Original Article

Maximal respiratory pressures and vital capacity: comparison between mouthpiece and face-mask evaluation methods*

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Background: Measurement of maximal respiratory pressures and vital capacity are essential in evaluating respiratory function. However, methodological variations may interfere with the interpretation of results.

Objective: To compare values obtained using mouthpiece and face-mask evaluation methods in the measurement of maximal respiratory pressures and vital capacity.

Method: We studied 30 patients (16 male), with a mean age of 55.9 ± 15.7, in the preoperative phase of abdominal surgery. Maximal inspiratory pressure and maximal expiratory pressure, as well as vital capacity, were evaluated using either a rigid flanged mouthpiece or a face mask, in randomized order.

Results: Evaluation with a face mask did not significantly alter vital capacity and maximal inspiratory pressure values, although maximal expiratory pressure values were significantly lower than when measured using a rigid mouthpiece. During measurement of maximal expiratory pressure, air leakage from around the mask was observed in 60% of cases. When maximal expiratory pressure measurements in which there was no such leakage were considered in isolation, face-mask values were higher than those obtained with the moutpiece

Conclusion: With a face mask, maximal inspiratory pressure and vital capacity can be accurately evaluated. Maximal expiratory pressure can also be adequately evaluated using a face mask, provided that air leakage from the mask edges can be avoided. However, such leakage and the consequent reduction in the values obtained are common and limit the use of this method of evaluation.

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Key words: Respiratory function tests. Maximal voluntary ventilation. Respiratory muscles.

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INTRODUCTION

The monitoring of the pulmonary function is used to determine the degree, the functional consequences and the progress of various pulmonary and neuromuscular dysfunctions. Evaluation of maximal respiratory pressures (MRPs) and vital capacity (VC) are frequently used for such monitoring[1]. The evaluation of MRP consists of the measurement of the maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) generated in the mouth. Since it is a static maneuver and involves airway occlusion, the evaluated mouth pressure reflects the pressure generated in the alveoli by the action of respiratory muscles[2-5]. Values of MIP and MEP are extensively used in the diagnosis of respiratory muscle weakness in patients with neuromuscular diseases[6,7] or pulmonary diseases[8], and is even used as a predictor of success in the discontinuation of mechanical ventilation[9]. The definition of VC is the maximum volume of expired air from the moment of maximum inspiration[10]. Reduced VC is an abnormality that is highly evident in patients with respiratory muscle weakness[11] or alterations in pulmonary mechanics that overload these muscles[1].

Although the importance of evaluating MRPs and VC has been well established in the literature, methodological variations and the degree of patient cooperation might interfere in the performance of the maneuver and affect measurements[2,7,12,13]. For both parameters, a rigid flanged mouthpiece, placed between the lips of the patient, is generally used, and the evaluation begins after the mouthpiece has been properly positioned and the pulmonary volume from the beginning of the maneuver has been established[2,12]. Air leakage around the mouthpiece is a problem that has been encountered in some studies[7,14,15], especially when evaluating patients with neuromuscular diseases or dental alterations that affect lip occlusion. even in the evaluation of healthy individuals, air leaks can occur during the maneuver used to obtain MEP values. This is due to the high level of positive pressure to which the oral cavity is submitted[13,14].

Face masks may be an alternative way of coupling the device used in the measurement of MRPs and VC to the patient evaluated. The use of a face mask may reduce the risk of air leaks during the evaluation. However, it is necessary to determine whether this is a methodologically applicable resource and if there is any difference between data obtained with this method and those obtained using the conventional method. Therefore, the objective of this study was to compare MRP and VC values obtained by oral and face-mask methods.

METHODS

We studied 30 patients, 16 of whom were male. Mean age was 55.9 (± 15.7). All subjects were hospitalized in the *Enfermaria de Gastrocirurgia* (Gastrointestinal Surgery Ward) of the *Hospital São Paulo* between April and December of 2002. The ethics committee of the institution approved the study protocol.

All the evaluated patients were in the preoperative phase and presented no symptoms of current or previous cardiorespiratory or neuromuscular disease.

Patients were submitted to measurement of MRPs and VC using oral and face-mask methods. For evaluation with the oral method, we used a rigid flanged mouthpiece (Figure 1), placed between the lips of the patient, who was asked to use his or her lips to form a seal around the mouthpiece in order to avoid air leaks. A nose clip was used to avoid nasal air leakage. For face-mask evaluation, we used a plastic face mask with an inflatable pneumatic border (Adult-5; Vital Signs, Inc., Totowa, NJ, USA), designed for noninvasive ventilation (Figure 2). Both the order of the application of the mouthpiece or face mask and the sequence of the evaluation of VC, MIP and MEP were randomized. Intervals of approximately one minute between each maneuver were established. All measurements were made by the same evaluator.

For evaluation of MRPs, we used an MTR analog manometer with a ± 300 cmH_2O operational interval. Both the mouthpiece and the mask used for the evaluation featured a small orifice with a diameter of 1 mm to 2 mm in the portion distal to the patient, with the objective of preventing the pressure generated by facial muscles to influence measurements. The MIP and MEP were determined by efforts initiated from the functional residual capacity, when patients were instructed to give maximum inspiration and maximum expiration, respectively. The evaluator provided verbal incentive to the patient during the maneuver in

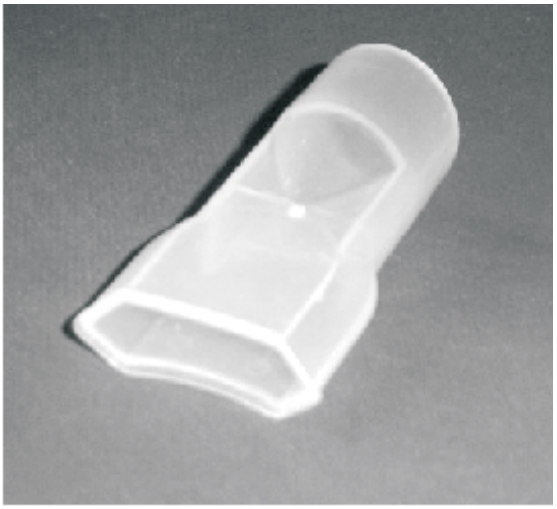

Figure 1 – Rigid flanged mouthpiece

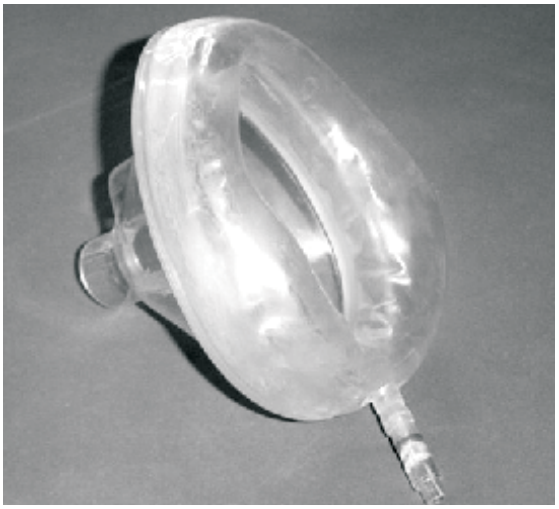

Figure 2 – Plastic face mask with an inflatable silicon border

order to attain maximum effort. We considered maximal pressures that were maintained for at least one second. Measurements were taken a maximum of six times, until three values with a variation of less than 5% were obtained. Only the highest values were considered in the analysis.

Patient VC was measured with a model 121 Ohmeda Respirometer (Ohmeda, Boulder, CO, USA), connected to the rigid plastic mouthpiece or to the face mask, determined from one inspiration to total lung capacity, followed by expiration until residual volume. Measurements were taken a maximum of six times, until three values with a variation of less than 5% were obtained. Only the highest values were considered in the analysis.

The statistical analysis of data was performed using the paired Student's *t*-test, comparing the values of MIP, MEP and VC obtained through the face mask to those obtained using the mouthpiece. Values of 0.05 or 5% were considered statistically significant.

RESULTS

The mean values of MEP, MEP and VC obtained through the evaluation with face masks and mouthpieces are described in Table 1. Values of MEP were significantly lower when evaluated with the face mask ($p < 0.01$). The means of measurement (face mask or mouthpiece) was found to have no influence on MIP or VC data ($p > 0.05$).

In 60% of the patients evaluated, we observed air leakage around the face mask during MEP measurement. Air leaks occurred principally in the region near the base of the nose, persisting even after the mask had been properly fitted to the face of the patient. During the evaluation of the other variables – MEP with the mouthpiece, MIP and VC with the face mask and with the mouthpiece – we observed no air leaks.

If we consider only the evaluated measurements of MEP in which there was no air escape, the statistic analysis shows that the values obtained with the use of the face mask were significantly higher than those obtained with the mouthpiece ($p < 0.05$).

DISCUSSION

In the last few years, great efforts have been made to standardize methods of evaluating pulmonary function[16,17]. Methodological variations prejudice the reproducibility of the evaluations[13,17]. However, alternative methods are required when the patients evaluated are incapable of performing the necessary maneuvers in the manner established in the literature.

According to Fiz et al.[7], many resources used for respiratory evaluation cannot be used in patients

with facial paralysis since air leakage from around the mouthpiece makes it impossible to evaluate the functional state of the lungs and the respiratory musculature of these patients. This problem extends to patients having difficulty in pursing their lips, especially elderly patients and those with dental alterations or missing teeth.

Data obtained in the present study show that there is no significant difference between face-mask and mouthpiece evaluation in terms of the values of MIP and VC obtained. Therefore, in these cases, the face mask can be used as the means of coupling the measurement device to the patient. The use of the face mask makes measurement of MIP and VC accessible to patients that normally present serious difficulties in performing the necessary maneuvers. Lip pursing is unnecessary when the evaluation is performed with the mask, thereby allowing these variables to be evaluated without any air leakage.

TABLE 1
Vital capacity, maximal inspiratory pressure, maximal expiratory pressure, and air leakage during face-mask evaluation of maximal expiratory pressure

Patient	VC face mask (L)	VC oral (L)	MIP face mask (cmH2O)	MIP oral (cmH2O)	MEP face mask (cmH2O)	MEP oral (cmH2O)	Air leakage during MEP evaluation with a face mask
1	1.25	1.25	-30	-40	20	40	yes
2	1.55	1.55	-70	-60	75	75	no
3	3	3.75	-25	-35	55	50	no
4	2.75	3.1	-65	-75	90	130	yes
5	2.8	2.5	-65	-75	90	130	yes
6	1.4	1.5	-60	-25	65	65	no
7	1.4	1.1	-75	-30	25	50	yes
8	2.05	2.56	-75	-90	30	120	yes
9	1.5	1.8	-75	-50	70	100	yes
10	1.2	1.35	-70	-40	50	60	yes
11	1.3	1.34	-25	-50	30	70	yes
12	2.5	2.1	-100	-90	50	75	yes
13	1.85	1.4	-40	-40	50	50	no
14	3.1	3.35	-90	-110	100	100	no
15	1.97	1.97	-40	-30	40	40	no
16	1.87	2.8	-45	-25	20	30	yes
17	2.11	2.14	-125	-80	55	80	yes
18	3.07	3.47	-60	-50	80	65	no
19	2.07	5.92	-25	-35	60	60	no
20	2.9	3.18	-75	-70	55	75	yes
21	2.77	2.92	-60	-75	25	50	yes
22	3.5	2.8	-65	-95	65	50	no
23	2.5	3.05	-30	-30	30	50	yes
24	4.73	3.07	-130	-125	150	125	no
25	2.4	1.9	-30	-20	30	55	yes
26	3.7	3.75	-75	-75	55	60	yes
27	3	2.75	-80	-75	65	55	no
28	2.75	2.7	-40	-25	40	80	yes
29	4	3.75	-55	-60	75	75	no
30	3.26	2.9	-75	-75	65	75	yes
Mean	2.47	2.59	-62.5	-58.5	57	71.3*	
SD	± 0.88	± 1.02	± 27.09	± 27.7	± 27.99	± 27.16	

VC: vital capacity; MIP: maximal inspiratory pressure; MEP: maximal expiratory; SD: standard deviation
*$p < 0.01$

The evaluation of MEP proved to be significantly influenced by the use of the face mask. Air leakage around the mask, present in 60% of patients, was the main inconvenience found during the evaluation and was responsible for the low values found.

Air leakage from around noninvasive ventilation masks, such as the ones used in our study, was the focus of a study conducted by Schettino et al.[18]. The authors used noninvasive ventilation in a mechanical lung model and determined that the air leakage was caused especially when the inner part of the mask was submitted to pressure levels higher than 15 cmH_2O. In our study, the expiratory effort of the patients evaluated generated a mean positive pressure of 70 cmH_2O in the inner part of the mask (above the pressure threshold), and this level was maintained without leakage. During the evaluation of VC, which requires expiratory effort without generating high levels of pressure, and MIP, which requires inspiratory effort with the generation of negative pressure, we observed no leaks. The absence of air leaks during the evaluation of MEP in some patients may be attributable to facial anatomy that is more favorable to the fitting of the mask.

When it was possible to evaluate MEP with a mask and without air leakage, the values obtained with the use of the mask were significantly higher than those obtained with the mouthpiece. In order to explain this result, which is undoubtedly surprising, we have to refer to the type of mouthpiece used in the study. According to Koulouris et al.[13] and Cook et al.[14], discrete air leakage around the flanged mouthpiece is common during the evaluation of MEP, even when healthy patients able to generate apparently adequate lip pressure are evaluated. Therefore, air leakage is a possible explanation for the lower levels obtained during the evaluation of MEP with the use of a mouthpiece. When it was possible to evaluate MEP with the mask and without any air leakage, the absence of any air leaks probably allowed higher values to be reached. It is important to note that air leakage around the mouthpiece is generally imperceptible, in contrast to that occurring with the use of the mask, which makes a characteristic sound when the air passes through the interface between the skin and the silicon border. The use of the face mask has proven to be more satisfactory than the use of the mouthpiece when it is possible to avoid air leaks. However, the high prevalence of air leaks limits its application.

The study conducted by Koulouris et al.[13] showed that MRP values can vary according to the means of coupling the manometer to the patient. The authors compared two types of mouthpiece: a circular rubber mouthpiece, 4 cm in diameter, which is externally fitted over the mouth of the patient, and a semi-rigid flanged mouthpiece, held within the lips. The circular mouthpiece allowed better evaluation of MRPs, as evidenced by the significantly higher values. According to Green et al.[2], this variation in MRP values between the circular mouthpiece and the flanged one should not be taken into clinical consideration since the conventional (flanged) mouthpieces are more readily available and easier to use. In our study, we opted to use the rigid flanged mouthpiece because it was more readily available on the market and is more widely used in clinical practice.

The MRP values found in the present study, whether evaluated with a mouthpiece or with a face mask, might seem low in relation to the reference values for the Brazilian population[3,4]. However, it is important to remember that we evaluated MIP and MEP with efforts initiated from the functional residual capacity, whereas the MIP and MEP reference values were obtained with efforts initiated from the residual volume and total lung capacity, respectively. Due to the influence of the elastic recoil forces generated by the respiratory system during the measurements, inspiratory pressures are higher when they are evaluated at volumes close to the residual volume, and expiratory pressures are higher when they are evaluated at volumes close to total lung capacity[13]. According to Green et al.[2], evaluating MRPs with efforts initiated from the functional residual capacity, as was done in the present study, may be more accurate for use in scientific studies since it rules out any influence of elastic recoil forces.

In an attempt to adapt the evaluations of respiratory function for use in patients with facial paralysis, Fiz et al.[7] carried out a prospective study involving 17 patients presenting facial paralysis of various etiologies. The evaluation of MEP was performed in three ways: by patients manually pressing the mouthpiece against their lips; by the

evaluators pressing the mouthpiece against the lips of the patient; and without any external pressure. The authors concluded that the external pressure, whether applied by the patient or by the evaluator, allows better evaluation of MEP. Using a similar methodology in another study, Fiz et al.[15] showed that, even among healthy patients, applying external pressure allows higher values of MEP to be obtained, possibly due to the prevention of air leakage around the mouthpiece. This seems to be the most appropriate way of evaluating MEP, whether in healthy patients or in patients presenting difficulty adequately pursing their lips.

The results obtained in this study show that MIP and VC can be evaluated with the use of a face mask without any interference in the results obtained. Evaluation of MEP with a face mask proved satisfactory when it was possible to avoid air leakage from around the mask, although the high prevalence of leaks and consequent reduction in the values obtained limit its use.

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