# Postoperative Incentive Spirometry Use

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# abstract

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The authors hypothesized that the use of incentive spirometry by orthopedic patients is less than the recommended level and is affected by patient-related factors and type of surgery. To determine its postoperative use, the authors prospectively surveyed all patients in their institution's general orthopedic ward who had undergone elective spine surgery or total knee or hip arthroplasty during a consecutive 3-month period in 2010, excluding patients with postoperative delirium or requiring a monitored bed. All 182 patients (74 men, 108 women; average age, 64.5 years; range, 32-88 years; spine group, n=55; arthroplasty group, n=127), per protocol, received preoperative spirometry education by a licensed respiratory therapist (recommended use, 10 times hourly) and reinforcement education by nurses. Patients were asked twice daily (morning and evening) regarding their spirometry use during the previous 1-hour period by a registered nurse on postoperative days 1 through 3. All data were collected by the same 2 nurses using the same standardized questionnaire. Spirometry use was correlated with surgery type, postoperative day/time, and patient's age and sex. Student's t test, Spearman test, and one-way analysis of variance were used to compare differences (P < .05). Spirometry use averaged 4.1 times per hour (range, 0-10 times). No statistical correlations were found between spirometry use and age. Sex did not influence spirometry use. The arthroplasty group reported significantly higher use than did the spine group: 4.3 and 3.5 times per hour, respectively. Mean use increased significantly between postoperative days 1, 2, and 3.



Figure: Incentive spirometry device.

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ostoperative fever after major orthopedic surgery can be a substantial source of morbidity and cost. In the orthopedic literature, several studies focusing on patients undergoing total hip or total knee arthroplasties have shown that postoperative fever affects approximately 15% of the population. 1,2 One study showed that the average cost of a positive fever workup in patients who had undergone total knee or hip arthroplasty was \$3358 per patient, not including the cost associated with additional hospital stay.<sup>2</sup> Similarly, in patients undergoing spine surgery, postoperative fever has been reported to occur in >42% of the patients and is associated with expensive workups.3

Most cases of fever in the immediate postoperative period after major orthopedic surgery have been attributed to normal inflammatory response mediated by local and systemic release of endogenous pyrogens, rather than infectious causes.4-6 In cases where infection is a concern, postoperative pulmonary complications (eg, pneumonia) are a leading cause of the infectious complication; in a large study of 13,872 cases of primary total knee arthroplasty patients in California, 21 patients had fever workup consistent with postoperative pneumonia.<sup>7</sup> Similarly, in another study of 3475 patients who underwent spine surgery, postoperative pneumonia was found in approximately 1%.8

The incentive spirometry device relies on sustained maximal breathing and is thought to prevent the development of atelectasis. Therefore, it is used for prophylaxis against postoperative pulmonary complications, as established by several groups in the 1970s. 9,10 One study, reporting results of a survey of medical directors of respiratory therapy departments of 289 hospitals across the United States in which cardiothoracic and abdominal surgery were performed, found that 95% routinely used incentive spirometry in postoperative care. Recent large systematic reviews focusing on incentive spirometer use after

abdominal surgery<sup>12</sup> and coronary artery bypass graft<sup>13</sup> have reported that there is no strong evidence for reducing pulmonary complications. However, from these studies, it remains unclear whether the nonbenefit is because of the lack of patient use of the device or because of an inherent lack of the device's effectiveness. In the current study, the authors aimed to clarify the issue of patient compliance in the use of the incentive spirometry device.

To the authors' knowledge, no studies in the orthopedic literature analyze the extent of incentive spirometry use in the orthopedic patient population or the factors that are correlated with patient compliance in using the incentive spirometry device. The authors hypothesized that use of such devices by orthopedic patients is far less than the recommended level and is affected by patient age and sex, surgery type, and postoperative day and time.

### **MATERIALS AND METHODS**

Institutional Review Board approval was obtained for this study. During a consecutive 3-month period in 2010, the authors prospectively surveyed all patients in their institution's general orthopedic ward who had undergone elective orthopedic spine or elective total joint arthroplasty surgery regarding their postoperative use of incentive spirometry devices. Patients transferred to a monitored setting or patients with postoperative delirium were excluded from the study.

Of the 182 patients included in the study (mean age at surgery, 64.5 years; range, 32-88 years), 55 (30%) had undergone elective spine surgery (20 cervical, 2 thoracic, and 33 lumbar surgeries) and 127 had undergone elective total knee (n=67) or hip (n=60) arthroplasties. In the cervical spine, all cases were spinal fusions; 14 patients had an anterior decompression and fusion procedure, and 6 patients had a posterior decompression and fusion procedure. The average number of cervical levels operated on were 1.9 anteriorly and 3.0 posteriorly. In the thoracic spine, both



**Figure 1:** AirLife Volumetric Incentive Spirometer BAX001902A device (Carefusion Solutions, San Diego, California).

patients had spinal fusion. In the lumbar spine, 20 patients had spinal fusion and 13 had decompression only.

On the day of surgery, all patients received an education session with a licensed respiratory therapist about the benefits and technique of incentive spirometry use and the recommended use of 10 times per hour when awake, a value arbitrarily set by a previous study. 10 Air-Life Volumetric Incentive Spirometer BAX001902A devices (Carefusion Solutions, San Diego, California) (Figure 1) were distributed to the patients on arrival to their rooms in the ward. Patients were further educated in the ward by their assigned nurse because incentive spirometry device use frequency was included in the postoperative orders. All patients were on a standardized patient-controlled analgesia protocol for postoperative pain control, which involved the use of intravenous narcotic pain medication on postoperative day 1 and then a transition to oral pain medication as tolerated per patient request.

Patients were asked about their incentive spirometry use during the previous 1-hour period, once during the morning (before lunch) and once during the evening (before dinner), by a registered nurse (M.L.V., N.N.S.) during postoperative days 1 through 3. All data were collected

by the same 2 nurses using a standardized questionnaire. Incentive spirometry use was then correlated with patient age and type of orthopedic surgery and postoperative day and time.

The Spearman test was used to check the correlation between patient age and average incentive spirometry use per hour. Student's t test was used to calculate the difference in incentive spirometry use between the 2 sexes and between morning and evening measurements and for the difference in incentive spirometry use between the spine surgery and arthroplasty groups. One-way analysis of variance was used to analyze the relationship between the postoperative day and incentive spirometry use. Statistical significance was set at P < .05. All statistical analyses were performed using Stata/SE version 11.0 statistical software (Stata Corp LP, College Station, Texas).

# RESULTS Overall Incentive Spirometry Use

Mean incentive spirometry use reported was 4.1 times per hour (range, 0-10 times) (Figure 2). Eighteen (9.9%) patients reported using the incentive spirometry device at least 10 times per hour. Nineteen (10.4%) patients reported not using the device at all.

#### Role of Age and Sex

No statistical correlations were found between incentive spirometry use and age (Spearman correlation=-0.019; P=.7993). No statistical differences were found between men and women in average incentive spirometry use (P=.4936).

# Type of Orthopedic Surgery

Mean incentive spirometry use in patients undergoing elective spine surgery was 3.5 times per hour (range, 0-10 times). No statistically significant differences were found in use between patients who underwent cervical and lumbar spine surgery (P=.7553). No significant difference was found in incentive spirometry

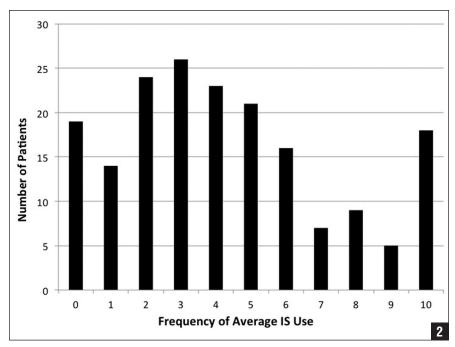


Figure 2: Distribution of incentive spirometry use in all patients. Abbreviation: IS, incentive spirometer.

use between the anterior vs posterior cervical approaches (P=0.9). No significant difference was found in average incentive spirometry use between the lumbar spine surgery patients who had fusion vs decompression only (P=0.1). Mean incentive spirometry use in patients undergoing elective total joint arthroplasty was 4.3 times per hour (range, 0-10 times). Patients undergoing total joint arthroplasty reported significantly higher use than did those undergoing spine surgery (P=.014). However, no difference was found between patients undergoing total hip and total knee arthroplasty (P=0.267).

# **Influence of Postoperative Day and Time**

Mean incentive spirometry use differed significantly over postoperative days 1, 2, and 3 (P=.0085): 3.6 times per hour (range, 0-10 times), 4.4 times per hour (range, 0-10 times), and 4.6 times per hour (range, 0-10 times), respectively.

Patients reported a significantly higher average incentive spirometry use in the

evening than in the morning (P=.0013): 4.6 times per hour (range, 0-10 times) vs 3.7 times per hour (range, 0-10 times), respectively.

# Comparison of Most and Least Compliant Patients

Thirty-one (17%) patients reported using incentive spirometry at least 8 times per hour during their hospital stay. Average age of these patients was 64.3 years (range, 42-88 years). Of these patients, 10 (32%) had undergone spine surgery and 21 had undergone total joint arthroplasty. Only 18 (10%) patients used incentive spirometry as recommended (ie, 10 times per hour).

Fifty-nine (32%) patients reported using incentive spirometry <2 times per hour during their hospital stay. Average age of these patients was 64.2 years (range, 32-86 years). Of these patients, 25 (42%) had undergone spine surgery and 34 had undergone total joint arthroplasty.

No statistical difference was found in the average age (P=.9889), percentage of women (P=.175), or proportion of spine surgery patients (P=.3496) between the 2 compliance groups.

#### DISCUSSION

Incentive spirometry use has gained substantial popularity and is routinely used in postoperative care since it was first introduced by Bartlett et al<sup>9</sup> in the early 1970s. It was proposed that this device would help prevent postoperative pulmonary complications by encouraging sustained alveolar inflation and maintenance of normal functional residual capacity. Studies in the cardiac and abdominal literature have shown benefits of incentive spirometer use for reducing pulmonary complications over intermittent positive-pressure breathing. 14,15 However, a recent analysis conducted by the Cochrane group showed that the use of incentive spirometry was not effective for the prevention of postoperative pulmonary complications after upper abdominal surgery.<sup>12</sup> Other studies focusing on incentive spirometry use in postoperative cardiothoracic patients also did not show a benefit in preventing pulmonary complications. 13,16,17

However, from these studies, it remains unclear whether the nonbenefit of the incentive spirometer is because of a lack of patient compliance with the device or an inherent ineffectiveness of the device. Based on an understanding of the pathogenesis of postoperative atelectasis, it is plausible that deep breathing exercises, which the device is designed to promote, would help prevent atelectasis-related complications. 9.10,18,19 The current authors hypothesized that it is more likely that the lack of incentive spirometer device use explains the nonbenefit results and chose to study patient compliance in their own orthopedic population.

In the current study of 182 consecutive patients undergoing elective hip or knee arthroplasty or elective spine surgery, incentive spirometry use was far less than what is recommended: only 1 patient in 10 met the recommended usage level (10 times per hour), only 1 in 6 patients used the device >7 times per hour, and approximately one-third of patients used the de-

vice <2 times per hour or not at all. Multiple reasons were hypothesized for the poor compliance observed in the study.

First, the main reason for lack of compliance, especially on the first postoperative day, may be that patients often experience pain, lack of activity drive, and residual sedation from anesthesia in the first 24 hours after surgery. Such fatigue and pain may limit a patient's motivation and ability to use the incentive spirometry device. Based on this hypothesis, one would expect an increase in spirometry use as patients recover from their fatigue and pain, an expectation supported by the current study data: each subsequent postoperative day had statistically higher compliance with incentive spirometry use than the previous day.

Second, patients undergoing spinal surgery may experience an additional level of discomfort, leading to decreased incentive spirometry use, compared with patients undergoing arthroplasty procedures, because spinal procedures involve core muscles. The study data are consistent with this hypothesis: patients undergoing spine surgery had significantly lower compliance with incentive spirometry use than did patients undergoing total hip or knee arthroplasty. However, a difference was not found in incentive spirometry use between patients undergoing lumbar vs cervical spine surgery.

Age and sex were not correlated with incentive spirometry use, and a distinct subpopulation of patients (32% of all patients) stayed noncompliant (≤2 uses of the incentive spirometry device per hour) during their entire hospital stay. Several reasons may exist for this finding: (1) they may have had higher levels of pain or fatigue than their compliant peers; (2) they may not have received an adequate understanding of the benefits of incentive spirometry use during their preoperative education session; and (3) they may not have received adequate in-hospital encouragement to use the incentive spirometry device provided.

One potential limitation of this study was that incentive spirometry use was determined based solely on patient reporting to the nurse. The device did not have the capacity to record use, primarily because of cost constraints. Although digital incentive spirometer devices are available on the market, they typically cost 5 to 7 times more and are not routinely used in most large medical institutions. Another limitation is that differences in intraoperative anesthesia medications, as well as amount of postoperative analgesia used, may have played a role, particularly on postoperative day 1. However, intraoperative and postoperative protocols are largely standardized at the authors' institution, with general endotracheal anesthesia and postoperative patient-controlled analgesia used in standardized protocols in most patients. Patients with postoperative delirium were not included in the study.

### **CONCLUSION**

Compliance with incentive spirometry use in the orthopedic patient population was poor and was largely influenced by type of orthopedic surgery performed and postoperative day. Because postoperative pulmonary complications such as atelectasis, fever, and pneumonia continue to affect outcomes after major orthopedic surgery, including total joint arthroplasty<sup>1,2,4,5,7,20</sup> and spine surgery,<sup>3,6</sup> a need exists for improved preoperative and in-hospital counseling strategies regarding incentive spirometry use and for objective measurements for monitoring incentive spirometry use and potential confounding variables. O

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