cdot min^{-1}$	8.91 (1.7)		8.81 (1.6)
VT l	0.62 (0.10)		0.57 (0.12)
f min^{-1}	14.8 (3.2)		15.8 (3.8)
TI s	1.61 (0.40)		1.70 (0.39)
TE s	2.65 (0.63)		2.37 (0.65)
TI/Ttot	0.37 (0.04)	+	0.42 (0.04)
eeP s	0.26 (0.26)	+	0.05 (0.10)
VTI/TI $l \cdot s^{-1}$	0.43 (0.09)	*	0.37 (0.07)
V̇Imax $l \cdot s^{-1}$	0.66 (0.12)	++	0.50 (0.09)
VTE/TE $l \cdot s^{-1}$	0.27 (0.06)		0.26 (0.06)
V̇Emax $l \cdot s^{-1}$	0.48 (0.12)	+	0.37 (0.08)
VTI/TI)/V̇Imax	0.66 (0.04)	++	0.74 (0.07)
VTE/TE)/V̇Emax	0.56 (0.06)	++	0.69 (0.07)

Values are means with SD in parentheses. *: $p<0.01$; +: $p<0.001$; ++: $p<0.0005$; $P_{0.1}$: mouth occlusion pressure; V̇E: minute ventilation; VT: tidal volume; f: breathing frequency; TI: inspiratory time; TE: expiratory time; TI/Ttot: duty cycle; eeP: end-expiratory pause; VTI/TI and VTE/TE: mean flows; V̇Imax and V̇Emax: peak flows; (VTI/TI)/V̇Imax and (VTE/TE)/V̇Emax: ratio of mean to peak inspiratory and expiratory flow, respectively; UawO: upper airway obstruction.

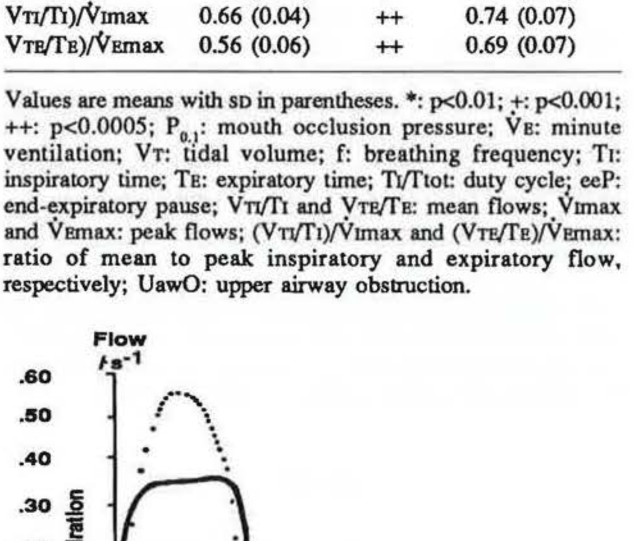

Fig. 1. – Mean flow/time curve (re-drawn) of a patient with UawO (continuous trace) superimposed on that of a control (dotted line), to stress differences in flow and shape. ············ : healthy control; ——— : upper airway obstruction.

The correlation analyses showed significant degrees of association between TI/Ttot and RawI (r=0.66) and RawE (r=0.61) in the UawO patients. In the analyses of variables of resting breathing and those of the MFVL, only the correlation between resting (VT/TE)/V̇Emax and FIF_{50} (r=0.70) was significant. The following correlations between resting breathing pattern variables were found to be significant: VT/TI and V̇Imax (r=0.87); VT/TI and V̇Emax (r=-0.74); V̇Imax and V̇Emax (r=-0.69); and, finally, (VT/TI)/V̇Imax and (VT/TE)/V̇Emax (r=0.84).

Discussion

The UawO patients of the present study exhibited the characteristic abnormalities in lung function previously reported (tables 1 and 2). Both inspiratory and expiratory Raw were significantly increased. Arterial oxygen tension (Po_2) and carbon dioxide tension (Pco_2) were within normal limits, except in patient No. 3 in whom Po_2 was 9.4 kPa (71 mmHg), less than predicted, and Pco_2 was 6.4 kPa (48 mmHg). Judging from the dyspnoea reported by our patients and from their pulmonary function data, we can say that different degrees of obstruction were present in the group although there was a predominance of mild cases.

The use of noseclip, mouthpiece and a sizeable deadspace may increase V̇E, VT, TI and VT/TI, and decrease f, inducing a more regular breathing pattern [12, 13]. However, a direct recording of airflow is necessary when the objective is to analyse the flow-time profile of breathing. On the other hand, inductive plethysmography does not provide sufficiently accurate data on peak flow and is not devoid of some substantial sources of error [14, 15]. Nevertheless, any possible artefacts of breathing due to the system used for recording of flow at the mouth are not likely to explain the differences in breathing pattern observed in the present study. Our UawO patients showed a breathing pattern different from normal in that VT/TI and V̇Imax were significantly lower while TI/Ttot was significantly higher. The (VT/TI)/V̇Imax and (VT/TE)/V̇Emax ratios were also significantly higher, whereas the end-expiratory pause was practically nil. The low VT/TI was related to the increased inspiratory load caused by the increased inspiratory flow resistance (0.66 $kPa \cdot l^{-1} \cdot s$ in our patients), which was only partly compensated for by the increase in neuromuscular inspiratory drive as reflected in a significant increase in $P_{0.1}$ (table 3). The concomitant increase of TI/Ttot compensated for the decrease in VT/TI to such an extent that minute ventilation was essentially the same in the UawO patients as in the normal controls. This increase in TI/Ttot was mainly due to an increase in TI, which might be attributable to the longer mechanical time constant of the respiratory system resulting from the increased flow resistance [16]. In fact, TI/Ttot was the only variable showing a significant correlation (r=0.66, $p<0.01$) with plethysmographic airway resistance. The finding of a similar VT/TE in patients and HC can probably be explained in part by the shorter duration of the patients' end-expiratory pause, *i.e.* an increased expiratory flow resistance will reduce the rate of lung emptying but V_T/T_E will remain unchanged, provided that the duration of expiration is sufficiently long [17]. A reduction in post-inspiratory activity of the inspiratory muscles and/or recruitment of expiratory muscle activity may also play a role in maintaining a fixed V_T/T_E in the face of increased flow resistance [17].

Since $\dot{V}_I$max and $\dot{V}_E$max were significantly lower in patients, both flow ratios, $(V_T/T_I)/\dot{V}_I$max and $(V_T/T_E)/\dot{V}_E$max, were found to be higher in UawO ($p<0.0005$) (table 3) and this finding indicates that the shape of the pneumotachogram will be more "rectangular" (fig. 1). Empirically, we can say that for constant flow (*i.e.* rectangular shape of the pneumotachogram) the value of these ratios should be 1. For a sinusoidal shape the ratios should be 0.64, and for a triangular pattern, 0.50. The rectangular shape provides more volume of air for similar phase time and peak flow. Therefore, the differences in shape of the flow-time profile of our patients with respect to the controls may, again, be interpreted as an adaptation to maintain $\dot{V}_E$.

Thus far, the changes of resting breathing in our patients have been attributed directly to the increased inspiratory load. An alternative explanation, however, is suggested by the paucity of correlation between variables of resting breathing and MFVL, which implies that the two flow recordings convey independent information. The flow limitation observed in the MFVL was not evident in resting breathing. For example, on average, V_T was 18% of FVC and $\dot{V}_I$max reached only 28% of its value in the MFVL. Thus, one can speculate that changes in the resting pattern may represent an adaptive central response to minimize the increased turbulent flow characteristic of UawO.

The finding of a high T_I/Ttot is unusual in respiratory disease. BELLEMARE and GRASSINO [18] pointed out that an increase in T_I/Ttot brings the inspiratory muscles closer to their fatigue threshold. Thus, together with the low V_T/T_I, a high T_I/Ttot could be regarded as disadvantageous in the event of concurrent respiratory disease in UawO patients.

Information about changes in the resting breathing pattern due to long-standing increased flow resistance comes almost exclusively from observation of patients with chronic obstructive pulmonary disease (COPD) [19–22]. At rest, such patients tend to breathe with a significantly higher $\dot{V}_E$ than healthy people. Patients attain this mainly by increasing f, thus shortening both T_I and T_E, whilst leaving T_I/Ttot unchanged [19, 21]. V_T has been found to be either normal or slightly higher [19, 20], whereas V_T/T_I has consistently been found to be high in COPD patients. Thus, it appears that in COPD patients $\dot{V}_E$, f, T_I/Ttot and V_T/T_I differ entirely from what we have observed in patients with UawO.

ZECHMAN *et al.* [23] studied the breathing pattern of healthy subjects breathing through resistance of increasing magnitude applied to inspiration, expiration or both. With inspiratory resistance there was a reduction of inspiratory flow and f, a notable increase of T_I and T_I/Ttot (from about 0.45 to 0.54, as one can estimate from figure 2 in their paper), a more rectangular inspiration and almost no change in expiration. The resistance applied to the whole respiratory cycle altered both phases in terms of flow magnitude and profile, induced a marked reduction of f and decreased T_I/Ttot. With expiratory resistance the subjects increased their inspiratory flows and f and decreased T_I/Ttot. Inspiration tended to be more triangular and expiration more rectangular. While these changes are similar to those exhibited by patients with COPD, most of the characteristics exhibted by our UawO patients seem to fit better into the two previous situations: resistance applied to inspiration or to the whole respiratory cycle.

In summary, we conclude that increased airflow resistance in the extrathoracic airway induces abnormalities in the pattern of resting breathing, and that these abnormalities seem to be different from those of patients with generalized lung disease.

References

1. Miller RD, Hyatt RE. – Obstructing lesions of the larynx and trachea: clinical and physiologic characteristics. *Mayo Clin Proc*, 1969, 44, 145–161.

2. Miller RD, Hyatt RE. – Evaluation of obstructing lesions of the trachea and larynx by flow-volume loops. *Am Rev Respir Dis*, 1973, 108, 475–481.

3. Jordanoglou J, Pride NB. – A comparison of maximum inspiratory and expiratory flow in health and in lung disease. *Thorax*, 1968, 23, 38–45.

4. Empey DW. – Assessment of upper airway obstruction. *Br Med J*, 1972, 3, 503–505.

5. Rotman HH, Liss HP, Weg JG. – Diagnosis of upper airway obstruction by pulmonary function testing. *Chest*, 1975, 68, 796–799.

6. Engström H, Grimby G. Söderholm B. – Dynamic spirometry in patients with tracheal stenosis. *Acta Med Scand*, 1964, 176, 329–334.

7. Owens GR, Murphy DMF. – Spirometric diagnosis of upper airway obstruction. *Arch Intern Med*, 1983, 143, 1331–1334.

8. Medical Reseach Council's Committee on the Aetiology of Chronic Bronchitis. – Standardized questionnaires on respiratory symptoms. *Br Med J*, 1960, 2, 1665.

9. Vincken W. – Value of spirometric indices of upper airway obstruction (UAO). *Bull Eur Physiopathol Respir*, 1987, 23 (Suppl. 12), 382S (abstract).

10. Quanjer PH. – Standardized lung function testing. Report of Working Party, "Standardization of Lung Function Tests". European Community for Coal and Steel. *Bull Eur Physiopathol Respir*, 1983, 19 (Suppl. 5), 11–38.

11. Whitelaw WA, Derenne JP, Milic-Emili J. – Occlusion pressure as a measure of respiratory center output in conscious man. *Respir Physiol*, 1975, 23, 181–199.

12. Gilbert RJ, Auchincloss JH, Brodsky J, Boden W. – Changes in tidal volume, frequency, and ventilation induced by their measurement. *J Appl Physiol*, 1972, 33, 252–254.

13. Askanazi J, Silverberg PA, Foster RJ, Hyman AI, Milic-Emili J, Kinney JM. – Effects of respiratory apparatus on breathing pattern. *J Appl Physiol: Respirat Environ Exercise Physiol*, 1980, 48, 577–580.

14. Guyatt R, McBride MJ, Meanock CI. – Evaluation of the respiratory inductive plethysmograph in man. *Eur J Respir Dis*, 1983, 64, 81–89.

15. Hudgel DW, Capehart M, Johnson B, Robertson D. – Accuracy of tidal volume, and flow measurements by inductance vest in COPD patients. *J Appl Physiol: Respirat Environ Exercise Physiol*, 1984, 56, 1659–1665.

16. Miserocchi G, Milic-Emili J. – Effect of mechanical factors on the relation between rate and depth of breathing in cats. *J Appl Physiol*, 1976, 41, 277–284.

17. Milic-Emili J, Zin WA. – Relationship between neuromuscular respiratory drive and ventilatory output. *In:* Handbook of Physiology, Sec. 3, The Respiratory System, Vol. III, part 2, Chp. 35. P.T. Macklem, J. Mead eds, American Physiological Society, Bethesda, 1986, pp. 631–646.

18. Bellemare F, Grassino A. – Effect of pressure and timing of contraction on human diaphragm fatigue. *J Appl Physiol: Respirat Environ Exercise Physiol*, 1982, 53, 1190–1195.

19. Sorli J, Grassino A, Lorange G, Milic-Emili J. – Control of breathing in patients with chronic obstructive lung disease. *Clin Sci Mol Med*, 1978, 54, 295–304.

20. Tobin MJ, Chadha TS, Jenouri G, Birch SJ, Gazeroglu HB, Sackner MA. – Breathing patterns. 2. Diseased subjects. *Chest*, 1983, 84, 286–294.

21. Loveridge B, West P, Anthonisen NR, Kryger MH. – Breathing patterns in patients with chronic obstructive pulmonary disease. *Am Rev Respir Dis*, 1984, 130, 730–733.

22. Loveridge B, West P, Kryger MH, Anthonisen NR. – Alteration in breathing pattern with progression of chronic obstructive pulmonary disease. *Am Rev Respir Dis*, 1986, 134, 930–934.

23. Zechman F, Hall FG, Hull WE. – Effects of graded resistance to tracheal airflow in man. *J Appl Physiol*, 1957, 10, 356–362.

Le type de respiration au repos chez les patients atteints d'obstuction des voies aériennes supérieures. J. Sanchis, J.L. Díez-Betoret, P. Casan, J. Milic-Emili.

RÉSUMÉ: Nous avons enregistré les courbes débit/temps pendant la respiration au repos chez 14 patients (âge 36±16 ans) avec des symptômes légers à modérés d'obstruction des voies aériennes supérieures (UaWO), et les avons comparées à celles de 28 sujets contrôle bien portants (HC) afin de caractériser le type respiratoire de ces patients. Le rapport temps inspiratoire/temps total (T_I/T_{tot}) est plus élevé chez les patients (0.42 SD 0.04) que chez les contrôles sains (0.37 SD 0.04) ($p<0.001$); le rapport volume courant (V_T) sur T_I est plus bas chez les patients (0.37 SD 0.07 $l\cdot s^{-1}$) que chez les contrôles (0.43 SD 0.09 $l\cdot s^{-1}$) ($p<0.01$). Les débits de pointe inspiratoires et expiratoires au repos s'avèrent également abaissés chez les patients ($p<0.001$). Chez ceux-ci, le rapport du débit moyen sur le débit de pointe à l'inspiration (0.74 SD 0.07) est plus élevé que chez les sujets normaux (0.66 SD 0.04) ($p<0.0005$). Ceci indique une vague plus rectangulaire d'inspiration chez les patients. Toutes ces modifications pourraient être dues à une augmentation de la charge inspiratoire. Toutefois, puisque les patients respiraient au repos avec des valeurs de V_T et de débit bien inférieures à leurs valeurs sur la boucle débit-volume maximal, les modifications peuvent également être interprétées comme étant une adaptation plutôt qu'une conséquence imposée des limitations mécaniques absolues.

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