Thorax 1989;**44**:419–421

How many manoeuvres should be done to measure maximal inspiratory mouth pressure in patients with chronic airflow obstruction?

J A FIZ, J M MONTSERRAT, C PICADO, V PLAZA, A AGUSTI-VIDAL

From the Servei de Pneumologia, Hospital Clinic, Barcelona, Spain

ABSTRACT To determine the number of maximal mouth pressure manoeuvres needed to obtain a reproducible value of maximal inspiratory mouth pressure (MIP), we studied 44 patients with chronic airflow obstruction, with a mean (SD) % predicted FEV_1 value of 53·9 (25), who were clinically stable. Maximal inspiratory mouth pressure was determined with an anaeroid manometer during maximal inspiratory efforts in a quasi static condition at residual volume. All patients performed 20 consecutive maximal inspiratory mouth manoeuvres, each one separated by 30–40 seconds. The mean (SD) values of MIP varied from 71·5 (25·5) cm H_2O at the first measurement to 80·1 (27) cm H_2O at the last measurement. Maximal values of MIP were usually achieved after nine determinations. It is concluded that to obtain a reproducible MIP value in patients with chronic airflow obstruction who are untrained and unexperienced in such manoeuvres a minimum of nine technically acceptable maximal mouth pressure manoeuvres should be performed.

Introduction

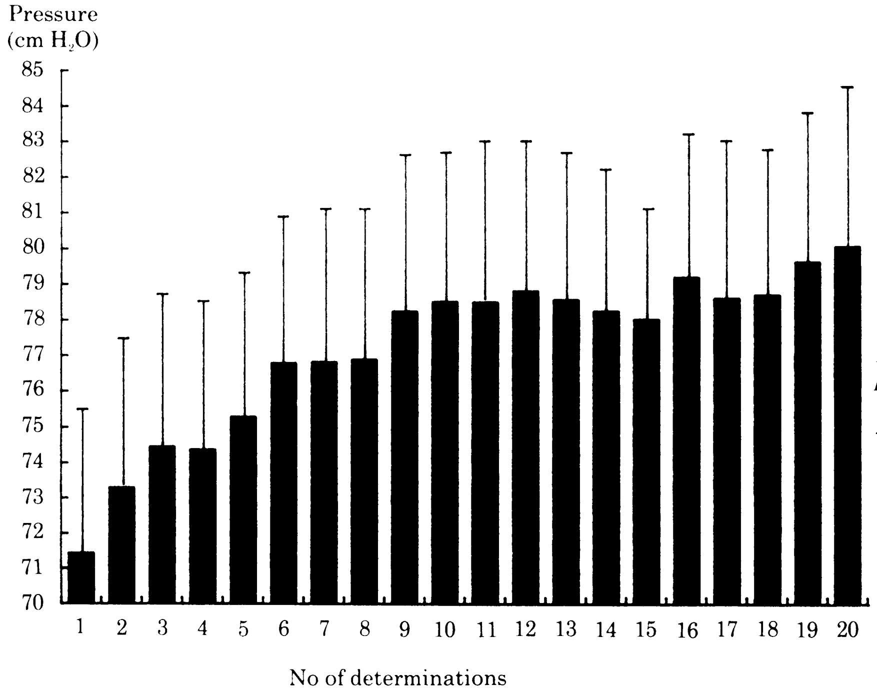
The measurement of maximal inspiratory pressure generated at the mouth (MIP) is an accepted non-invasive clinical method for evaluating the strength of respiratory muscles. There is, however, wide variation in reference normal values,[1–5] probably in part due to a learning effect. In a previous study we evaluated the learning effect in 10 healthy people and found that the mean (SEM) for MIP increased from 138 (7·8) to 158 (4·90) cm H_2O when repetitive studies of muscular strength are carried out three times, one day a week, for six consecutive weeks.[6] Although MIP measurement has gained an established place in the management of patients with chronic airflow obstruction,[7,8] it is not clear how many manoeuvres should be carried out to achieve a maximal MIP. We have analysed 20 consecutive MIP measurements in 44 patients with chronic airflow obstruction to determine the minimal number of MIP manoeuvres necessary to obtain a maximal value for MIP.

Address for reprint requests: Dr J M Montserrat, Canal Servei de Pneumologia, Hospital Clinic, C/Villarroel 170, Barcelona 08036, Spain.

Accepted 10 February 1989

Methods

We studied 44 patients with chronic airflow obstruction (34 male and 10 female) attending our chest clinic. The mean (SD) age was 55·5 (11·3) years. The patients selected had clinical and functional evidence of chronic airflow limitation and were clinically stable at the time of the study. The spirometric values (mean (SD), expressed as percentages of the normal values[9]) were: FEV_1 53·9 (25), forced vital capacity (FVC) 66·5 (17) and FEV_1/FVC ratio 50·6 (15). None had been trained or had carried out maximal mouth pressure manoeuvres before. Patients with coexisting diseases were excluded. Maximal inspiratory mouth pressure was obtained with an anaeroid manometer (inspiratory force meter, model 4101, Boehringer Laboratories, Wynnewood, Pennsylvania) during maximal inspiratory efforts in a quasi static condition at residual volume (RV). The manometer range was ± 150 cm H_2O with an accuracy $\pm 3\%$. It was calibrated against a water column system every two weeks during the study and was linear from -10 to at least 80 cm H_2O. All determinations were performed by the same physician (JAF). Each patient received exactly the same instructions. The patients inspired through a mouthpiece with a small leak (1·5 mm diameter) to prevent the use of buccinator muscles. If close inspection showed air leakage around the lips



Maximal inspiratory pressure measurements (means with SEM) for the 20 manoeuvres.

this manoeuvre was rejected. All patients performed 20 consecutive maximal inspiratory mouth manoeuvres, separated by 30–40 seconds.

Results are expressed as means with SD or SEM in parentheses. Two way analysis of variance and Scheffe's test[10] were used to compare results.

Results

The mean (SEM) MIP values obtained in the 20 manoeuvres are shown in the figure. The mean (SD) values of MIP varied from 71·5 (25) cm H_2O at the first determination to 80·1 (27) cm H_2O at the last measurement. Maximal values of MIP were usually achieved at the ninth or tenth determination. There were significant intrasubject differences (two way analysis of variance, $F = 2{\cdot}99$, $p < 0{\cdot}05$) and significant differences between the highest value (the 20th determination) and the first eight determinations (Scheffe's test). The difference between the ninth and the twentieth determinations were not significant.

Discussion

The need to quantify the performance of the respiratory muscles has been highlighted by recent studies on muscle fatigue and muscle training.[11-13] There is general agreement that for clinical purposes MIP is the measure of choice of muscle strength.[2] Although some data are available on normal maximal inspiratory pressure, especially at residual volume (RV),[1-5] little work has been done on the effect of learning on MIP determinations. We measured MIP at RV, following the recommendations of several authors.[14] Our results show that a minimum of nine technically acceptable manoeuvres of maximal mouth pressure manoeuvres are necessary to obtain a reproducible MIP in untrained and unexperienced patients with chronic airflow obstruction. Our conclusions differ from those of Black *et al*,[1] who studied normal values of MIP in 120 patients. They tested the effect of learning in only six individuals over three consecutive days and found no significant differences between the mean values on the first day and on the second and third days. The highest value for MIP on the third day was less than 10% greater than the value on the first day in three subjects and was unchanged or lower in the other three subjects. Black *et al* concluded that the short term learning effect is slight. The limited number of subjects and manoeuvres used to analyse the learning effect may explain the discrepancy between these results and ours. Ringquist *et al*[4] studied normal values of MIP using 10 or more measurements of MIP, and reported higher maximal pressures than Black *et al* and Leech *et al*,[5] who used only two and three measurements respectively to determine their normal values. This suggests that the learning effect is important if maximal and reproducible MIP measurements are to be obtained. We had no serious problems in carrying out repeated measurements of MIP, and only two patients were unable to perform the 20 manoeuvres, though some patients were exhausted at the end of the 20. Nine manoeuvres, however, were well tolerated by almost all the patients.

References

1 Black LF, Hyatt RE. Maximal inspiratory pressures: normal values and relationship to age and sex. *Am Rev Respir Dis* 1969;**99**:696–702.

2 Smyth RJ, Chapman KR, Rebuck A. Maximal inspiratory and expiratory pressures in adolescents. Normal values. *Chest* 1984;**86**:568–72.

3 Gaultier C, Zinman R. Maximal static pressures in healthy children. *Respir Physiol* 1983;**51**:46–61.

4 Ringqvist T. The ventilatory capacity in healthy subjects: an analysis of causal factors with special reference to the respiratory forces. *Scand J Clin Invest* 1966;**18** (suppl):87–93.

5 Leech JA, Ghezzo H, Stevens D, Becklake MR. Respiratory pressures and function in young adults. *Am Rev Respir Dis* 1983;**128**:17–23.

6 Fiz JA, Montserrat JM, Picado C, Agusti-Vidal A. Presion inspiratoria maxima estatica (PIM). Relaciones entre las presiones pico-meseta y efecto aprendizaje. *Archivos Bronconeumologia* 1987;**23**: 253–5.

7 Rochester DF, Arora NS. Determinants of maximal inspiratory pressure in chronic obstructive pulmonary disease. *Am Rev Respir Dis* 1985;**132**:42–7.

8 Rochester DF, Arora NS, Braun NMT, Goldberg SK. The respiratory muscles in chronic obstructive pulmonary disease (COPD). *Bull Eur Physiopathol Respir* 1979;**15**:951–75.

9 Roca J, Sanchis J, Agusti-Vidal A, Segarra F, Navajas D, Rodriguez R, Casan P, Sans S. Spirometric reference values from a Mediterranean population. *Bull Eur Physiopathol Respir* 1986;**22**:217–24.

10 Godfrey K. Comparing the means of several groups. *N Engl J Med* 1985;**313**:1450–6.

11 Rochester DR, Braun NMT, Laine S. Diaphragmatic energy expenditure in chronic respiratory failure: the effect of assisted ventilation with body respirators. *Am J Med* 1977;**63**:223–32.

12 Edwards RHT. The diaphrag as muscle: mechanisms underlying fatigue. *Am Rev Respir Dis* 1979;**119** (suppl):81–4.

13 Belman MJ, Sieck GC. The ventilatory muscles. Fatigue, endurance and training. *Chest* 1982;**82**:761–6.

14 Clausen JL. Maximal inspiratory and expiratory pressures. In: JJ Clausen, ed. *Pulmonary function testing: guidelines and controversies*. New York: Academic Press, 1982:187–91.