Patient Factors Associated with Successful Incentive Spirometry

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ABSTRACT

BACKGROUND: Incentive spirometers (IS) are commonly prescribed after various surgical procedures with the intended effect of reducing postoperative pulmonary complications. Factors associated with correct use of IS by postoperative patients has not previously been studied.

METHODS: A cross-sectional analysis of postoperative patients was completed to assess whether patients knew how to correctly inhale on their IS. For each patient, the following variables were collected: whether the device was within arm's reach of the patient, if the patient reported having used their IS, if they considered the IS to be helpful, and if they felt more confident using IS after a brief educational intervention was performed by study investigators.

RESULTS: A total of 26.2% (11/42) of patients failed to use their IS correctly, and 38.1% (16/42) denied ever using the device in their postoperative care. Device location, perceived benefit, and previous use were identified as statistically significant determinants of successful use. Following a brief educational intervention by a physician, 73.8% (31/42) of patients were more confident in their ability to use IS during the remainder of their care.

DISCUSSION: A substantial portion of postoperative patients failed to correctly utilize their IS. Device proximity to the patient, patient perspectives on potential benefits of IS, and previous use of the device may affect correct use. Patient education and optimization of device placement should be considered to increase compliance during IS implementation.

KEYWORDS: Incentive spirometry; patient perspectives; device placement; quality improvement; patient factors; respiratory care; postoperative pulmonary complications

INTRODUCTION

Incentive spirometers (IS) are disposable, plastic devices (**Figure 1**) that are prescribed to reduce postoperative pulmonary complications (PPCs) through facilitating the generation of sustained maximal inspiration. IS was developed in the 1970s, after observations that yawning may have a respiratory benefit for postoperative patients.[1] Guidelines from the American Association for Respiratory Care recommend IS for patients undergoing thoracoabdominal surgery, with limited postoperative mobility, prolonged bed rest, and for those with risk factors including COPD who may face increased risk of atelectasis, pneumonia, and other PPCs.[2]

Figure 1. An incentive spirometer

Proper IS use requires patients to perform a slow, continuous inhalation on their device for at least five seconds followed by a breath-hold and normal expiration. This deep inspiratory maneuver is thought to promote pulmonary hygiene through opening a de-recruited lung. For patients with recent thoracoabdominal injury or surgery, taking deep breaths may be painful,[2] which may worsen atelectasis, PPCs, and IS use adherence.

Though IS is a mainstay of postoperative care, recent guidelines indicate that routine IS use after surgery is controversial due to lack of supportive evidence.[2] Numerous

studies evaluating the effects of IS on clinical outcomes, including multiple meta-analyses, have demonstrated that IS's clinical effectiveness remains uproven.[3-9] A recent randomized controlled trial evaluating the effect of IS after bariatric surgery was unable to demonstrate any effect on postoperative hypoxemia or rates of PPCs.[10] However, in combination with patient education, IS has been shown to reduce rates of PPCs and unplanned intubations.[11] The lack of definitive evidence in the literature has been attributed to methodological flaws in previous study design,[12] the possibility that IS is not clinically effective[10], and most notably, an absence of reported data on subject adherence.[13]

As with all patient-administered therapies, adherence is an essential component of IS therapy and thus an essential component for evaluating the benefit of postoperative incentive spirometry. However, a recent large national survey of respiratory therapists and nurses from academic societies including the American Association for Respiratory Care, the Academy of Medical-Surgical Nurses, the American Society of Peri-Anesthesia Nurses, and the American Association of Critical-Care Nurses highlights the fact that though 91.1% of surveyed providers believe IS should be used postoperatively,[14] 86.0% believe that patient adherence remains poor.[15] As with all patient-administered therapies, adherence and correct utilization are essential components of IS therapy and thus essential components for evaluating evidence on the benefits of postoperative incentive spirometry.

As no prior studies have evaluated the proper use of IS by patients, the objective of the present investigation was to evaluate the rates of proper use amongst patients and identify factors that may be associated with successful use. It was hypothesized that many patients would not know how to use their IS correctly.

METHODS

This study was exempted from institutional review board review and completed as part of a quality improvement effort. A cross-sectional analysis was completed on postoperative patients on the orthopedic surgery service at Rhode Island Hospital, where emergent and elective spine, trauma, adult reconstruction, upper extremity, foot and ankle, and sports medicine adult patients are managed. All patients were prescribed IS as part of their standard of postoperative care and therefore eligible for inclusion. Data were collected prospectively over two, randomly selected days in November and December 2017 from patients in various stages of recovery.

On first entering each patient's room, the location of IS was determined by whether the device was within arm's reach (1 meter) of the patient. Patients were immediately asked to demonstrate use of their IS. If the patient inhaled on their first attempt, then it was noted as a "success"; if they exhaled, then it was noted as "unsuccessful." Investigator physicians then provided each patient with approximately two minutes of educational coaching, instructing patients to 'slowly take as deep of a breath in as possible' in accordance with relevant clinical guidelines.[2] Following the brief educational session, patients were asked several questions (**Table 1**).

Table 1. Patient questions

Question	Variable
Have you ever used your incentive spirometer?	Previous Use
Do you believe your incentive spirometer will be helpful in your recovery?	Perceived Benefit
Do you feel like you know how to use your incentive spirometer better now than you did before?	Confidence Improvement

Descriptive statistics were calculated for each of the categorical variables assessed by this study: (1) *Device Location*, (2) *Patient Success*, (3) *Previous Use*, (4) *Perceived Benefit*, and (5) *Confidence Improvement*. It was hypothesized that having IS within arms' reach, endorsing previous use, and perceiving IS as beneficial in recovery may be associated with successful IS. Probabilities of successful IS use and their 95% confidence intervals were calculated using the binomial distribution and tested against the null hypothesis that probability of success is equivalent to chance, or 50%, with Bonferroni's correction for multiple tests. Subsequently, contingency tables were generated between *Device Location, Previous Use, and Perceived Benefit*; Fisher's exact test was used to assess each relationship. Similarly, Bonferroni's correction was applied to address Type I error. Without existing data available on correct IS use rates, power analysis could not be performed *a priori*; therefore, all available patients were evaluated on the days data collection was performed.

Patient Success was also cross-tabulated with *Confidence Improvement* to assess the effect of the brief education intervention within and between each sub-group. It was hypothesized that patients who were initially unsuccessful at IS demonstration would be more likely to rate their procedural confidence as improved. Fisher's exact test was used to test the significance of the odds ratio.

RESULTS

A total of 42 consecutive postoperative patients were included, each of whom had IS prescribed. All participants successfully completed the survey (response rate – 100% (42/42)).

Incentive Spirometry Assessment and Use

A total of 26.2% (11/42) of patients failed to correctly use the IS on their first attempt. Furthermore, the device was located outside of the patients' reach in 23.8% (10/42) of rooms (**Table 2**).

Of the patients who had their IS within arms' reach, 81.3% (26/32) demonstrated successful use whereas of those whose

Table 2. Initial IS assessment

Initial IS Demonstration	
Inhales – Successful	*Exhales – Unsuccessful*
73.8% (31/42)	26.2% (11/42)
Device Location	
Within Reach	*Outside of Reach*
76.2% (32/42)	23.8% (10/42)

device was outside of their reach only 50.0% (5/10) demonstrated successful use (**Table 3).** Similarly, 84.6% (22/26) of patients who had previously used the device demonstrated successful use compares to 56.3% (9/16) of patients with no prior experience. Lastly, patients who perceived the device as useful demonstrated more successful use of the device compared to those who didn't (78.6% (22/18) v. 64.3% (9/14), respectively) (**Table 3**).

Probabilities of successful IS use (i.e., inhale v. exhale), were significantly greater than chance for patients who had their IS within arms' reach at the time of assessment, endorsed previous IS use, and in those who perceived IS as helpful for their recovery (P<0.01, P<0.01, and P=0.022, respectively) (**Figure 2**). In contrast, patients in each complementary group were likely to perform IS successfully at a rate no greater than chance.

Relationship between Patient Factors

Though 38.1% (16/42) of patients denied using the device during their postoperative care, 66.7% (28/42) believed that IS would be helpful in their recovery (**Figure 3).**

Figure 2. Drivers of successful IS

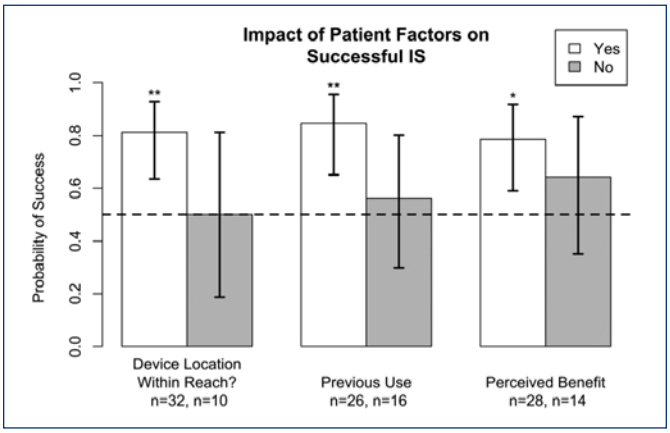

Figure 3. Patient-reported data

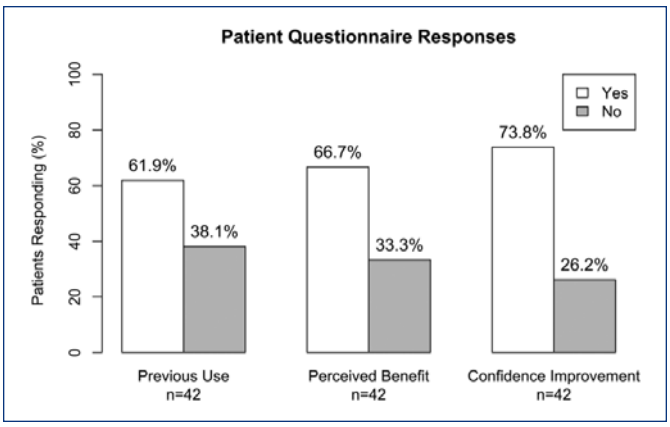

Table 3. Rates of successful IS

	Initial IS Demonstration				
	Successful Inhales	Unsuccessful Exhales	Probability of Success [95% CI]	P-Value	Bonferroni-Adjusted P-Value
Device Location					
Within Reach (n=32)	81.3% (26/32)	18.7% (6/32)	[0.636, 0.928]	<0.001	<0.01
Outside of Reach (n=10)	50.0% (5/10)	50.0% (5/10)	[0.187, 0.813]	>0.99	>0.99
Previous Use					
Yes (n=26)	84.6% (22/26)	15.4% (4/26)	[0.651, 0.956]	<0.001	<0.01
No (n=16)	56.3% (9/16)	43.7% (7/16)	[0.299, 0.802]	0.80	>0.99
Perceived Benefit					
Yes (n=28)	78.6% (22/28)	21.4% (6/28)	[0.590, 0.917]	<0.01	0.022
No (n=14)	64.3% (9/14)	35.7% (5/14)	[0.351, 0.871]	0.42	>0.99

Table 4. Cross-tabulation of patient factors

	Perceived Benefit		**Fisher's exact test**	
	Yes (n=28)	*No (n=14)*	*P-Value*	*Bonferroni-Adjusted P-Value*
Device Location				
Within Reach	89.3% (25/28)	50.0% (7/14)	<0.01	0.025
Outside of Reach	10.7% (3/28)	50.0% (7/14)		
Previous Use				
Yes	75.0% (21/28)	35.7% (5/14)	0.020	0.0602
No	25.0% (7/28)	64.3% (9/14)		
	Previous Use			
	Yes (n=26)	No (n=16)		
Device Location				
Within Reach	84.6% (22/26)	62.5% (10/16)	0.14	0.43
Outside of Reach	15.4% (4/26)	37.5% (6/16)		

Further analysis demonstrated that 43.8% (7/16) of patients who denied using their IS believed it would be helpful in their recovery (**Table 4**).

Contingency table analysis demonstrated a significant association between *Device Location* and *Perceived Benefit* (P<0.01). Additionally, the association between *Previous Use* and *Perceived Benefit* was shown to trend towards significance (P=0.060) (**Figure 4**).

Figure 4. Inter-related patient factors surrounding IS use

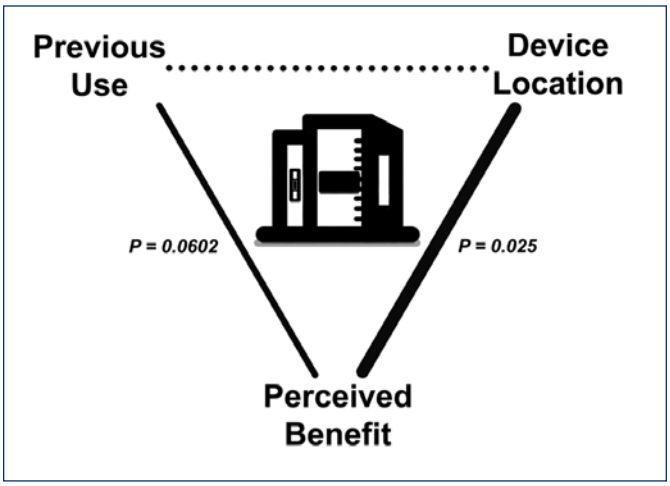

ILLUSTRATION BY THOMAS J. MARTIN

Educational Intervention

Following a brief educational intervention, 73.8% (31/42) of patients reported that they understood better how to use their IS (**Table 5**). This finding was consistent across patient sub-groups as 71.0% (22/31) of subjects that were initially successful and 81.8% (9/11) that were initially unsuccessful at IS both affirmed increased procedural confidence after the brief educational intervention. Contrary to our hypothesis, analysis by Fisher's exact test demonstrated that *Confidence Improvement* and *Patient Success* were not related (P = 0.70).

Table 5. Cross-tabulation of patient factors

	Patient Success		Odds Ratio	Fisher's exact test
	Successful Inhales (n=28)	Unsuccessful Exhales (n=14)	OR [95%CI]	P-Value
Confidence Improvement				
Yes (n=31)	71.0% (22/31)	81.8% (7/31)	0.551 [0.0487, 3.51]	0.70
No (n=11)	29.0% (4/26)	18.2% (6/16)		

DISCUSSION

A cross-sectional analysis of patients was completed to evaluate the correct use of IS and factors associated with successful use. Over a quarter of the patients did not know how to use their device properly prior to the investigators' educational intervention. Device location within arm's reach, prior patient use, and perceived patient benefit were identified as drivers of successful use. These inter-related patient factors surrounding postoperative IS may also affect use frequency or compliance.

Over one-third of patients denied using IS during their postoperative care. This finding is consistent with the low patient-reported use demonstrated in a recent trial examining the effects of postoperative IS use after bariatric surgery.[10] In order to draw meaningful conclusions from the existing evidence on the use of IS, an accurate reporting of patient adherence is required. However, Narayanan et al. reported that of 36 randomized controlled trials evaluating IS between 1972 and 2015, only 16.7% included such reports on patient compliance.[13] Furthermore, patients cannot be compliant with IS as a therapy if their use of the device is incorrect. Hence, future IS investigations need not only assess compliance but also if that compliance reflects correct use.

Further, this investigation highlighted certain discrepancies that may exist between patients' beliefs and their use of IS in the postoperative setting. For example, nearly half of the patients who denied ever using their device believed that doing so would be helpful in their recovery. If IS does reduce the rate of postoperative pulmonary complications, then it is important to assess factors associated with successful use and determine how to increase patient adherence to prescribed guidelines. The majority of the patients in the present investigation responded positively to a brief education session with increased procedural confidence, *independent* of their initial ability to use IS successfully. A previous investigation demonstrated that a patient education intervention around IS was associated with reduced rates of postoperative pneumonia and unplanned reintubations.[11] Patient education and device location should be considered during IS implementation; nurses and respiratory therapists might consider spending additional time educating patients whose IS is located outside of their reach.

Although patient factors (e.g., postoperative day number, procedure type, emergent vs. elective surgery, general vs. regional anesthesia, patient age, patient cognitive status) were not collected, the design of this cross-sectional analysis ensures that presented data are representative of the population at that point in time. The data collection occurred on randomly selected days at a large accredited academic medical center, where standard of care and procedures are provided. An interesting study would be to evaluate the interaction effects of general vs. regional anesthesia on postoperative cognitive impairment and patient ability to follow instructions and use IS correctly. Additionally, the ability

of healthcare professionals to successfully provide patient education on correct use should be evaluated and considered in future studies.

To more definitively evaluate the effectiveness of IS, additional well-designed clinical studies are needed that account for both compliance and correct use – these factors may have significant impact on patient outcomes. In the interim, providers should aim to improve patient education on appropriate IS use and to optimize device placement within patient rooms.

References

1. Bartlett RH, Krop P, Hanson EL, Moore FD. Physiology of yawning and its application to postoperative care. Surg Forum 1970;21:222-224.
2. Restrepo RD, Wettstein R, Wittnebel L, Tracy M. Incentive spirometry: 2011. Respir Care 2011;56(10):1600-1604.
3. Thomas JA, McIntosh JM. Are incentive spirometry, intermittent positive pressure breathing, and deep breathing exercises effective in the prevention of postoperative pulmonary complications after upper abdominal surgery? A systematic overview and meta-analysis. Phys Ther 1994;74(1):3-10; discussion 10-16.
4. Overend TJ, Anderson CM, Lucy SD, Bhatia C, Jonsson BI, Timmermans C. The effect of incentive spirometry on postoperative pulmonary complications: a systematic review. Chest 2001;120(3):971-978.
5. Agostini P, Singh S. Incentive spirometry following thoracic surgery: what should we be doing? Physiotherapy 2009;95(2):76-82.
6. Carvalho CR, Paisani DM, Lunardi AC. Incentive spirometry in major surgeries: a systematic review. Rev Bras Fisioter 2011;15(5):343-350.
7. Freitas ER, Soares BG, Cardoso JR, Atallah AN. Incentive spirometry for preventing pulmonary complications after coronary artery bypass graft. Cochrane Database Syst Rev 2012(9):CD004466.
8. Rupp M, Miley H, Russell-Babin K. Incentive spirometry in postoperative abdominal/thoracic surgery patients. AACN Adv Crit Care 2013;24(3):255-263.
9. do Nascimento Junior P, Modolo NS, Andrade S, Guimaraes MM, Braz LG, El Dib R. Incentive spirometry for prevention of postoperative pulmonary complications in upper abdominal surgery. Cochrane Database Syst Rev 2014(2):CD006058.
10. Pantel H, Hwang J, Brams D, Schnelldorfer T, Nepomnayshy D. Effect of Incentive Spirometry on Postoperative Hypoxemia and Pulmonary Complications After Bariatric Surgery: A Randomized Clinical Trial. JAMA Surg 2017;152(5):422-428.
11. Cassidy MR, Rosenkranz P, McCabe K, Rosen JE, McAneny D. I COUGH: reducing postoperative pulmonary complications with a multidisciplinary patient care program. JAMA Surg 2013;148(8):740-745.
12. Branson RD. The scientific basis for postoperative respiratory care. Respir Care 2013;58(11):1974-1984.
13. Narayanan AL, Hamid SR, Supriyanto E. Evidence regarding patient compliance with incentive spirometry interventions after cardiac, thoracic and abdominal surgeries: A systematic literature review. Can J Respir Ther 2016;52(1):17-26.
14. Eltorai AEM, Baird GL, Eltorai AS, Pangborn J, Antoci V, Jr., Cullen HA, et al. Perspectives on Incentive Spirometry Utility and Patient Protocols. Respir Care 2018;63(5):519-531.
15. Eltorai AEM, Baird GL, Eltorai AS, Pangborn J, Antoci V, Jr., Cullen HA, et al. Incentive Spirometry Adherence: A National Survey of Provider Perspectives. Respir Care 2018;63(5):532-537.

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