Looking at lung volumes in postoperative upper abdominal surgical patients, the author conducted a study to determine whether lung volumes can be increased more when a nurse verbally encourages a patient to perform a sustained maximal inspiration or compared to when a nurse verbally encourages the patient to perform a deep breathing maneuver. It was determined that of the 14 patients studied between postoperative hours one and two, the decrease in the functional residual capacity was significantly less in the patients who utilized the sustained maximal inspiration maneuver as compared to the patients who used the deep breathing maneuver. The sustained maximal inspiration maneuver may be more effective in preventing the rapid decline of lung volumes in the immediate postoperative period as compared to the deep breathing maneuver.

Despite many recent advances, postoperative complications can and do arise after a successful operative procedure. A postoperative complication can be defined as any untoward event occurring within 30 days after the surgical procedure. Common postoperative complications include wound infection, hepatitis, nerve palsies, cardiac complications, and respiratory complications.

Pulmonary complications are the single largest cause of morbidity and mortality in the postoperative period. After upper abdominal surgery, 20-30% of the patients exhibit one or a combination of the following pulmonary complications: tachypnea, tachycardia, decreased lung volume, intrapulmonary shunting, and atelectasis.

Moreover, various investigators have reported an incidence of 4.5-76.0% with an average of 11% for pulmonary complications following abdominal operations. Most of the research has indicated that the incidence of postoperative complications is the highest after upper abdominal surgery and thoracic surgery.

Background

In the immediate postoperative period, anesthesia interventions have focused on the prevention of postoperative pulmonary complications by the use of the "stir-up" regimen. This regimen consists of the nurse verbally encouraging the patient to perform a deep breathing maneuver, performance of a cough maneuver and repositioning the patient. Despite well-planned and implemented anesthesia interventions in the immediate postoperative period, pulmonary complications following surgery continue to be a major cause of postoperative morbidity and mortality.

Atelectasis or collapse of alveoli is a common
postoperative pulmonary complication. It is estimated that atelectasis accounts for more than 90% of the postoperative pulmonary complications. Normally, adults breathe regularly and rhythmically and spontaneously perform a maximal inspiration or sigh every 5 to 10 minutes. During anesthesia or in the postoperative period when there is an absence of these spontaneous deep breaths, lung compliance decreases resulting in a lower alveolar volume.

As the lung volumes decrease in the immediate postoperative period, transpulmonary pressure at resting lung volumes also decreases. The lungs and thorax are viscoelastic structures. The lower the pressure differential across the lungs (transpulmonary pressure), the less the expansion of the lungs. The transpulmonary pressure reflects the pressure difference between the alveoli and the pressure surrounding the lungs (pleural pressure). Without periodic lung hyperinflations (sigh) lung volumes decrease. As lung volumes decrease, lung recoil increases. Hence, with increased lung recoil, the lungs will require significantly higher inflation pressures to achieve the same volume. The relation between force (pressure) and stretch (volume) is termed compliance.

Compliance is expressed as the volume increase in the lungs for each unit increase in transpulmonary pressure. In the immediate postoperative period, a high lung recoil and low transpulmonary pressure at resting lung volumes will result in a low lung compliance and a stiffer lung, the ultimate consequence is lower lung volumes.

As the lung volumes diminish, the small airways become narrower and may become totally obstructed resulting in airway closure. In the normal lung at residual volume, the pleural pressure in the dependent lung zones exceeds the airway pressure leading to airway closure. The result is gas trapping behind closed airways. The lung volume where airways begin to close is termed the closing volume.

In the postoperative period, the functional residual capacity (FRC) is reduced. The reduction in FRC in the postoperative period may be due to a monotonous ventilatory pattern. When the FRC plus tidal volume (Vr) falls below the closing volume (CV), the airways leading to dependent lung zones may be effectively closed throughout the respiratory cycle. Inspired gas is then distributed mainly to the upper or nondependent lung zones. Perfusion continues to follow the normal gradient with higher flows to the dependent areas. Postoperatively, as airway closure occurs, gas will be trapped in significant amounts behind the closed airways. Over a period of time, this sequestered air is absorbed and the alveoli become airless (atelectasis). Atelectasis leads to decreased ventilation as compared to perfusion; the result is a widening of the alveolar-oxygen gradient and hypoxemia.

To reverse the events which lead to alveolar collapse, voluntary deep breathing or sustained maximal inspiration, such as a sigh or yawn, can be used to increase the patient’s lung volumes and consequently reinflate the collapsed alveoli. These techniques are believed to inflate alveoli, increase lung compliance, and reduce surface tension, thus promoting an increase in the inspiratory capacity and the functional residual capacity.

The study that is the focus of this AANA Journal article was designed to compare two techniques, sustained maximal inspiration and voluntary deep breathing, in terms of their effectiveness in increasing functional residual capacity (FRC) and inspiratory capacity (IC) in the immediate postoperative period.

Statement of the problem
Bartlett, et al. have demonstrated the FRC and IC decrease in the postoperative period when compared to preoperative measurements. Without adequate respiratory maneuvers to enhance the FRC and IC in the immediate postoperative period, pulmonary complications may result. The optimal maneuver for augmenting the FRC and IC in the immediate postoperative period has not been identified. The question proposed in the present study was whether lung volumes can be increased more when the nurse verbally encourages a patient to perform a sustained maximal inspiration or when the nurse verbally encourages the patient to perform a deep breathing maneuver.

Purpose of the study
The purpose of this study was to determine whether the sustained maximal inspiratory maneuver or the deep breathing maneuver is more effective in prohibiting the fall in the FRC and the IC in the immediate postoperative period. By utilizing the most effective technique to increase or limit the fall in the FRC and IC, nurses can help prevent pulmonary complications postoperatively and consequently improve patient care outcomes.

Hypotheses
It was hypothesized that:
1. At the first hour postoperatively, there would be a significant decrease (.05 level) from the preoperative measurement of the FRC and IC.
in the patient undergoing upper abdominal surgery.

2. After both the sustained maximal inspiratory maneuver and deep breathing maneuver, there would be a significant increase (.05 level) in the FRC and IC from the first hour postoperatively to the second hour postoperatively in patients undergoing upper abdominal surgery.

3. From the first hour postoperatively to the second hour postoperatively in patients undergoing upper abdominal surgery, the FRC and IC would show a significantly greater increase (.05 level) in patients who use the sustained maximal inspiratory maneuver as compared to patients who use the deep breathing maneuver.

Model

The following model (Figure 1) illustrates how anesthesia nursing interventions enhance the pulmonary function of the patient in the immediate postoperative period. Conceptually, by the use of respiratory maneuvers performed in the immediate postoperative period, the rapid decline in lung volumes can be reduced. Hence, the lung volumes will be enhanced in the patient who received the respiratory maneuvers. Operationally, by instigating the sustained maximal inspiration or deep breathing maneuver, the functional residual capacity and inspiratory capacity will increase.

Definitions

The following definitions pertain to the study:

Sustained maximal inspiration (SMI): a respiratory maneuver in which the patient is encouraged to take a deep inspiration and at the peak of the inspiration, the patient is encouraged to hold the inspired air for three seconds, at which time the patient is encouraged to exhale the air.

Voluntary deep breathing (DB): a respiratory maneuver that involves encouraging the patient to take a deep inspiration and at the peak of the inspiration, the patient is encouraged to exhale.

Method

Research design. An experimental research design was used to study the effects of the sustained maximal inspiration maneuver versus a voluntary deep breathing maneuver on the functional residual capacity (FRC), inspiratory capacity (IC), vital capacity (VC) and the forced expiratory volume in one second (FEV₁) in the immediate postoperative period in patients who had upper abdominal surgery. Control measurements were taken within the 24 hours prior to surgery and premedication. Postoperative measurements were obtained at one and two hours after the patient was admitted to the recovery room. To control variability between subjects, each patient served as his or her own control and the data were analyzed in terms of change in percentage predicted values.

Sample and setting. A convenience sample was used for subject selection. The first 14 patients from the surgical population of patients in a southwestern medical center who met the criteria for selection and who agreed to participate in this study were randomly assigned to one of the two treatment groups by the use of a table of random numbers. Group I consisted of patients who received the deep breathing maneuver. Group II was comprised of the patients who received the sustained maximal inspiration maneuver. In the preoperative period, subjects in Group I were
taught the DB maneuver and subjects in group II were taught the SMI maneuver.

The following screening criteria to initially approach a subject for inclusion in the study in the preoperative period were used. The patient was:

1. Scheduled to have upper abdominal surgery.
2. Able to communicate using the English language.
3. Able to present no documented pulmonary function abnormality.
4. At least 18 years of age but less than 70 years of age.
5. Able to perform the maneuvers required for the lung volume measurements.
6. Scheduled to receive a general inhalation anesthetic intraoperatively.

**Research method.** The treatment protocol outlined below was followed for each subject. The experimental treatment (SMI or DB) was determined by random assignment of the subjects. Permission was obtained from the subject, attending physician and the study was approved by the university and hospital human subjects committee. Within 24 hours prior to surgery, two measurements of the FRC, IC, VC, and FEV<sub>1</sub> were obtained with the subject in semi-Fowler's position. Upon completion of the preoperative data collection, either the SMI or DB maneuver was taught to the subject depending upon the group to which the subject was assigned. Upon admission to the recovery room, the subject was assisted in performing the assigned maneuver five times every 15 minutes. If the subject was transferred to the surgical unit before the completion of the study, the assigned maneuver was performed by the subject, with the aid of the investigator, every 15 minutes until the completion of the study period.

At hours one and two in the immediate postoperative period, FRC, IC, VC, and FEV<sub>1</sub> measurements were obtained with the subject in the semi-Fowler’s position. The subject remained on bedrest until the final measurements were taken. Upon arrival in the recovery room, the subjects were screened a second time to determine if they would remain in the study. The criteria were that the subjects:

1. Had met the standards for the initial preoperative screening.
2. Were alert and oriented.
3. Were not intubated.
4. Did not receive mechanical ventilation postoperatively.
5. Had upper abdominal surgery.
6. Had received a general inhalational anesthetic intraoperatively.

**Analysis of data**

**Characteristics of sample.** The sample consisted of 14 subjects, who were divided into two

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Sex</th>
<th>Ht. (cm)</th>
<th>Wt. (kg)</th>
<th>Smoking history</th>
<th>Duration of anesthesia (min)</th>
<th>Duration of surgery (min)</th>
<th>Type of surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36</td>
<td>F</td>
<td>150</td>
<td>57.7</td>
<td>10 pack years</td>
<td>255</td>
<td>185</td>
<td>Exploratory laparotomy</td>
</tr>
<tr>
<td>2</td>
<td>49</td>
<td>F</td>
<td>157</td>
<td>46.1</td>
<td>25 pack years</td>
<td>165</td>
<td>105</td>
<td>Bowel resection</td>
</tr>
<tr>
<td>3</td>
<td>29</td>
<td>M</td>
<td>178</td>
<td>81.9</td>
<td>10 pack years</td>
<td>180</td>
<td>155</td>
<td>Spleenectomy</td>
</tr>
<tr>
<td>4</td>
<td>55</td>
<td>M</td>
<td>170</td>
<td>80</td>
<td>10 pack years</td>
<td>95</td>
<td>70</td>
<td>Colostomy closure</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>M</td>
<td>177</td>
<td>70</td>
<td>None</td>
<td>235</td>
<td>195</td>
<td>Spleenectomy</td>
</tr>
<tr>
<td>6</td>
<td>56</td>
<td>F</td>
<td>167</td>
<td>57</td>
<td>None</td>
<td>165</td>
<td>125</td>
<td>Exploratory laparotomy</td>
</tr>
<tr>
<td>7</td>
<td>39</td>
<td>F</td>
<td>164</td>
<td>67</td>
<td>20 pack years</td>
<td>165</td>
<td>115</td>
<td>Exploratory laparotomy</td>
</tr>
</tbody>
</table>
treatment groups consisting of seven subjects in each group. All of the subjects had undergone an upper abdominal surgical procedure and met the criteria for selection established. The total group consisted of eight females and six males whose ages ranged from 19-70 years of age with a mean age of 41.86. There was no significant difference in age between the two treatment groups ($p=0.793$). There was an equal distribution of male and female subjects between the two groups.

All the subjects received a general endotracheal anesthetic. Similar anesthetic agents were used for all subjects. There was no significant difference in the duration of anesthesia ($p=1.000$) or duration of surgery ($p=0.675$) between the two treatment groups. All of the subjects received a narcotic during the first two hours postoperatively.

Nine of the 14 subjects were smokers. Eight of the nine subjects were presently smoking up to the time of surgery. The ninth smoker had ceased smoking one week prior to surgery. Using Fisher's Exact test,$^{14}$ it was demonstrated that there was no

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**Table II**

Mean and standard deviation of percent predicted values for FRC, IC, VC, and FEV$_1$ measurements in the Deep Breathing Maneuver Group (Group I) at each time.

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Hour one postoperative</th>
<th>Hour two postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
<td>Mean</td>
</tr>
<tr>
<td>FRC</td>
<td>101.6</td>
<td>6.4</td>
<td>81.0*</td>
</tr>
<tr>
<td>IC</td>
<td>107.1</td>
<td>16.4</td>
<td>52.0*</td>
</tr>
<tr>
<td>VC</td>
<td>89.1</td>
<td>15.2</td>
<td>40.3*</td>
</tr>
<tr>
<td>FEV$_1$</td>
<td>85.1</td>
<td>12.5</td>
<td>39.4*</td>
</tr>
</tbody>
</table>

*Significant difference from preoperative measurement ($p < .05$).

**Table III**

Characteristics of subjects in Sustained Maximal Inspiration Maneuver Group (Group II)—Age, sex, height, weight, smoking history, duration of anesthesia, duration of surgery, and type of surgery.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Sex</th>
<th>Ht. (cm)</th>
<th>Wt. (kg)</th>
<th>Smoking history</th>
<th>Duration of anesthesia (min)</th>
<th>Duration of surgery (min)</th>
<th>Type of surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>70</td>
<td>M</td>
<td>182.8</td>
<td>93</td>
<td>40 pack years</td>
<td>150</td>
<td>125</td>
<td>Colon resection</td>
</tr>
<tr>
<td>2</td>
<td>66</td>
<td>F</td>
<td>156</td>
<td>80</td>
<td>None</td>
<td>180</td>
<td>130</td>
<td>Exploratory laparotomy</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>F</td>
<td>147</td>
<td>70</td>
<td>None</td>
<td>185</td>
<td>170</td>
<td>Cholecystectomy</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
<td>F</td>
<td>165</td>
<td>60</td>
<td>8 pack years</td>
<td>365</td>
<td>330</td>
<td>Exploratory laparotomy</td>
</tr>
<tr>
<td>5</td>
<td>23</td>
<td>M</td>
<td>165</td>
<td>66.8</td>
<td>2 pack years</td>
<td>185</td>
<td>160</td>
<td>Spleenectomy</td>
</tr>
<tr>
<td>6</td>
<td>23</td>
<td>F</td>
<td>150</td>
<td>48.7</td>
<td>3 pack years plus pipe</td>
<td>130</td>
<td>115</td>
<td>Cholecystectomy</td>
</tr>
<tr>
<td>7</td>
<td>66</td>
<td>M</td>
<td>185.42</td>
<td>67</td>
<td>None</td>
<td>65</td>
<td>35</td>
<td>Exploratory laparotomy</td>
</tr>
</tbody>
</table>

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August/1984
significant difference (p = .5) in the percentage predicted measurements of FRC between the smokers and nonsmokers. Hence, it was found that preoperative and one- and two-hour postoperative changes in percentage predicted FRC measurements using either maneuver were independent of the variable of smoking.

Deep Breathing Maneuver Group (Group I). The DB Group consisted of seven subjects, four females and three males. Table I summarizes the characteristics of the subjects in the Deep Breathing Maneuver Group. Table II describes the mean and standard deviation of percent predicted values for the FRC, IC, VC, and FEV<sub>1</sub> measurements in the DB Group at each time of measurement.

Sustained Maximal Inspiration Maneuver Group (Group II). The SMI Group consisted of seven subjects, four females and three males. Table III summarizes the characteristics of the subjects in the group. Table IV describes the mean and standard deviation of percent predicted values for the FRC, IC, VC, and FEV<sub>1</sub> measurements in the SMI Group at each time of measurement.

Comparison of flow and volume measurements between the treatment groups. As can be seen in Figure 2, from the preoperative percentage predicted measurement to the hour one postoperative measurement, FRC was decreased significantly for both treatment groups. Between hour one to hour two postoperatively, the FRC significantly decreased in both treatment groups. However, the decrease in mean percentage predicted FRC between postoperative hours one to two was significantly less (p < .05) for the subjects who utilized the SMI maneuver.

Similarly, there was a significant decrease in the preoperative to the hour one postoperative measurements of the IC and the FEV<sub>1</sub> in both treatment groups. The decrease in percentage predicted measurements of the IC and FEV<sub>1</sub> from hour one to hour two postoperatively was significantly decreased (p = .038 and p = .021) in the deep breathing group but not the SMI Group. As can be seen in Figures 3 and 4, the IC and FEV<sub>1</sub> tended to increase or remain unchanged in the SMI Group and decrease in the DB Group from postoperative hour one to hour two. However, these changes were not statistically significant.

The percentage predicted measurements of the VC were significantly decreased in both treatment groups from the preoperative to the first hour postoperatively. However, from postoperative hours one to two, the percentage predicted measurements of the VC were not significantly decreased in the subjects in the DB Group or the SMI Group. The VC in the subjects in the SMI Group tended to increase from postoperative hours one to two, whereas the VC in the subjects in the DB Group continued a decline (Figure 5). However, these changes were not statistically significant.

Findings related to the hypotheses. First, it was hypothesized that there would be a significant decrease at the .05 level from the preoperative to the first hour postsurgical measurements of the FRC and IC in the patients undergoing upper abdominal surgery. The findings demonstrated a significant decrease (p < .05) in the percentage predicted measurements of FRC and IC from the preoperative to the first hour postoperatively. Therefore, the hypothesis was accepted.

Secondly, after the performance of either of

<table>
<thead>
<tr>
<th>Table IV</th>
</tr>
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<tbody>
<tr>
<td>Mean and standard deviation of percent predicted values for all FRC, IC, VC, and FEV&lt;sub&gt;1&lt;/sub&gt; measurements in the Sustained Maximal Inspiration Group (Group II) at each time.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>FRC</td>
</tr>
<tr>
<td>IC</td>
</tr>
<tr>
<td>VC</td>
</tr>
<tr>
<td>FEV&lt;sub&gt;1&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

*Significant difference from preoperative measurement (p < .05).  
**Significant difference from postoperative hour one measurement (p < .05).
the two respiratory maneuvers, it was hypothesized that there would be a significant increase at the .05 level in the FRC and IC from the first hour to the second hour postoperatively. In both Groups I and II, there was a significant decrease (p < .05) in the percentage predicted measurements of FRC from hour one to hour two postoperatively. The decrease in the IC percentage predicted measurements from the first to the second hour postoperatively was significant for Group I (p < .05) but not for Group II. Since there was no significant increase in either group, the hypothesis was rejected.

Finally, it was hypothesized that between postoperative hours one and two, the FRC and IC would increase in patients who used the SMI maneuver as compared to patients who utilized the DB maneuver. Using the paired t test within groups, there was a significant decrease in the FRC (p < .05) in both groups from hour one to hour two postoperatively. The percentage predicted measurements of IC for Group I significantly decreased (p < .05) from hour one to hour two postoperatively. Although not statistically significant, the IC in Group II showed a trend toward an increase from hour one to hour two postoperatively (Figure 4). Since there was no significant increase in the FRC and IC in either group, the hypothesis was rejected.

However, it was noted (one tailed t test for the differences between means) that the decrease in the mean percentage predicted FRC between hours one and two postoperatively was significantly less (p < .05) in the subjects who utilized the SMI maneuver as compared to the subjects who used the DB maneuver. The magnitude of the decrease in the IC between hours one and two postoperatively was not statistically significant between the two groups. However, a trend for a further reduction in the IC in Group I and an increase in the IC in group II was seen from hour one to hour two postoperatively (Figures 2 and 3). Hence, the subjects who utilized the SMI maneuver had a smaller decrease in their FRC from hours one to two postoperatively.

**Discussion and conclusions**

*Postoperative lung volumes.* Previous investi-
gators found that lung volume measurements of FRC and VC in the immediate postoperative period up to seven days postoperatively, were significantly reduced as compared to predicted normals or preoperative measurements.\(^7\,10\) Ali et al. demonstrated a fall in FRC and VC in subjects who had undergone upper abdominal surgical procedures.\(^7\) The VC was significantly reduced during the first seven days postoperatively. The FRC was significantly reduced from day one through day five in patients undergoing upper abdominal surgery. In the 11 subjects studied on the day of surgery, the FRC did not change significantly from preoperative to hours four and 10 postoperatively, but there was a significant fall in the FRC by hour 16.

Meyers et al. also found that the VC, FEV\(_1\), and FRC were markedly reduced postoperatively as compared to preoperative values, with the maximum decrease on days one and two and a gradual return toward preoperative values by day five.\(^16\)

In the Meyers study, there was a rapid, progressive return of the FRC, VC, and FEV\(_1\) to the preoperative value by the fifth postoperative day in most instances. The FRC in five of the 28 patients studied developed severe reductions on postoperative day one (42-58% of their preoperative values). These patients were found to have clinical manifestations of pulmonary dysfunction. Ali et al. was the only investigator to measure the FRC during the day of surgery at hours four, 10, and 16 postoperatively.\(^7\)

In the present study the FRC findings at hours one and two postoperatively were lower than the Ali study's findings. It is impossible to explain these differences with the data available. One speculation is that there was a difference in subject selection and measurement technique. Secondly, there could be an immediate fall in FRC which then returns to baseline by hour four, with a second subsequent fall. In the present study, these FRC findings at hour one postoperatively were higher than the Meyers study findings on day one. Although, the FRC measurements in the present study at postoperative hour two were similar to the measurements reported by Meyers: the mean VC for postoperative hour two ranged from 37.5 to 47.5% predicted. The VC findings in the present study are similar to Meyers' findings.

![Figure 4](image1.png)

**Figure 4**
Changes in mean percent predicted measurements of the forced expiratory volume in one second for the subjects in the Deep Breathing Maneuver and Sustained Maximal Inspiration Groups preoperatively, and at hours one and two postoperatively.

![Figure 5](image2.png)

**Figure 5**
Changes in mean percent predicted measurements of the vital capacity for the subjects in the Deep Breathing Maneuver and Sustained Maximal Inspiration Groups preoperatively, and at hours one and two postoperatively.
Latimer *et al.* also found the VC and FEV₁ to be markedly reduced postoperatively as compared to preoperative values with the maximum reduction occurring on the day of operation. In the present study, the VC and FEV₁ measurements were markedly reduced in the immediate postoperative period. The VC findings in the present study were similar as compared to the measurements in Latimer's study on the day of operation. In the present study, the mean FEV₁ at postoperative hour one ranged from 39.4-39.6% predicted and from 36.2-39.9% predicted at hour two postoperatively. The FEV₁ measurements in the present study, as compared to the percentage of the preoperative value of FEV₁ in the Latimer study, were similar.

Wightman demonstrated that patients undergoing upper abdominal surgical procedures experience the highest rate of pulmonary complications. In the present study, all the subjects underwent an upper abdominal surgical procedure. Anesthesia, site of surgery, and the narcotics used postoperatively, can be considered major factors proceeding to the slow, sighless ventilatory pattern which ultimately leads to the progression of events that results in atelectasis or collapse of the alveoli. Pain as a factor affecting the breathing pattern could not be directly assessed in the present study population. All the subjects complained of severe pain within the first 30 minutes postoperatively. All the subjects received meperidine (Demerol®) intravenously 1-3 times during the first two hours postoperatively.

Half of the subjects in the present study were treated with the incentive spirometer (SMI) and the other group was treated with intermittent positive pressure breathing (IPPB). Although specific data on the change in lung volumes in the postoperative period are lacking, the investigators suggested that the SMI was somewhat more effective than IPPB in preventing pulmonary complications.

Other investigators²,¹⁷,¹⁸ have reported on the effectiveness of the SMI in reducing postoperative pulmonary complications, although these studies did not measure FRC, VC, or IC. Instead, these studies mainly used physical signs and chest radiography as a measurement of the effectiveness of the maneuvers in preventing postoperative complications.

In the present study, there was a significant decrease from the preoperative percentage predicted measurements to the first hour postsurgical measurement of FRC and IC in patients undergoing upper abdominal surgery.

The decrease in the FRC in both groups from postoperative hour one to hour two was statistically significant. The decrease in the FRC in the subjects in the SMI Group between postoperative hours one and two was significantly less when compared to the subjects in the DB Group. Although not statistically significant, a trend can be seen for a steady increase and no further fall in the IC, VC, and FEV₁ measurements from hours one to two postoperatively in the SMI Group; a trend can also be seen toward a further fall in the same measurements in the DB Group. Consequently, the SMI maneuver may be more effective than the DB maneuver in preventing a further reduction in lung volumes in the immediate postoperative period.

Both the DB maneuver and the SMI maneuver generate a high transpulmonary pressure gradient. However, the alveolar inflating time, which is utilized in the SMI maneuver but not the DB maneuver, may be of critical importance in enhancing the pulmonary function and reducing the postoperative pulmonary complications in the patient who has undergone upper abdominal surgery.

**Clinical implications.** The purpose of this study was to evaluate the effectiveness of the SMI maneuver as compared to the DB maneuver in prohibiting the fall in FRC and IC in the immediate postoperative period. It was demonstrated that in the immediate postoperative period, the decrease in the FRC was significantly less in the subjects utilizing the SMI maneuver as compared to the subjects using the DB maneuver.

Although not statistically significant, trends were seen for an increase or no further fall in the IC, VC, and FEV₁ in the subjects utilizing the SMI maneuver. In contrast, the trend in the IC, VC, and FEV₁ flow and volume measurements in the subjects utilizing the deep breathing maneuver continued to steadily decrease in the same immediate postoperative period.

Based on the statistically significant data and the trends developed from the present study, it can be concluded that the nurse who is responsible for supportive measures in patient care in the recovery room (postanesthesia recovery) should assist and encourage the patient to use the SMI maneuver as opposed to the DB maneuver. By hindering a further decrease in the FRC during the first two hours of the immediate postoperative period, the progression of atelectasis may be slowed or prevented and finally, postoperative pulmonary complications may be reduced.

Moreover, other investigations have indicated that the SMI maneuver will increase lung volumes to a greater extent during the postoperative course.
up to day seven. Therefore, the nurse who is responsible for supportive measures in patient care on the postoperative surgical unit should assist and encourage the patient to continue in using the SMI maneuver.

Based on the subjective opinion of this researcher, it is further believed that if the nurse explains the rationale of the SMI maneuver and properly instructs the patient in the use of the technique preoperatively, he or she may then correctly utilize the SMI maneuver postoperatively. The performance of the SMI maneuver, with or without mechanical devices, should be monitored by the nurse to insure proper production of a sustained inspiration with a 3-second inspiratory hold.

REFERENCES


AUTHOR

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