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SCIENTIFIC ARTICLE

Influence of different body positions in vital capacity in patients on postoperative upper abdominal



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KEYWORDS

Positioning the patient;
Forced vital capacity;
Postoperative complications;
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Abstract

Rationale: The changes in body position can cause changes in lung function, and it is necessary to understand them, especially in the postoperative upper abdominal surgery, since these patients are susceptible to postoperative pulmonary complications.

Objective: To assess the vital capacity in the supine position (head at 0° and 45°), sitting and standing positions in patients in the postoperative upper abdominal surgery.

Methods: A cross-sectional study conducted between August 2008 and January 2009 in a hospital in Salvador/BA. The instrument used to measure vital capacity was analogic spirometer, the choice of the sequence of positions followed a random order obtained from the draw of the four positions. Secondary data were collected from the medical records of each patient.

Results: The sample consisted of 30 subjects with a mean age of 45.2 ± 11.2 years, BMI 20.2 ± 1.0 kg/m². The position on orthostasis showed higher values of vital capacity regarding standing (mean change: 0.15 ± 0.03 L; $p=0.001$), the supine to 45 (average difference: 0.32 ± 0.04 L; $p=0.001$) and 0° (0.50 ± 0.05 L; $p=0.001$). There was a positive trend between the values of forced vital capacity supine to upright posture (1.68 ± 0.47 ; 1.86 ± 0.48 ; 2.02 ± 0.48 and 2.18 ± 0.52 L; respectively).

Conclusion: Body position affects the values of vital capacity in patients in the postoperative upper abdominal surgery, increasing in postures where the chest is vertical.

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PALAVRAS-CHAVE

Posicionamento do paciente;
Capacidade vital forçada;
Complicações pós-operatórias;
Cirurgia abdominal

Influência de diferentes posições corporais na capacidade vital em pacientes no pós-operatório abdominal superior

Resumo

Justificativa: As alterações no posicionamento corporal podem ocasionar mudanças na função respiratória e é necessário compreendê-las, principalmente no pós-operatório abdominal superior, já que os pacientes estão suscetíveis a complicações pulmonares pós-operatórias.

Objetivo: Verificar a capacidade vital nas posições de decúbito dorsal (cabeceira a 0° e 45°), sentado e em ortostase em pacientes no pós-operatório de cirurgia abdominal superior.

Métodos: Estudo transversal, feito entre agosto de 2008 e janeiro de 2009, em um hospital na cidade de Salvador (BA). O instrumento usado para mensuração da capacidade vital (cv) foi o ventilômetro analógico e a escolha da sequência das posições seguiu uma ordem aleatória obtida a partir de sorteio das quatro posições. Os dados secundários foram colhidos nos prontuários de cada paciente.

Resultados: A amostra foi composta por 30 indivíduos com idade média de $45,2 \pm 11,2$ anos e IMC $20,2 \pm 1,0$ kg/m². A posição em ortostase apresentou valores maiores da CV em relação à sedestração (média das diferenças: $0,15 \pm 0,03$ litros; $p=0,001$), ao decúbito dorsal a 45° (média das diferenças: $0,32 \pm 0,04$ litros; $p=0,001$) e 0° ($0,50 \pm 0,05$ litros; $p=0,001$). Houve um aumento positivo entre os valores de CVF do decúbito dorsal para a postura ortostática ($1,68 \pm 0,47$; $1,86 \pm 0,48$; $2,02 \pm 0,48$ e $2,18 \pm 0,52$ litros; respectivamente).

Conclusão: A posição do corpo afeta os valores da CV em pacientes no pós-operatório de cirurgia abdominal superior, com aumento nas posturas em que o tórax encontra-se verticalizado.

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Introduction

Upper abdominal surgical procedures account for a large number of postoperative pulmonary complications (PPC) because these procedures directly interfere with lung mechanics and tend to induce restrictive ventilatory disorders, as well as reflex inhibition of phrenic nerve and consequent diaphragmatic dysfunction.¹⁻³ During early postoperative period, patients may present hypoventilation related to the anesthetic process, as well as limiting ventilatory changes due to pain in surgical site.⁴

The prevalence rate of PPC in upper abdominal surgery varies between 17% and 88%.⁵ These changes are more marked in laparotomy procedures, but are also seen in laparoscopic surgeries.¹

Pulmonary function tests play an important role in the assessment, diagnosis, quantification of the ventilatory disorders intensity, and treatment course.⁶ The forced vital capacity (FVC) is a pulmonary function measure often used for this purpose and is defined as the maximum volume of air exhaled from after maximum inspiration.^{6,7} Decreased FVC is a fairly obvious abnormality in patients with respiratory muscle weakness or changes in lung mechanics that overload these muscles.^{7,8} These decreases after upper abdominal surgery range from 20% to 30% of the preoperative value and may achieve more significant values up to 50%.^{7,9-11}

Change in body positioning and the consequent change of gravity effect, among other factors, cause change in respiratory function at different intensities.¹² Thus, knowledge of the physiological effects of different body positions on pulmonary function is essential to guide the physical therapy procedures, including spirometry in clinical practice, so

that its values are comparable between different periods and patients.¹³ Therefore, the objective of this study was to investigate the functional vital capacity in the supine (head at 0° and 45°), sitting on the bed with hanging down legs, and upright positions in patients after upper abdominal surgery.

Method

Cross-sectional study conducted in the wards of Hospital Santo Antônio – Obras Sociais Irmã Dulce, Salvador, Bahia State, a city reference in abdominal surgery.

Patients aged over 18 years, on the second postoperative day of upper abdominal surgery, with history of previous functional independence and medical release and stand-up were included. Exclusion criteria were patients with irreversible pain with painkillers, neurological and/or cognitive impairment that prevented the FVC measurement and a decrease in blood pressure greater than 20% from baseline during position change.

The study was approved by the Research Ethics Committee of the hospital, protocol number 40/06. All patients signed an informed consent form (ICF).

Data collection was conducted from August 2008 to January 2009. Forced vital capacity (FVC) measurement was defined according to the 2002 guidelines for pulmonary function tests.⁶ The toll used for this measurement was the analog spirometer (Ferraris – Mark 8 Respirometer Wright, Louisville, CO, USA) coupled to a silicon face mask. The sequence of positions was randomized by blocks of envelopes. Subsequently, subjects were placed in selected positions and asked to perform a maximal inspiration to total

Table 1 Demographic data of patients included in the study.

| | Mean \pm SD | Percentage (n) |
|----------------------------|-----------------|----------------|
| Age (years) | 45.2 \pm 11.2 | |
| BMI (kg m^{-2}) | 20.2 \pm 1.0 | |
| Tipo | | |
| EL cholecystectomy | | 16.7 (5) |
| VLC cholecystectomy | | 50.0 (15) |
| Nephrectomy | | 10.0 (3) |
| Gastrectomy | | 3.3 (1) |
| Pancreaticoduodenectomy | | 16.7 (5) |
| Cystectomy | | 3.3 (1) |

EL, exploratory laparoscopic; VLC, videolaparoscopic.

lung capacity (TLC) followed by a maximal expiration to residual volume (RV). The vital capacity value adopted in each position was the highest value among three measurements with less than 10% difference between them. The four positions used in the present study were supine at 0°, supine at 45° sitting with hanging down legs, and upright. All measurements were performed by the same investigator. Clinical data were obtained through medical records of each patient.

Mean and standard deviation were used to represent the FVC values obtained in body positions analyzed. Analysis of Variance (ANOVA) with *post hoc* Bonferroni test was used to compare the mean values of FVC between each body position. All analyses were performed using SPSS version 14.0.

Results

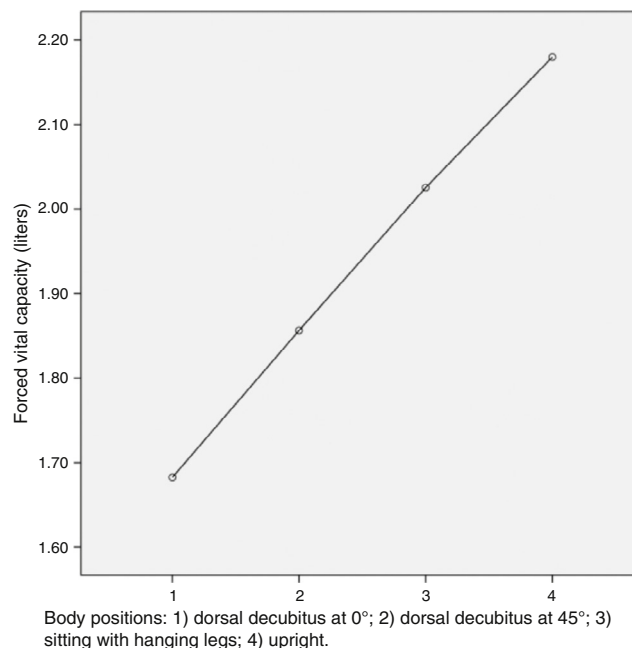
The population consisted of 30 subjects, mean age of 45.2 \pm 11.2 years, BMI of 20.2 \pm 1.0 kg m^{-2} , predominantly female (76.7%). Table 1 shows the demographic characteristics and operations performed. Values of FVC in different positions are shown in Table 2. The highest value obtained was for the upright position (FVC 2.18 \pm 0.52; 95% CI 1.99–2.37).

Compared with the other three positions, upright position showed significantly higher values in relation to sitting (mean of differences: 0.15 \pm 0.03; $p=0.001$), supine at 45° (mean of differences: 0.32 \pm 0.04; $p=0.001$), and supine at 0° (0.50 \pm 0.05; $p=0.001$). There were also significant differences between the sitting position with hanging down legs and supine position at 45° (mean of differences: 0.17 \pm 0.04;

Table 2 Evaluation of the forced vital capacity (FVC) in liters (L) in different body positions, with 95% confidence interval (95% CI).

| Body position | Mean | Standard deviation | Confidence interval (95% CI) |
|---------------|------|--------------------|------------------------------|
| Supine (0°) | 1.68 | 0.47 | 1.51–1.85 |
| Supine (45°) | 1.86 | 0.48 | 1.68–2.04 |
| Sitting | 2.02 | 0.48 | 1.84–2.21 |
| Upright | 2.18 | 0.52 | 1.99–2.37 |

Data are expressed as mean and standard deviation of forced vital capacity (FVC) in liters (L) in different body positions ($n=30$).

**Figure 1** Mean VC (L) in different positions: (1) dorsal decubitus at 0°; (2) dorsal decubitus at 45°; (3) sitting with hanging legs; and (4) upright.

$p=0.001$) and at 0° (mean of difference: 0.34 \pm 0.04; $p=0.001$), as well as between supine at 45° and 0° (mean difference: 0.17 \pm 0.04; $p=0.001$) (Fig. 1). There was a positive trend between supine FVC values to upright position (Table 3).

Discussion

The present study found that FVC increases progressively between supine at 0° and upright positions in patients after upper abdominal surgery. This is the first study to evaluate respiratory mechanics through VC in this type of surgical patients, which is somewhat relevant, as the upper surgeries predispose to complications and positioning may minimize some ventilatory changes.

Compared to other positions evaluated in this study, there was a greater decrease in FVC in supine position at 0°, a finding that is in agreement with that of other studies.^{14,15} This decrease may be attributed to decreased dynamic lung compliance and increased resistance to pulmonary blood flow, resulting from reduced FRC in this position.^{15,16} In supine position, anatomical changes occur in the pharynx, such as the reduction of its diameter, which increases the upper airway resistance. The cephalic displacement of the diaphragm due to increased abdominal pressure, and the increased intrathoracic blood volume, are also factors that result in reduced lung volume at rest and justify an increase in airway resistance in this body position.¹⁵

In the present study, the sitting position showed an increase of 20.2% in FVC compared to supine position. This finding corroborates other studies that showed increased FVC in this position ranging from 4.6% to 20% in patients undergoing abdominal procedure.^{14–17} This finding may be related to the favorability of deep breaths in this posture,

Table 3 Comparison of forced vital capacity (FVC) in liters with mean differences between different body positions ($n = 30$).

| Selected body position | Compared body position | Mean | Standard deviation | p |
|--------------------------------|------------------------|--------------------|--------------------|-------|
| Supine (0°) | 45° | -0.17 ^a | 0.04 | 0.001 |
| | Sitting | -0.34 ^a | 0.04 | 0.001 |
| | Upright | -0.50 ^a | 0.05 | 0.001 |
| Supine (45°) | 0° | 0.17 | 0.04 | 0.001 |
| | Sitting | -0.17 | 0.04 | 0.001 |
| | Upright | -0.32 | 0.04 | 0.001 |
| Sitting with hanging down legs | 0° | 0.34 | 0.04 | 0.001 |
| | 45° | 0.17 | 0.04 | 0.001 |
| | Upright | -0.15 | 0.03 | 0.001 |
| Upright | 0° | 0.50 | 0.05 | 0.001 |
| | 45° | 0.32 | 0.04 | 0.001 |
| | Sitting | 0.15 | 0.03 | 0.001 |

^a Significant difference ($p < 0.05$).

and overcomes the tendency to airway closure related to changes in lung compliance and lower pressure of the abdominal organs in relation to the diaphragm.¹⁸

The upright position showed the highest increases in FVC. A similar finding was reported by other authors who suggest that the upright position provides greater mechanical advantage to the respiratory muscles, as abdominal contents do not interfere with diaphragm displacement and, thus, generates higher ventilation pressures.^{19,20} In contrast, Costa et al. and Domingos-Benício et al. found no statistically significant difference in FVC between the sitting and upright positions, but these studies were conducted with a non-surgical, healthy, and young population.^{17,21} According to Pereira et al., FVC in adults and elderly is higher in the upright position (1–2%) and lower in the supine position (7–8%) compared to the sitting position, which does not occur in younger people.⁶

The main explanation factor for the increase in FVC in a more vertical chest position is the possible reduction in transthoracic pressure, as even in the 45° position there is less compressive effect of the abdominal wall, which is greater in the 0° horizontal position. Valenza et al. demonstrate the impact of increased pleural pressure under the diaphragm, as the force exerted on the Trendelenburg position was higher compared with the sitting position,¹⁶ which was also shown in a study by Behrakis et al. regarding compliance.¹⁵

Another explanation for FVC reduction in supine position at 0° may be due to the reduction in alveolar area, and not only by the increased frequency of atelectasis, as reported by Pankow et al.²² However, in the present study this finding was not evident since the reduced FVC may be due to inhibition of phrenic nerve reflex and not necessarily to the increased respiratory system elastance by the abdominal surgical trauma.

The upper abdominal surgery induces a diaphragmatic dysfunction lasting for about a week and may be a major cause of postoperative pulmonary restrictive pattern.² Reduced diaphragmatic function may be responsible for atelectasis, reduced vital capacity, and hypoxemia.³

Although anesthesia and pain may be responsible for respiratory muscle dysfunction, studies support the hypothesis that an inhibitory reflex due to the abdominal cavity manipulation is the main mechanism.^{1–3,23–25} Therefore, the low FVC values seen in patients in the present study in different positions may be due to diaphragmatic dysfunction mediated by reflex mechanism of afferent phrenic nerve inhibition.

Thus, knowledge of body positions that favor lung function can be used as a therapeutic measure, aiming at improving lung volume, oxygenation, and respiratory mechanics and minimizing disturbances produced by major surgical procedures, with reduced incidence of atelectasis and prevention of pulmonary complications.^{16,26–29}

This study has some limitations, such as the lack of intra-abdominal pressure (IAP) measurement, as its elevation may be present after abdominal surgery and generate changes in spirometric data. However, IAP measurement is an invasive procedure requiring specialized professional, which would hinder the study conduction. Another possible limitation is the use of a facemask as a measuring tool instead of the nozzle. According to Fiore et al.,³⁰ VC evaluations may be done using a facemask without interfering in the results and become accessible to patients who have difficulty in performing the evaluation, as lip pressure becomes unnecessary.

Conclusion

Body position affects VC values in patients after upper abdominal surgery, with an increase in postures where the chest is more vertically positioned. The most favored respiratory function is in the upright position, followed by the sitting position, compared with the supine position at 0° and 45° .

Conflicts of interest

The authors declare no conflicts of interest.

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