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ORIGINAL ARTICLE

FLOW-ORIENTED INCENTIVE SPIROMETER VERSUS VOLUME-ORIENTED SPIROMETER TRAINING ON PULMONARY VENTILATION AFTER UPPER ABDOMINAL SURGERY

By

Aly Rafea,[1] Khaled Wagih,[2] Hasan Amin,[3] Rokia El-Sabagh,[4] Samia Yousef [4]

[1]Chest, [4] Physical Therapy Departments, El Mataria Teaching Hospital, [2]Chest department, Faculty of medicine, Ain Shams University, [3] Chest department, Faculty of medicine Cairo university, Egypt

Correspondence to: Aly Rafea, Email: ali.rafeah@yahoo.com

Background: *Postoperative pulmonary complications are a major problem after upper abdominal surgery. They lead to a prolonged hospital stay as well as increased costs and are one of the main causes of early postoperative morbidity and mortality.*

Aim of study: *This study was designed to evaluate the efficacy of two various methods in the management of upper abdominal surgery to improve respiratory function and to control postoperative pulmonary complications after upper abdominal surgery.*

Materials and Methods: *This study was conducted on sixty female patients who had undergone upper abdominal surgery in the department of general surgery in EL Mataria Teaching Hospital, their age ranged between 20 to 50 years ; patients were randomly assigned into three equal groups: Group A: twenty patients received triflo training program (flow–oriented incentive spirometer); group B: twenty patients received coach training program (volume– oriented incentive spirometer); group C: twenty patients received traditional chest physical therapy program. Spirometry measurements in form of FVC and FEV_1 were taken for all three groups preoperative, at the 1st and at the 7th day postoperatively. Results: The current study revealed a significant improvement in FVC and FEV_1, at the 7th day postoperatively in the three groups of the study, the highest percentage of improvement in both respiratory variables was seen in group B which received volume–oriented incentive spirometer training program.*

Abbreviations: *FVC: Forced Vital Capacity, FEV_1: Forced Expiratory Volume in first second.*

INTRODUCTION

Postoperative pulmonary complications (PPCs) are a major problem after upper abdominal or thoraco-abdominal surgery. They lead to a prolonged intensive care unit (ICU) stay as well as increased costs and are one of the main causes of early postoperative mortality. The mortality ranges from 10 to 60% according to the severity of respiratory failure. The most important complications are interstitial and alveolar pulmonary edema, atelectasis, postoperative pneumonia, hypoventilation, and aspiration.(1) Pulmonary complications occur more frequently than cardiac complications and may arise from pneumonia, atelectasis, respiratory failure, bronchospasm and exacerbation of underlying chronic lung disease.(2)

The incidence of complication is inversely related to the distance of the surgical incision from the diaphragm, the complication rates for upper abdominal and thoracic surgery are the highest.[3]

The basic mechanism of PPCs is a lack of lung inflation which occurs because of change in breathing pattern to a shallow, monotonous breathing without periodic sighs, prolonged recumbent position and temporary diaphragmatic dysfunctions, mucocilliary clearance also is impaired post-operatively which along with decreased cough effectiveness increase risk associated with retained pulmonary secretions.[4]

The first incentive spirometer was constructed by Barlett in 1970s, then many different types of incentive spirometers have been developed. In general, incentive spirometer is activated by an inspired effort, that is, breathing is visualized by an uplifted plate or ball in a transparent cylinder during sustained inspiration on a calibrated scale on the cylinder. The uplifted plate or ball on the spirometer displays either the inspired volume (a volume oriented incentive spirometer) or the generated flow (a flow oriented incentive spirometer). Incentive spirometer is used clinically as a part of routine prophylactic and therapeutic regimen in perioperative respiratory care, however the efficacy of incentive spirometry still is controversially discussed.[5]

The incentive spirometer has a wide application for the prophylaxis and treatment of postoperative atelectasis in abdominal, thoracic, and neurosurgical patients. Benefits attributed to incentive spirometry include the amelioration of atelectasis, and improved coughing mechanism due to improved inspiratory capacity, and a strengthening of the diaphragm. Also one of proposed benefits for incentive spirometer is that patient can assume responsibility for their own treatment, thus reducing the amount of direct patient contact time with the therapist.[4]

Aim of study: This study was designed to evaluate the efficacy of two various methods, flow and volume oriented spirometers training, in the management of upper abdominal surgery to improve respiratory function and to control postoperative pulmonary complications.

PATIENTS AND METHOD

Sixty female patients who had undergone upper abdominal surgery participated in the present study. These patients were selected from General Surgery Department, El Mataria Teaching Hospital. Their ages ranged from 20 to 50 years. All patients did not have any abdominal surgery in the past. All patients have no preoperative chest or cardiovascular diseases that might restrict their activity and influence the results. Patients were divided into three groups:

Group (A): Twenty patients received exercise package in form of flow-oriented incentive spirometer training.

Group (B): Twenty patients received exercise package in form of volume – oriented incentive spirometer training.

Group (C): Twenty patients received exercise therapy in form of traditional chest physical therapy.

Methods:

- Primary medical tests were made to get a complete medical history of the health status of each patient to know if the patient is allowed to undergo the experiment or if there is any contraindication.
- A brief description about the assessment procedure including technical steps to obtain pulmonary function data and variables were explained.
- Each patient was instructed not to exhaust the respiratory or abdominal muscles.

Pulmonary Assessment:

Ventilatory function was performed by using electronic spirometer (Schiller AG, CH 6340). Patient was asked to expire forcefully (after deep inspiration) and rapidly as much as possible in the mouthpiece and what appeared on the screen were printed on a tape. They were tested from standing position The data were obtained for three successive readings, and the best readings for forced vital capacity (FVC) and forced expiratory volume in the first second (FEV_1) were recorded. These parameters were measured 24 hours before surgery (pre-operative), 24 hours and 7 days after surgery (post-1 and post-2).

Treatment procedures:

The actual therapeutic procedures were divided into 3 main procedures:-

a) ***Treatment by (Flow-oriented) triflo incentive spirometer: Patients (group A) were asked to:***

   1. Hold the incentive spirometer in an upright position.
   2. Exhale normally, then place lips tightly around the mouthpiece.
   3. Inhale slowly to raise the ball in the chamber and continue inhaling and try to raise the ball as high as she can.
   4. When she cannot inhale any larger, remove the mouthpiece and hold her breath for 10 seconds or as long as she can.

5. Exhale normally.
6. Repeat exercise 10 times every hour while awake.

b) ***Treatment by (volume - oriented) coach spirometer: Patients (group B) were asked to:***

1. Hold the incentive spirometer in a full upright position in bed.
2. Exhale normally, then place lips tightly around the mouth piece.
3. Inhale slowly to raise piston in the chamber and to continue inhaling and try to raise top of the piston as high as possible.
4. Hold breath for 10 seconds or as long as possible.
5. Exhale normally.
6. Returns the piston to its initial starting position.
7. Repeat exercise 10 times every hour while awake.

c) ***Treatment by Traditional Chest Physical Therapy procedures:***

In group (C), when the patients were haemodynamically stable, they received a traditional postoperative physical therapy program which started after recovery from anesthesia. Patients were in half-lying position while practicing the breathing exercises and chest physical therapy approaches.

During the treatment session, the patient performed three to five deep breathes interspersed with periods of quiet breathing followed by three cough with wound supported.

Proprioceptive stimulation from the therapist's hand placement was given to encourage breathing emphases in the appropriate area .This maneuver was carried out at least 10 times over 15 minutes period. Patients were instructed to perform breathing and coughing exercises independently every while awake hour. Additional technique such as positioning and chest wall percussion to increase the clearing of the excessive or retained pulmonary secretions.

Breathing exercises program:

1. Apical breathing exercises: From long sitting position, first with his feet rested on the floor, her hips and knees go flexion. The therapists hands were placed just below the clavicles. The subjects head was turned toward the opposite side from the therapist, then the subject was instructed to inspire deeply attempting to direct the inspired air toward the therapist's hands who applied firm pressure at the end of expiration and release the pressure as the subject inspired. The patient's hand was placed over the incision to support it.
2. Sustained maximal inspiration technique: The subject was instructed to take deep breathing to total lung capacity and hold her breath for 2-3 seconds at the completion of inspiration then to exhale. This maneuver was repeated three successive times with a rest for two seconds then repeated for 5 minutes.
3. Lateral basal expansion: The same position and the same previous steps were repeated. The therapist's hand was placed bilaterally over the lower costal margin with both thumbs opposing each other over the xiphoid process. The subject was instructed to inspire deeply and move the therapist's hands with her lower costal region. The previous instructions were repeated.
4. Posterior basal expansion: The same position and the subject instructed to sit slightly leaning forward, the therapist stood behind the subject with his hands placed over the posterior aspect of the lower ribs just below the inferior angle of scapula. The subject was asked to breathe in deeply and move the therapist's hand over the posterior chest wall. Therapist gives slight pressure at end of expiration .The previous instructions were repeated.
5. Diaphragmatic breathing exercises: - The subject lied down at 45˚ with her hips and knees flexed to relax the abdominal muscles. The subject's dominant hand was placed over the midrectus abdominus area, while the other hand was placed over the mid-sternal area. Then the dominant hand was allowed to rise as inspiration continues while avoiding excessive movement under the other hand. The previous instructions were repeated. This exercise was applied to increase ventilation and improve the pulmonary function.

RESULTS

In this study, sixty female patients with upper abdominal surgery have been selected from general surgery department of El-Mataria Teaching Hospital.

The data collected at preoperative (Pre), after first day (Post 1), and at 7^{th} day (Post 2) post operative, for all groups , to determine their role on ventilatory function following upper abdominal surgery.

As regards Demographic Data for three groups Table 1: One way repeated measure analysis of variance (ANOVA) among three groups A,B and C revealed the following results: There were no statistical significant differences (P>0.05) of mean values of patient's age, weight, height, BMI, at entry of the study.

There were no statistical significant differences (P>0.05) of mean values of operative duration among three groups.

As observed in Table 2, the one way repeated measure analysis of variance (ANOVA), of FVC and FEV_1 at pre operative among three groups revealed non statistical significant differences (P>0.05).

Table 3. The one way repeated measure analysis of variance (ANOVA), of FVC and FEV_1 at 1st day postoperative, (Post 1), among three groups revealed non statistical significant differences (P>0.05).

Table 4. The one way repeated measure analysis of variance (ANOVA), of FVC and FEV_1 at 7th day postoperative among three groups revealed highly statistical significant differences (P < 0.001).

Table 5. Post Hoc test (Tukey test) for multiple comparative analysis of the mean values of FVC (L) at Post (2) among groups (C,A &B) of study. revealed that:

There was a non-statistical significant difference (P>0.05) in FVC at 7th day postoperative for group A when compared with mean values of group C at seventh day postoperative.

There was a highly statistical significant increase (P< 0.001) in FVC at 7th day postoperative for group B when compared with mean values of group C at 7th day postoperative.

There was a statistical significant increase (P<0.05) in FVC at 7th day postoperative for group B when compared with mean values of group A at 7th day postoperative.

Table 6. Post Hoc test (Tukey test) for multiple comparative analysis of the mean values of FEV_1 (L) at Post (2) among groups (C,A &B) of study. revealed that:
There was a non-statistical significant difference (P>0.05) in FEV_1 at 7th postoperative day for group A when compared with mean values of group C at postoperative 7th day:

There was a highly statistical significant increase (P<0.001) in FEV_1 at 7th day postoperative for group B when compared with mean values of control at 7th day postoperative.

There was a statistical significant increase (P<0.05) in FEV_1 at 7th day postoperative for group B when compared with mean values of group A at 7th day postoperative.

Table 1. Comparative analysis of the mean values of patient's age, weight, height, BMI, operative duration among groups of the study.

Items	Group C	Group A	Group B	F-value	P-value	Sig.
	$\bar{X}$ ± S.D	$\bar{X}$ ±S.D	$\bar{X}$ ± S.D			
Age(year)	36.53±6.54	38.06±8.18	38.06±8.69	0.39	0.67	NS
Weight(Kg)	84.66±13.9	80.6±4.01	89.46±16.13	1.88	0.16	NS
Height(cm)	153.46 ±4.27	155.26±3.47	155.2±4.41	0.94	0.39	NS
BMI(Kg/m2)	35.88±5.29	33.46±2	37.49±7.2	2.2	0.12	NS
Operative duration(min.)	78.66±21.83	80.66±44.63	72±33.15	0.26	0.77	NS

$\bar{X}$ Mean; S.D= Standard deviation; P-value = Probability level; F-value=F-distribution; NS= Non Significant.

Table 2. Shows comparative analysis of the mean values of FVC and FEV_1 at preoperative among groups of the study (C,A,B).

Items	Group C	Group A	Group B	F. value	P. value	Sig
	$\bar{X}$ ± S.D	$\bar{X}$ ± S.D	$\bar{X}$ ± S.D			
FVC (Liter)	2.84 ± 0.26 L	2.88 ± 0.48 L	2.78 ± 0.36L	0.24	0.78	NS
FEV_1(Liter)	2.3 ± 0.23 L	2.35 ± 0.28 L	2.45 ± 0.4 L	0.9	0.4	N.S

$\bar{X}$ Mean, SD± = Standard deviation; F-value=F-distribution; P-value = Probability level.
Sig.= Significance.; NS= Non Significant.

Table 3. Shows comparative analysis of the mean values of FVC and FEV_1 at 1st day postoperative Post (1) among, groups of the study (A,B,C).

Items	Group C	Group A	Group B	F. value	P. value	Sig
	$\bar{X}$ ± S.D	$\bar{X}$ ± S.D	$\bar{X}$ ± S.D			
FVC (Liter)	1.44 ± 0.24L	1.54 ± 0.49L	1.7 ± 0.4L	1.65	0.2	N.S
FEV1(Liter)	1.22 ± 0.21L	1.28 ± 0.48 L	1.46 ± 0.35 L	1.7	0.1	N.S

$\bar{X}$= Mean; SD= Standard deviation F-value=F-distribution; P-value = Probability level,
Sig. = Significance; NS = Non Significant.

Table 4. Shows comparative analysis of the mean values of FVC at 7th day postoperative among groups of the study (C,A,B).

Items	Group C	Group A	Group B	F-value	P-Value	Sig.
	$\bar{X}$ ± S.D	$\bar{X}$ ± S.D	$\bar{X}$ ± S.D			
FVC (Liters)	2.22 ± 0.27L	2.42 ± 0.36L	2.71 ± 038L	7.8	0.001	HS
FEV_1 (Liters)	1.88 ± 0.4	2.03 ± 0.12 L	2.34 ± 0.41 L	6.9	0.001	H.S

$\bar{X}$= Mean, SD±= Standard deviation; F-value=F-distribution; P-value = Probability level.
Sig. = Significance, HS=Highly significant.

Table 5. Shows multiple comparative analysis of the mean values of FVC (L) at 7th day postoperative (Post-2) among groups of the study (C,A,B).

Statistics	FVC (Liter) at 7th day postoperative Post(2)					
	Group C	Group A	Group C	Group B	Group A	Group B
$\bar{X}$ ± S.D	2.22 ± 0.27	2.42 ± 0.36	2.22 ± 0.27	2.71 ± 0.38	2.42 ± 0.36	2.71 ± 0.38
MD	0.2		0.49		0.29	
P-Value	0.27		0.001		0.05	
Sig.	NS		HS		S	

$\bar{X}$ = Mean; SD= Standard deviation; MD= Mean difference; Pre=Preoperative; Post (1) = 1st day postoperative. Post (2) = Seven days of postoperative; P-value = Probability level; F-value=F- distribution; Sig. = Significance HS = Highly significant; NS=Non-Significant.

Table 6. Shows multiple comparative analysis of the mean values of FEV_1 (L) at 7th day postoperative (Post- 2) among groups (C,A,B) of study.

Statistics	FEV_1 (Liter) at 7th day postoperative Post (2)					
	Group C	Group A	Group C	Group B	Group A	Group B
$\bar{X}$ ± S.D	1.88 ± 0.4	2.03 ± 0.12	1.88 ± 0.4	2.34 ± 0.41	2.03 ± 0.12	2.34 ± 0.41
MD	0.15		0.46		0.31	
P-Value	0.48		0.002		0.04	
Sig.	NS		HS		S	

$\bar{X}$ = Mean, SD= Standard deviation. MD= Mean difference. Pre = Preoperative; Post (1) = 1st day postoperative. Post (2) = Seven days of postoperative; P-value = Probability level; F-value=F- distribution; Sig. = Significant. HS=highly significance; NS=Non-Significance.

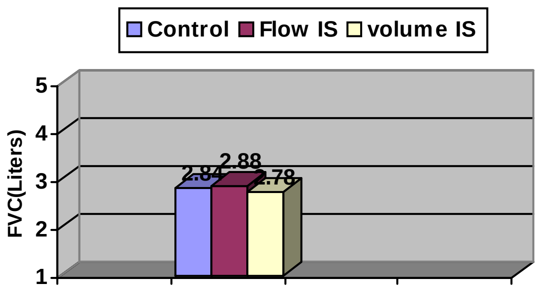

Fig 1. Shows the mean values of FVC at preoperative for control, Flow IS, and volume IS groups.

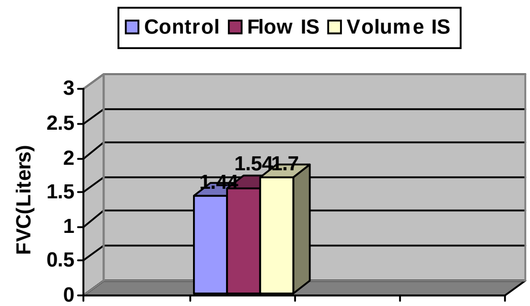

Fig 2. Shows the mean values of FVC at 1st day postoperative for Flow IS, volume IS, and control groups.

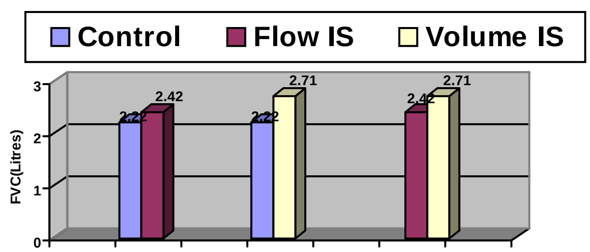

Fig 3. Shows the mean values of FVC at 7th day postoperative for groups C (control), A (Flow IS) and B (Volume IS).

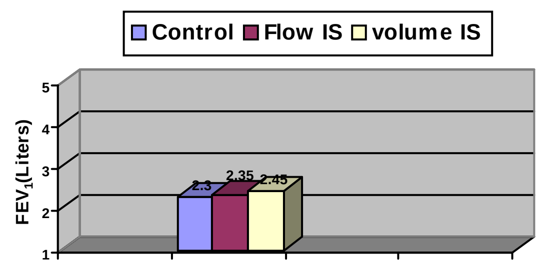

Fig 4. The mean values of FEV_1 at preoperative for control, Flow IS, and volume IS, groups.

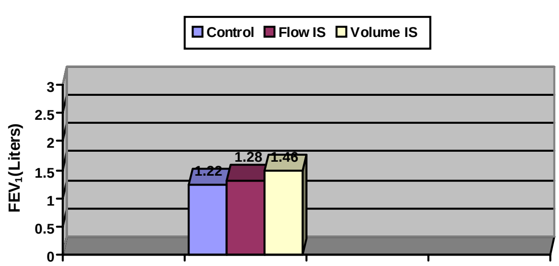

Fig 5. Mean values of FEV_1 at 1st day post operative for groups A,B,C.

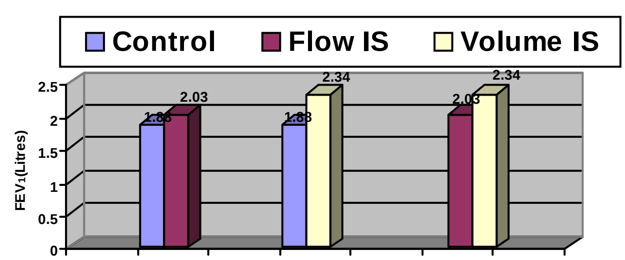

Fig 6. Shows the mean values of FEV_1 at 7th day Postoperative for groups A,B,C.

DISCUSSION

This study was conducted to determine the efficacy of flow-oriented incentive spirometer versus volume-oriented spirometer training in management of pulmonary complications after upper abdominal surgery. It included sixty female patients who had upper abdominal surgery with their ages ranging from 20 to 50 years old, the patients were equally and randomly assigned into

3 equal groups: Group (A), twenty female patients received flow-oriented (triflo) incentive spirometer training. Group (B), twenty female patients received volume oriented (coach) incentive spirometer training. Group (C), twenty female patients received traditional physical therapy program.

Incentive spirometry (IS) is simply a visual and /or audio feed-back device that encourages slow and deep inspiration i.e. the visual input of ball rising in chambers, colored lights, sounds, or dials reflect the degree of inspiratory effort. It provides low level resistive training while minimizing the potential of hypoxaemia that may be reduced with this technique. Incentive spirometry can be used independently by the patients. The technique ensures that each inspiration is physiologically optimal and is reproduced precisely from one inspiration to the next. Patients who are surgically at risk can benefit from being taught the use of the incentive spirometer during preoperative teaching to promote better inflation of the lungs with IS postoperatively.[6]

The presence of preoperative respiratory symptoms and impaired spirometric parameters as forced vital capacity (FVC) and forced expiratory volume in 1st second (FEV1) were the most valuable risk factors for early prediction of post operative pulmonary complications.[7]

The results of this study pointed out that there were significant differences between the pre application and post treatment application. Also all factors that might affect the parameters of the study have been controlled including age, operative duration, type of operation, type of anesthesia and pre application obtained data were evaluated and compared with no significant differences between the three groups.

By comparing the results of the 3 groups it revealed that there was non-statistical significant difference ($P>0.05$) in FVC at 7th day postoperative for patients treated with flow IS when compared with mean values of control group at 7th day postoperative.

- There was highly statistical significant increase ($P<0.01$) in FVC at 7 th day postoperatively for patients treated with volume IS when compared with mean values of control at 7 th day postoperative.
- There was statistical significant increase ($P<0.05$) in FVC at 7 th day postoperative for patients treated with volume IS when compared with mean values of flow IS at 7 th day postoperative.
- There was non statistical significant difference ($P>0.05$) in FEV_1 at 7 th day postoperative for patients treated with flow IS when compared with mean values control group at 7th day postoperative.
- There was highly statistical significant increase ($P<0.001$) in FEV_1 at 7th day postoperative for patients treated with volume IS when compared with mean values of control at 7th day postoperative.
- There was statistical significant increase ($P<0.05$) in FEV^1 at 7 th day postoperative for patients treated with volume IS when compared with mean values of flow IS at 7th day postoperative.

Stephen et al., 2003 studied the effect of incentive spirometry (IS) versus deep breathing exercise (DBE) on reducing the decline in vital capacity in patients undergoing abdominal surgery and found that IS is more effective than DBE in restoring vital capacity to preoperative levels.[8]

Parreira et al., 2005 evaluated incentive spirometery using volume (coach and voldyne) and flow oriented (triflo II and respirex) devices in healthy subjects and found that when the two volume oriented incentive spirometers were compared, minute ventilation reaching the lungs was larger with voldyne due to a larger tidal volume associated with a low respiratory frequency ; and also abdominal motion was larger during the use of volume oriented incentive spiroeters compared to flow oriented incentive spirometers.[9]

Ricksten et al., 1986 compared the effect of 3 days of hourly (30 breaths) IS, continuous positive airway pressure (CPAP), and positive end expiratory pressure (PEEP) on gas exchange, lung volumes, and development of atelectasis. The patients who received both CPAP and PEEP were superior to IS for alveolar-arterial oxygen pressure difference, FVC, and the incidence of atelectasis.[10]

Celli et al., 1984 compared a no-treatment control group to groups receiving 15 min. of IS, intermittent positive pressure breathing(IPPB) or deep breathing exercise (DBE)in patients who had undergone both upper and lower abdominal surgery. Compared to no treatment, the three treatment techniques were equally more effective in preventing PPCs. The author suggested that IS may be preferable following upper abdominal surgery, because it appeared to shorten the patient's length of stay.[11]

Postoperative hypoxemia reduced by I.S due to its ability to encourage long, slow, sustained deep inspiration which leads to achieve maximal inflating pressure in the alveoli and maximal inhaled volume, and also to maintain the patency of the smaller airways, it can also improve inspiratory muscle performance and stimulate normal patterns of pulmonary hyperinflation.[5]

Shu-Chuan et al., 2000 found significant differences in regional expansion of the chest and abdomen and suggest that patient with volume oriented I.S achieved a larger inspiratory lung volume than did patients using flow oriented I. S.[12]

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