Received: 3 October 2020 | Revised: 11 September 2021 | Accepted: 25 September 2021

DOI: 10.1111/ijn.13023

ORIGINAL RESEARCH PAPER

INTERNATIONAL JOURNAL of NURSING PRACTICE WILEY

Nurse-guided incentive spirometry use and postoperative pulmonary complications among cardiac surgery patients: A randomized controlled trial

Saja Ahmad Alwekhyan MSc, Lecturer[1] | Jafar Alasad Alshraideh PhD, Professor[2] | Khalil Moh'd Yousef PhD, Associate Professor[2,3] | Ferial Hayajneh PhD, Professor[2]

[1]Princess Muna College of Nursing, Mutah University, Mu'tah, Jordan

[2]School of Nursing, University of Jordan, Amman, Jordan

[3]School of Humanities, Social Sciences and Health University of Wollongong, Dubai

Correspondence
Jafar Alasad Alshraideh, School Of Nursing, University Of Jordan, Amman, Jordan.
Email: jalasad@ju.edu.jo

Funding information
University of Jordan

Abstract

Aims: To assess the effect of nurse-guided use of incentive spirometer on postoperative oxygenation and pulmonary complications after coronary artery bypass graft surgery.

Background: Deep breathing exercises have been shown to improve postoperative lung expansion and reduce pulmonary complications. An incentive spirometer is a deep breathing exercises device that imitates continuous sigh-like maximal inspiration.

Design: Randomized control trial, two groups nonblinded parallel design.

Methods: A total of $n = 89$ eligible patients were randomized to either control or intervention group. Patients in the intervention group received bihourly nurse-guided incentive spirometry for 48-h postextubation. The endpoints were: the number and duration of hypoxic events during the first 24-hr postsurgery, pneumonia and pulmonary function parameters. Data were collected May to September 2019.

Results: Patients in the intervention group had a significantly lower mean number of hypoxic events with shorter duration and shorter length of stay in the hospital and the ICU. Patients in the intervention group also had greater postoperative forced expiratory volume in 1 second.

Conclusion: Nurse-guided use of the incentive spirometer reduces the risk of pulmonary complications and hospital length of stay after cardiac surgery.

KEYWORDS

cardiac surgery, forced expiratory volume, hypoxia, incentive spirometer, length of stay, nursing

Summary statement

What is already known about the topic?

- There are controversies regarding the effectiveness of incentive spirometers in the prevention of pulmonary complications post-cardiac and thoracic surgeries.
- Reports of patients' compliance with use of an incentive spirometer are scarce and inconsistent.

- Breathing and coughing exercises are considered key to prevent postoperative pulmonary complications.

What this paper adds?

- The use of nurse-guided incentive spirometry reduces the number and duration of postoperative hypoxic events, shortens intensive care unit and hospital length of stay and improves postoperative forced expiratory volume in 1 second.
- The use of nurse-guided incentive spirometry improves consistency of use and enhances patients' compliance.

Implications of this research

- Use of incentive spirometry after cardiac surgery improves patient outcomes.
- Use of nurse-guided incentive spirometry is better than routine care as it reduces postoperative pulmonary complications and shortens hospital length of stay.

1 | BACKGROUND AND AIM

Postoperative pulmonary complications including hypoxemia, pneumonia, atelectasis and respiratory failure are common following cardiac surgery (Perello-Diez & Paz-Lourido, 2018; Soman et al., 2018). Naveed et al. (2017) stated that as a result of their research, 3%–16% of patients after coronary artery bypass graft and 5%–7% of patients after valvular surgeries were affected by respiratory and other problems. Such complications affect pulmonary function and oxygenation level (Ji et al., 2013) and are associated with poor patient outcomes and increased cost of care (Branson, 2013; Soman et al., 2018).

Deep breathing exercises have been shown to improve postoperative lung expansion and ventilation resulting in a marked reduction in pulmonary complications (Branson, 2013). An incentive spirometer is a deep breathing exercises device that imitates continuous sigh-like maximal inspiration through slow, constant and monotonous breathing to increase lung expansion and prevent postoperative pulmonary complications. Despite reviews (Eltorai et al., 2017; Junior et al., 2014; Kotta & Ali, 2020) to integrate and unite the evidence regarding the effectiveness of incentive spirometer usage after major surgeries, evidence regarding its clinical effectiveness to prevent postoperative pulmonary complications is still inconclusive and inconsistent. Lack of sample size calculation and randomization were the main methodological flows of studies that assessed the effectiveness of incentive spirometry (Freitas et al., 2012; Narayanan et al., 2016). Such flaws may generate bias in the interpretation of results obtained from use of the incentive spirometer (Carvalho et al., 2011).

Patients' noncompliance remains one of the major issues for utilizing incentive spirometry. To build stronger evidence about incentive spirometer effectiveness in patients after major surgeries, compliance monitoring should be assessed (Matsui, 2009). Patients' forgetfulness in particular is a common cause that hinders patients' compliance with deep breathing exercises and incentive spirometer use (Eltorai, Baird, et al., 2018). Although there is no standardized method to monitor compliance, a variety of methods have been proposed such as electronic monitoring, self-reports, questionnaires or direct supervision by staff. Direct observation and monitoring by skilful staff appears to be an appropriate method in the clinical settings where time and manpower are available (Narayanan et al., 2016) However, there is a paucity of robust evidence for the contribution of nursing interventions to improve compliance with incentive spirometry, reduce complications and improve patients' outcomes post-cardiac.

This study therefore aimed to assess the effect of nurse-guided incentive spirometry use on postoperative hypoxic events (number and duration), ICU and hospital length of stay, the incidence of pneumonia and pulmonary function tests (forced expiratory volume in 1 second [FEV_1], forced vital capacity [FVC] and FEV_1/FVC%) among patients after cardiac surgery.

2 | METHODS

2.1 | Study design

Nonblinded, two groups parallel randomized controlled trial design was used with a 1:1 ratio.

2.2 | Participants and sample size

This study recruited adult patients >18 years old who were planned for elective cardiac surgery. Exclusion criteria included a previous history of asthma, chronic obstructive pulmonary disease, pulmonary hypertension and postoperative intubation for more than 48 h.

The sample size was calculated using G power software version 3.1.6 (Faul et al., 2009) based on power calculations for the Independent sample t-test (two-tailed, $\alpha = 0.05$, power = 0.8 and 0.8 effect

size). The required sample size was 26 patients per group; the actual number of patients included in the analyses was 39 patients in each group.

2.3 | Settings

The study was conducted at Queen Alia Heart Institute in the Jordanian Royal Medical Services. The institute is a 215-bed regional referral centre that offers comprehensive cardiac services. Routine care at this site entailed nurses conducting an hourly round to their assigned patients from 6 a.m. till 10 p.m. and bihourly from 10 p.m. till 6 a.m. The round policy facilitates monitoring of patients and ensuring adherence to prescribed therapeutic regimens during hospitalization.

2.4 | Interventions

The interventions were bihourly sessions for the patient's use of an incentive spirometer guided by registered nurses during the 24th to 48th hr starting from the fourth postextubation hour which is the routine time to introduce the incentive spirometer for patients after ensuring tolerance to deep breathing exercise. The session frequency, number of breaths performed per session and the volume achieved were recorded for each patient. Patients were guided to use the incentive spirometer every 2 hrs (8 sessions per day) for 48 hr with 10 breaths per session and a volume of at least 600 ml per breath. The session was continued until the desired breath was achieved.

2.5 | Control

Patients in the control group received only the routine respiratory physiotherapy and self-use of incentive spirometer from the fourth postextubation hour after cardiac surgery without nursing guidance. The routine postoperative respiratory care also included breathing and coughing exercises and intermittent positive pressure breathing as required.

2.6 | Outcome measures

The primary outcomes were as follows: the number and duration of hypoxic events (SpO_2 < 92% for more than 10 s; Berry et al., 2012) during the second 24 hr of the spirometer use and ICU and hospital length of stay. Secondary outcomes were pneumonia, and pulmonary function tests including FVC, FEV_1 and FEV_1/FVC %.

The postoperative hypoxic events were measured through the oxygen-haemoglobin saturation (SpO_2) levels using a wrist-held pulse oximeter device (AP-10, Shenzhen creative industry Co., Ltd) which provides 24-hr monitoring and data storage with a screen display of SpO_2. Data and waveforms were recorded and stored in the device every 1 s with artefact detection and exclusion. The left index finger was consistently used for all patients without any nail polish or any artificial nails. The pulse oximeter was clipped to the index finger, over the nail bed, and the patients were asked to keep their fingers immobile during measurement to avoid motion artefacts. The patient's measurements were downloaded from the device at the end of the 24-h monitoring period. Hypoxemia was defined as a SpO_2 level of less than 92% for more than 10 s. Patients in both groups had a facemask applied with a flow of oxygen set at 10 L/min for the duration of the data collection period, which is within the routine flow rate used as per institution policy for such patients.

The outcome measure of pneumonia was based on the clinical evidence of pneumonia and the medical diagnosis by the attending physician. The pulmonary function test (PFT) was performed by trained respiratory therapists. A Schiller Spirovit SP-1 spirometer was used to perform PFT according to American Thoracic Society Standards. Three technically accepted trials were performed then, the highest values were recorded. All measured pulmonary variables were compared against predicted standards for age, gender and height and expressed as predicted percentage values (Graham et al., 2019). Evaluation of pulmonary functions was performed for all patients in both study groups preoperatively on the day before the surgery and postoperatively on the third postextubation day. Length of stay after surgery was calculated in days from the first postoperative day till the day of home discharge. Data were collected from May to September 2019.

2.7 | Randomization and blinding

Eligible patients were interviewed 1 day before the scheduled surgery to introduce the study and obtain informed consent. Patients who agreed to participate in the study were randomized to either the control or intervention group using the Urn adaptive randomization method to keep the number of patients reasonably balanced in both groups as the trial progresses (Friedman et al., 2010). Small papers with numbers marked as either intervention or control were placed in an urn. If an intervention paper was drawn at random, the patient was assigned to the intervention group. The paper was returned to the urn, and another control paper was added to the urn. Whereas if a control paper was drawn at random, the patient was assigned to the control group and the paper was returned to the urn and another intervention paper was added to the urn. No blinding was applied in this study as it was not feasible due to the nature of the intervention.

2.8 | Statistical methods

Data were reviewed and analysed using IBM SPSS 23. All SpO_2 data from the oximeter were downloaded and reviewed with oximeter data manager software (V5.5.0.0). Independent samples *t*-test (two-tailed) was used to test for differences between the control and intervention groups in mean number and duration of hypoxic events, PFT and the ICU and hospital length of stay.

2.9 | Ethical considerations

The study was ethically approved by the Institutional Review Board at Queen Alia Heart Institute (Ref. 3–1–2065, 26 Feb. 2019). Patients' participation was voluntary and based on informed consent. Patients' identifiable data were not included in any report or disclosed in any form.

3 | RESULTS

The initial sample included 105 patients who were scheduled for elective coronary artery bypass graft surgery at Queen Alia Heart Institute in Jordan. All patients were contacted and invited to participate in the trial over 3 months (May to July 2019). Of those, one patient was excluded due to a history of asthma. Eighteen patients had their surgeries cancelled. Seven patients declined to participate in the study. The remaining 89 patients were randomized into two groups: 46 in the intervention group and 43 in the control. In the intervention group, five patients were noncompliant to deep breathing exercises using an incentive spirometer, and one patient had a prolonged period of endotracheal intubation for more than 48 h. In the control group, one patient missed the postoperative pulmonary functions test, one patient died in the first 24 h after surgery and two patients had a prolonged period of endotracheal intubation for more than 48 hours. Therefore, 39 patients per group were included in the statistical analysis (Figure 1).

3.1 | Baseline data

Overall, no differences were noted between the study groups in baseline characteristics as shown in Tables 1 and 2. Both groups had similar baseline demographic characteristics.

The mean age of the sample was 57.4 ± 8.1 years. The majority of the sample were male (92.3%) and smokers (61.5%). The preoperative pulmonary function variables included FVC, forced expiratory volume in 1 s (FEV_1) and their ratio (FEV_1/FVC). The sample means ±SD for these parameters were (3.6 ± .9, 5.5

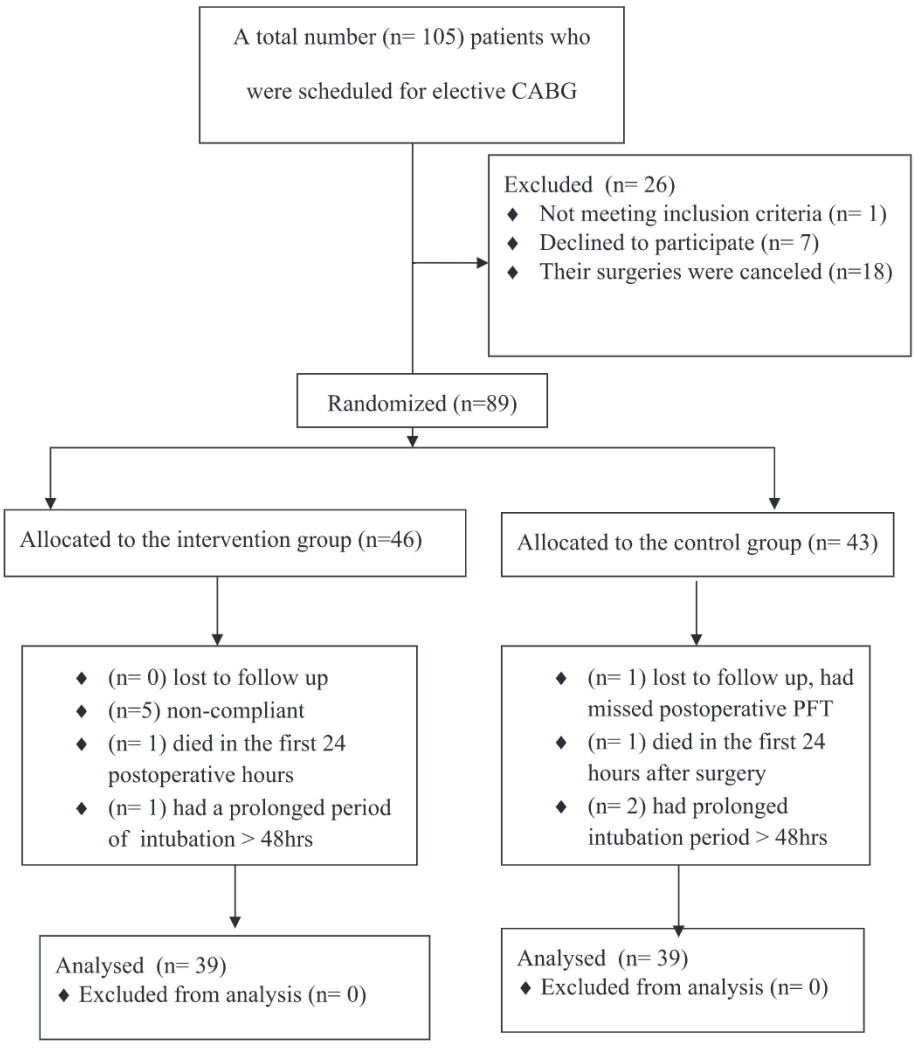

FIGURE 1 Flow diagram of the study design and enrollment

TABLE 1 Demographic characteristics of the intervention and the control group

Demographic variables	Intervention $n = 39$ N (%)	Control $n = 39$ N (%)	Total $n = 78$ N (%)	Test used	Test value	P value
Sex				Fisher exact test	.00	1.00
a. Males	36 (92.3)	36 (92.3)	72 (92.3)			
b. Females	3 (7.7)	3 (7.7)	3 (7.7)			
Educational level				Chi square test		
a. Illiterate	0 (0)	3 (7.7)	3 (3.8)			
b. Primary	3 (7.7)	8 (20.5)	11 (14.1)			
c. Secondary	22 (56.4)	16 (41)	38 (48.7)			
d. Graduate and above	14 (35.9)	12 (30.8)	26 (33.3)			
History of smoking				Chi square test	1.56	.46
a. Smokers	22 (56.4)	26 (54.2)	48 (61.5)			
b. Nonsmoker	14 (35.9)	9 (23.1)	23 (29.5)			
c. Quit-smoking	3 (7.7)	4 (10.3)	7 (9)			
Age in years M + SD	57.4 ± 8.2	57.4 ± 8.1	57.4 ± 8.1	Independent samples *t*-test	−.01	.99
Height (m) M ± SD	1.7 ± .07	1.7 ± .07	1.7 ± .07	Independent samples *t*-test	−.14	.89
Weight (kg) M ± SD	78.6 ± 12.3	82.5 ± 17.3	80.5 ± 15.0	Independent samples *t*-test	−1.15	.25
BMI M ± SD	27.4 ± 4.0	28.6 ± 5.1	28.0 ± 4.6	Independent samples *t*-test	−1.14	.26

Abbreviation: BMI: body mass index.

TABLE 2 Preoperative pulmonary function, intra-operative and postoperative variables of the intervention group and the control group

Variables	Intervention $n = 39$ Mean (SD)	Control $n = 39$ Mean (SD)	Total $n = 78$ Mean (SD)	*t* value (df)	*p* value (two-tailed)
Pulmonary function variables					
FVC	3.69 (.97)	3.57 (.88)	3.63 (.92)	.60 (76)	.55
FEV_1	3.09 (.86)	7.97 (31.24)	5.53 (22.09))	−.97 (76)	.33
FEV/FVC	83.18 (7.06)	82.17 (9.70)	82.68 (8.45)	.53 (76)	.60
Duration of surgery (minutes)	246.41 (49.40)	266.41 (52.94)	256.41(51.85)	−1.725 (76)	.09
Number of grafts	3.21 (.70)	3.21 (.73)	3.21 (.71)	.00 (76)	1.00
ACX duration (min)	53.54 (20.74)	67.33 (24)	60.44 (23.78)	−2.661 (76)	.01
CBP duration (min)	84.38 (27.27)	96.82 (86.54)	90.60 (32.63)	−1.70 (70.30)[a]	.09
Mechanical ventilation duration (HH:MM)	12:31 (2:55)	13:50 (3:63)	13:10 (3:19)	−1.77 (76)	.08

Abbreviations: ACX: aortic cross-clamp; CBP: cardiopulmonary bypass pump; FEV_1: forced expiratory volume in 1 s; FVC: forced vital capacity.
[a]Levene's test for equality of variances was significant ($P > 0.05$) so separate variances were assumed as the results reported.

± 22.1, 82.7 ± 8.4), respectively. No significant differences were found between study groups in the preoperative pulmonary function variables.

The operative and postoperative variables included the duration of surgery in minutes, number of grafts, aortic cross-clamp duration in minutes, cardiopulmonary bypass pump duration in minutes and duration of mechanical ventilation in hours and minutes (HH: MM). The sample's mean ±SD number of grafts was 3.2 ± .7 with a range of (2–5). The mean duration of surgery was 256.4 ± 51.9 with a range of (180–240). The mean length of the cardiopulmonary bypass pump was 90.6 ± 32.6 with a range of (45–191). The mean duration of aortic cross-clamp was 60.4 ± 23.8 with a range of (24–117). The mean duration of mechanical ventilation duration was 13:10 ± 3:19 with a range of (9:00–23:00).

Significant differences were only noted between groups in the duration of the aortic cross-clamp. Patients in the control group had a longer mean duration of cross-clamp 67.3 ± 24.9 compared with 53.5 ± 20.7 in the intervention group ($p = 0.01$).

3.2 | Outcomes and estimation

3.2.1 | Primary outcomes

Hypoxemia occurred in all patients (100%). All patients experienced more than one episode of SpO2 < 92% for >10 s. Additionally, the results showed significant differences between both study groups. Patients in the intervention group had lower mean number of hypoxic events (9.4 ± 7.6) compared with the control group (30.9 ± 26.2), (t (44.4) $= -5.0$, $p < 0.001$). Furthermore, patients in the intervention group had a lower mean duration of hypoxemia (00:36:17 ± 00:32:15) compared with patients in the control (02:56:05 ± 02:28:16), (t (41.6) $= -5.8$, $P < 0.001$), Table 3.

Frequency of postoperative pneumonia: One patient (2.6%) developed pneumonia in the intervention group compared with seven patients (17.9%) in the control group. No statistical analyses were performed due to a small number of patients.

Postoperative pulmonary function variables on the third-day postextubation: A statistically significant decrease in FEV_1 was noted in the control group. However, there were no statistically significant differences between the intervention and the control group in postoperative FVC and FEV_1/FVC%. Patients in the control group had a greater decrease in the postoperative mean FEV_1 (1.8 ± 0.7) compared with the intervention group (2.2 ± 0.7) (t (2.1(76.0)), $p = 0.04$), see Table 4.

3.2.2 | Secondary outcomes: Postoperative hospital and ICU length of stay

The mean ±SD length of stays in the hospital (8.6 ± 3.7) and the ICU (1.8 ± .8) among patients in the intervention group were shorter than those mean ±SD in the control group (12.0 ± 7.7 and 12.0 ± 7.7, respectively), all $p < 0.05$ (Table 5).

3.3 | Harms

During the study period, no physical or psychological harm to participants were observed.

4 | DISCUSSION

Our findings suggest that use of nurse-guided incentive spirometer reduces the frequency and duration of hypoxemia episodes after coronary artery bypass graft surgery and decreases both the ICU and hospital length of stay. Although pneumonia occurred more frequently in the control group, the sample size was too small to detect statistically significant differences between the study groups.

4.1 | Monitoring Incentive Spirometer Use

Even though incentive spirometry is a standard postoperative intervention, it can only be effective if used by patients. This trial answers a very important clinical question: Does incentive spirometry work without healthcare professional guidance? In this trial, we report favourable results of incentive spirometry when its use is guided by

TABLE 3 Postoperative oxygenation in the intervention group and the control group

Oxygenation variables	Intervention $n = 39$ Mean (SD)	Control $n = 39$ Mean (SD)	t (df)[a]	P value (two-tailed)
Number of hypoxic events	9.4 ± 7.6	30.9 ± 26.2	−5.0 (44.4)[a]	<.001
Duration of hypoxic events (HH:MM:SS)	00:36:17 ± 00:32:15	02:56:05 ± 02:28:16	−5.8 (41.6)	<.001

[a]Levene's test for equality of variance was significant ($p < 0.05$) so equal variances were not assumed as the results reported.

TABLE 4 Postoperative pulmonary function's variables in the intervention group and the control group

Postoperative pulmonary function variables	Intervention $n = 39$ Mean (SD)	Control $n = 39$ Mean (SD)	Total $n = 78$ Mean (SD)	t (df)[a]	P value (two-tailed)
FVC	2.66 (.89)	2.31 (.90)	2.49 (.91)	1.73 (76)	.09
FEV_1	2.16 (.72)	1.82 (.71)	1.99 (.73)	2.11 (75.99)[a]	.04
FEV_1/FVC	80.30 (9.68)	81.19 (12.50)	80.75 (11.12)	−.35 (76)	.73

Abbreviations: FEV, forced expiratory volume; FVC, forced vital capacity.
[a]Levene's test for equality of variance was significant ($P < 0.05$) soequal variances were not assumed as the results reported.

TABLE 5 Hospital and intensive care unit length of stay among the intervention group and the control group

Variables	Intervention $n = 39$ Mean (SD)	Control $n = 39$ Mean (SD)	t (df)[a]	P value (two-tailed)
Postoperative hospital stay (days)	8.6 ± 3.7	12.0 ± 7.7	−2.46 (54.81)	.02
Postoperative ICU stay (days)	1.8 ± .80	12.0 ± 7.7	−3.30 (66.34)	<.001

[a]Levene's test for equality of variance was significant ($P < 0.05$) so equal variances were not assumed as the results reported.

nurses. Several authors reported similar findings. Gbiri et al. (2016) reported that the supervision and monitoring of patients to ensure their compliance with the incentive spirometer use was associated with a lower incidence of postoperative pulmonary complications. Similarly, a study by Mueenudheen et al. (2012) reported that the monitored use of incentive spirometry had a positive effect on pulmonary function and partial pressure of oxygen and carbon dioxide in the first three postoperative days after uncomplicated coronary artery bypass graft surgery. Evidence suggests that when incentive spirometry is used without healthcare professional guidance no significant improvement in pulmonary functions is observed (Tyson et al., 2015). Pantel et al. (2017) in their RCT of 224 patients studied the effect of incentive spirometry on hypoxemia and 30-day postoperative pulmonary complications including atelectasis, pneumonia and reintubation after bariatric surgery. The compliance of incentive spirometer use was collected on a log sheet on the first and second postoperative days. The authors concluded that the unmonitored routine use of incentive spirometer is not recommended.

4.2 | Oxygenation after coronary artery bypass graft surgery

Decreased oxyhaemoglobin saturation level (SpO_2) is a common pulmonary complication after coronary artery bypass graft surgery, yet there is a paucity of studies evaluating postoperative hypoxemia continuously for 24 h after coronary artery bypass graft surgery. In this trial, all patients experienced SpO_2 level <92% for >10 s in the second 24 h after starting the use of incentive spirometry despite supplemental oxygen. Similar results have been reported in the literature. A study by Lundstrøm et al. (2005) reported that the incidence of postoperative hypoxemia (SpO_2 < 90% or a drop of 4% from baseline within a maximum period of 2 min) was 56% on the second postoperative night and 89% on the third postoperative night after coronary artery bypass graft surgery.

Although all patients in this study had more than one episode of hypoxemia (SpO2 < 92% for >10 seconds), our findings report lesser frequency and duration of hypoxemic events when incentive spirometry was guided by nurses. The lower number of hypoxic events in the intervention group are likely linked to the direct monitoring and guidance by nurses which ensured proper usage and adherence to the incentive spirometer in the postoperative period. Incentive spirometry allows maximal inspiration which helps to reexpand collapsed alveoli and thus improves gas exchange (Shamy et al., 2014). Compliance with repeated exercises is essential to ensure the therapeutic effect. These findings are corroborated by other findings from the literature which showed that continuous maximal inspiration exercise when repeated hourly after major surgeries reduces intrapulmonary shunt through alveolar inflation and consequently improves ventilation/perfusion mismatch and alveolar partial arterial pressure of oxygen gradient (Eltorai, Szabo, et al., 2018). Moreover, a study by Rizwan et al. (2012) demonstrated a significant improvement in oxygenation after a series of three sets of deep breaths on the second postoperative day after mitral valve replacement.

4.3 | Pneumonia development after coronary artery bypass graft surgery

In this trial, postoperative pneumonia occurred in 10.3% of the total sample. This percentage falls within the reported range of pneumonia post-cardiac surgery of 1.5%–20% (Al-Qubati et al., 2013; Sachdev & Napolitano, 2012; Vera Urquiza et al., 2016). Incidence was higher in the control group (17.9%) compared with the intervention group (2.6%). Even though this difference was clinically significant, it was not statistically significant, potentially due to the small sample size in each group. The similarities of clinical and demographic characteristics between the intervention and the control group suggest that the difference in the occurrence of postoperative pneumonia is due to compliance in incentive spirometry.

4.4 | Pulmonary function after coronary artery bypass graft surgery

In this trial, a reduction in lung function was noted on the third postoperative day. A reduction in postoperative FEV_1 and FVC among all patients after cardiac surgery including those who used incentive spirometry or deep breathing exercises has been reported previously. This is likely linked to the loss of pleural integrity during cardiac surgery (Uzun et al., 2013). Secondary atelectasis due to lack of postoperative efforts for coughing or deep breathing or related to the left lower lobe injury caused by lung retraction during surgery is also another precipitating factor (Huffmyer & Groves, 2015). Increasing intrathoracic lung volume after cardiac

surgery correspondingly leads to a replacement of the functional gas unit by fluids. Reducing inspiratory muscle strength after cardiac surgery as well as pain and postoperative fatigue result in decreased inspiratory efforts (Miskovic & Lumb, 2017). Additionally, pleural opening in cardiac surgery necessitates the insertion of chest drainage which damages the parietal pleura and intercostal muscles. During respiratory movement, the tube irritates the costal nerves and causes pain. Thus, a superficial respiratory pattern occurs leading to impaired gas exchange and reduction in pulmonary function (Uzun et al., 2013).

The use of an incentive spirometer is a lung expansion technique. It allows sighing or yawning through slow, long deep breaths. It prevents and treats atelectasis in patients with shallow breathing patterns (Eltorai et al., 2017). In this trial, a significant difference between the intervention group and the control group in the postoperative mean FEV_1 values was found. These findings collectively suggest that optimizing strategies to improve oxygenation and pulmonary function after cardiac surgery is of particular importance. Our findings indicate that nursing guidance for incentive spirometry usage can achieve that purpose.

4.5 | Intensive care unit and hospital length of stay after coronary artery bypass graft surgery

Patients in the intervention group had a significantly shorter ICU and hospital length of stay compared with patients in the control group. Interestingly, when nursing guidance for the use of incentive spirometry was not utilized, evidence suggests that the length of stay is similar between those who used incentive spirometry and those who did not (Mueenudheen et al., 2012). Studies report several factors that affect the length of stay for those patients. For example, surgical details such as the aortic cross-clamp and cardiopulmonary bypass duration can affect the length of stay (Almashrafi et al., 2016). In this trial, patients in the control group had a longer mean duration of both cardiopulmonary bypass and aortic cross-clamp time compared with patients in the intervention group. This might have confounded our results.

4.6 | Study Limitations

There are several limitations to this study. The sample size was relatively small. Recruiting a larger sample size could have resulted in greater statistical power. Consequently, the homogeneity in gender between groups could not be established. Additionally, patient compliance with oxygen supplementation during the period of oxygenation monitoring was not recorded regularly during the study. Pneumonia occurrence was poorly documented in the medical records.

In this trial, the chest tube sites, size, amount of drainage and duration were not controlled for. The variable could have confounded pulmonary function testing. Additionally, we did not control for the duration of maximal inspiration as expressed by the duration of a patient's ability to hold the ball up as much as possible while using an incentive spirometer (Rizwan et al., 2012).

5 | CONCLUSIONS

The results of this trial suggest that use of nurse-guided incentive spirometry is superior to the routine use of an incentive spirometer in the prevention of pulmonary complications after coronary artery bypass graft surgery. Patients in the intervention group whose performance compliance to postoperative deep breathing exercise using incentive spirometer was guided by nurses had fewer numbers and duration of hypoxic events than patients in the control group whose performance compliance to postoperative deep breathing exercise using incentive spirometer was not guided by nurses. Likewise, the use of nurse-guided incentive spirometry was associated with lower ICU and hospital length of stay and higher postoperative forced expiratory volume in 1 s. However, significant changes could not be detected in terms of postoperative pneumonia occurrence and improvement in all pulmonary function variables. Thus, nurse-guided incentive spirometry is recommended to reduce the risk of pulmonary complications after coronary artery bypass graft surgery in nonresource-constrained hospitals.

Future RCTs can focus on applying a postoperative pulmonary complication bundle in different populations. Also, future research can investigate the pain level and the extent of pulmonary complications after cardiac surgery utilizing a larger sample size.

ACKNOWLEDGEMENTS

We would like to acknowledge the deanship of academic research at the University of Jordan for funding the study. Thanks are extended to workers of Queen Alia Heart Institution who facilitate the accomplishment of the study. Special acknowledgment goes to the team of Intensive Care Unit represented by all senior and bedside nurses. We also would like to acknowledge all patients who accepted to participate in the study.

CONFLICT OF INTEREST

We have no conflict of interest to declare.

AUTHORSHIP STATEMENT

All listed authors meet the authorship criteria, and all authors agree with the content of the manuscript. SA: preparing the initial draft of the proposal for the study, submit and follow up with IRB, data collection and intervention management, participate in drafting the manuscript. JA: analysis and interpretation of data, participate in writing all components of the manuscript, acted as the senior researcher, provided scientific advice all through the study, management, and handling of funding and submit the manuscript. KY: participate in writing the proposal for funding and approval of intervention, writing of methods, review of Analysis and preparing

draft results and revision and approval of the final version of the manuscript. FH: participate in writing the proposal for funding and approval of intervention, writing of methods, review of Analysis and preparing draft results and revision and approval of the final version of the manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Jafar Alasad Alshraideh https://orcid.org/0000-0002-2118-5257

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How to cite this article: Alwekhyan, S. A., Alshraideh, J. A., Yousef, K. M., & Hayajneh, F. (2022). Nurse-guided incentive spirometry use and postoperative pulmonary complications among cardiac surgery patients: A randomized controlled trial. *International Journal of Nursing Practice*, *28*(2), e13023. https://doi.org/10.1111/ijn.13023