INCENTIVE SPIROMETRY PRESCRIPTION AND INSPIRATORY CAPACITY RECOVERY GUIDELINE FOR THE EARLY PERIOD AFTER OPEN HEART SURGERY

LEELA A/P T. NARAYANAN

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Health Science)

Faculty of Biosciences and Medical Engineering
Universiti Teknologi Malaysia

MARCH 2018

This thesis is dedicated to the cherished memory of my loving parents,

the late Mr. T.Narayanan and Madam Hamalatha Narayanan.

Amma and Acha, I am who I am because of you.

I also dedicate this work to my dear husband,

Syed Rasul Bin G. Syed Hamid.

Ji, you are the wind beneath my wings.

ACKNOWLEDGEMENT

First and foremost, I would like to express my heartfelt gratitude to my thesis supervisor, Prof. Ir. Ing. Dr. Eko Supriyanto (Faculty of Biosciences and Medical Engineering (FBME), UTM), for his immense support and guidance all throughout my PhD journey. *"The best teachers are those who show you where to look, but don't tell you what to see" – Alexandra Trenfor.*

I would also like to thank Norayati Nordin (Biomedical Engineering Masters student, FBME) and Muhammad Akmal Ayob (Research Officer, FBME) for their participation and contribution in the development and validation of the data collection device used in this study. Without their unwavering and enthusiastic support, this research would not have been successfully conducted. Finally, my profound gratitude to Rumaisa Abu Hasan (Research Assistant, FBME), whose valuable insights and comments made my thesis preparation an exhilarating and enlightening experience.

To all of you, Thank you.

ABSTRACT

Incentive spirometry (IS) is often used as lung expansion therapy for increasing postoperative IS inspiratory capacity (ISIC) in open heart surgery (OHS) patients. However, currently there is a lack of guidelines and prescription on how this therapy should be administered for these patients. Although there is some information on several patient- and surgery- related factors associated with ISIC volumes after OHS, the role of IS performance variables such as IS inspiration volumes (ISv) and IS inspiration frequency (ISf) has not been investigated. In order to formulate evidence-based IS therapy guidelines and prescription, this study investigated factors, which included ISv and ISf, to identify predictors of ISIC recovery in a cohort of OHS patients in Hospital Sultanah Aminah, Johor Bahru (HSAJB). This study involved collection of objective and precise IS performance data of 95 OHS patients using a newly developed and validated multisensor data collection device (ISDCD) for five consecutive postoperative days (POD). Data analysis identified ISv as the sole predictor of ISIC recovery which explaines 23%, 24%, 17% and 25% of variances for ISIC recovery on POD2, POD3, POD4 and POD5 respectively. Three pathways for postoperative ISIC recovery were also identified, namely for patients following the fastest pathway having the highest ISIC recovery rate of 19% for each POD, followed by 16% for the middle pathway and 12% for slowest. The findings facilitated the formulation of evidence-based IS therapy prescription and ISIC recovery guidelines from POD1 to POD4. However, these findings need to be verified further through research involving comprehensive and objective evaluation of IS performance using appropriate technology devices.

ABSTRAK

Alat insentif spirometer (IS) sering digunakan untuk mengembangkan paru-paru dan meningkatkan keupayaan inspirasi IS (ISIC) selepas pembedahan jantung terbuka (OHS). Walau bagaimanapun, pada masa ini terdapat kekurangan garis panduan dan preskripsi bagaimana terapi ini perlu diberikan untuk pesakit-pesakit ini. Walaupun terdapat maklumat mengenai beberapa faktor berkaitan dengan pesakit dan pembedahan yang dikaitkan dengan pemulihan ISIC selepas OHS, peranan faktor-fator dan peramal prestasi IS seperti isipadu inspirasi IS (ISv) dan frekuensi inspirasi IS (ISf) belum disiasat. Untuk merumuskan garis panduan terapi dan preskripsi terapi IS yang berasaskan bukti, kajian ini menyiasat faktor, termasuk ISv dan ISf, untuk mengenal pasti peramal pemulihan ISIC dalam kohort pesakit OHS di Hospital Sultanah Aminah, Johor Bahru (HSAJB). Kajian ini melibatkan pengumpulan data prestasi IS yang objektif dan tepat bagi pesakit 95 OHS menggunakan alat pengumpulan data multisensor yang baru dihasilkan dan disahkan (ISDCD) berturut-turut selama lima hari pasca-pembedahan (POD). Analisis data mengenal pasti ISv sebagai peramal tunggal pemulihan ISIC yang menjelaskan 23%, 24%, 17% dan 25% variasi untuk pemulihan ISIC pada POD2, POD3, POD4 dan POD5 masing-masing. Tiga laluan untuk pemulihan ISIC pasca-pembedahan juga dikenalpasti, yaitu pesakit yang mengikuti laluan terpantas mempunyai kadar pemulihan tertinggi ISIC sebanyak 19% untuk setiap POD, diikuti oleh 16% untuk laluan tengah dan 12% untuk yang paling lambat. Penemuan-penemuan ini memudahkan penggubalan preskripsi terapi IS berasaskan bukti dan garis panduan pemulihan ISIC dari POD1 hingga POD4. Walau bagaimanapun, penemuan ini perlu disahkan menerusi penyelidikan yang melibatkan penilaian komprehensif dan objektif prestasi IS menggunakan peranti teknologi yang sesuai.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABS	-	Acrylonitrile butadiene styrene
ADC	-	Analogue to digital converter
am	-	Ante meridiem
ANOVA	-	Analysis of variance
BE-IS	-	Bartlett-Edwards incentive spirometer
BMI	-	Body mass index
CABG	-	Coronary artery bypass grafting
CI	-	Confidence interval
CICU	-	Cardiothoracic intensive care unit
C_{index}	-	Condition index
CPAP	-	Continuous positive airway pressure
CPB	-	Cardiopulmonary bypass
DBE	-	Deep breathing exercise
df	-	Degree of freedom
FEV_1	-	Force expiratory volume in first second
FIS	-	Flow-rate oriented incentive spirometer
FRC	-	Functional residual capacity
FVC	-	Forced vital capacity
GRC	-	Goal-recording counter
HSAJB	-	Hospital SultanahAminah Johor Bahru
IC	-	Inspiratory capacity
IPPB	-	Intermittent positive pressure breathing
IR	-	Infrared
IS	-	Incentive spirometry
ISDCD	-	Incentive spirometrydata collection device

ISf	-	Incentive spirometry inspiration frequency
ISIC	-	Incentive spirometry inspiratory capacity
$ISIC_{abs}$	-	Absolute value of ISIC
$ISIC_{rel}$	-	Relative value of ISIC
ISv	-	Incentive spirometry inspiration volume
ISv_{abs}	-	Absolute ISv
ISv_{c}	-	Cumulative ISv
ISv_{rel}	-	Relative ISv
LCD	-	Liquid crystal display
LED	-	Light emitting diode
LET	-	Lung expansion therapy
MAPE	-	Mean absolute percentage error
NIV	-	Noninasive ventilation
NRS	-	Numeric rating scale
OHS	-	Open heart surgery
Palv	-	Alveolar pressure
PC	-	Personal computer
PEP	-	Positive expiratory pressure
PIC	-	Predictive inspiratory capacity
P_L	-	Transpulmonary pressure gradient
pm	-	Post meridiem
POD	-	Postoperative days
P-P	-	Probability-probability
PPC	-	Postoperative pulmonary complication
Ppl	-	Pleural pressure
$PreopISIC_{abs}$	-	Absolute value of preoperative ISIC
RCT	-	Randomized controlled trial
RMSE	-	Root mean square error
SD	-	Standard deviation
SDHC	-	Secure digital high capacity
se	-	Standard error
SPSS	-	Statistical package for social science software
TLC	-	Total lung capacity

V/Q	-	Ventilation-perfusion
VAS	-	Visual analogue scale
VC	-	Vital capacity
VIS	-	Volume-oriented incentive spirometry

LIST OF SYMBOLS

α	-	Statistical significance level
β	-	Rate of type II error
%	-	Percentage
	-	Change
B	-	B- value or coefficient
B_s	-	Standardized B-value or coefficient
cm	-	centimetre
D	-	Distance
f	-	G*power effect size
F	-	F-score in ANOVA
g	-	gram
H	-	Height
kg	-	kilogram
L	-	Length
m	-	metre
ml	-	millilitre
N	-	Sample size of whole cohort
n	-	Sample size of subgroup
p-value	-	Probability value
r	-	Effect size
R	-	Pearson correlation coefficient
s	-	Infrared sensor output
t	-	t-score in t-test
V	-	volt
Vol	-	Inspired volume
W	-	Width

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

This study investigates factors and predictors of changes that occur in incentive spirometry inspiratory capacity (ISIC) volumes in the first five postoperative days (PODs) after open heart surgery (OHS). ISIC are volumes of air inspired by patients using volume-oriented incentive spirometer (VIS) devices while OHS is a surgical procedure where access to the heart and its associated structures is obtained through a midline sternotomy incision. OHS patients are at high-risk for postoperative pulmonary complications (PPCs) due to various surgery and patient-related factors which cause diminished lung volumes, causing increased susceptibility to PPCs (Warner, 2000). This underscores the need for effective lung expansion therapies (LET) to improve lung volumes in the early postoperative period after OHS. One such commonly used LET for facilitating maximal inspiratory breaths in postoperative patients is incentive spirometry (IS),

The process of IS requires the patient to inspire to maximal inspiratory volumes on each postoperative day and these volumes are increased progressively throughout the course of IS therapy in order to achieve preoperative ISIC volumes

prior to discharge. However, there is not much information on ISIC volume changes that occur in the postoperative period after OHS. Current IS guidelines also do not specify the magnitude of increases in ISIC volume goals that should be targeted for OHS patients. This makes it difficult to ascertain suitable target volumes for achieving optimal outcomes for each postoperative day.

Several surgery and patient-related factors and predictors have been identified as risk factors for reduced lung volumes and increased propensity towards PPCs after OHS. However, patient-related factors such as compliance and performance of IS therapy has not been investigated comprehensively. Patient compliance with IS therapy is essential for maintaining and improving alveolar patency and pulmonary function (Fisher, 2013). Compliance, in clinical situations, is the extent to which therapeutic prescriptions or recommendations are followed by the patient (Martin, 2005) and in the context of IS, patient's performance and self-administration of this therapy may be insufficient or vary throughout the course of intervention to cause an impact on outcomes. IS therapy is often based on prescriptions comprising several performance parameters such as the frequency at which the therapy should be done and the amount of volume that should be inspired during each inspiration. However, there is lack of supportive evidence on the relationship and effects of IS parameters on lung volume outcomes. Current guidelines on IS therapy (Restrepo *et al.*, 2011) also reflect these uncertainties they do not specify optimal dosages for IS performance parameters.

Despite the lack of sufficient scientific evidence on its efficacy on clinical outcomes, ease and simplicity of use makes IS a favored option for postoperative LET in many healthcare settings (Fisher, 2013) and this practice has been deemed counterproductive, especially in the context of increasing healthcare costs (Branson, 2013). Hence, given the dearth of evidence on IS performance-related factors, there is a need for more research to explore these perspectives as well. In order to accomplish this, ISIC volume changes and IS performance-related variables need to be studied comprehensively in an objective manner. One of the constraints preventing such efforts may be the lack of data collection features in current IS

devices, which could be overcome using appropriate technological approaches. Hence this study aimed to conduct an objective longitudinal investigation into ISIC volume changes in relation to patient and surgery-related factors, as well as IS performance variables obtained using an appropriate technology device.

1.2 Problem Statement

Cardiothoracic surgery service is one of the major fast growing specialties in Malaysian Ministry of Health hospitals and the need for effective evidence-based interventions to optimize patient care and outcomes is espoused in its operational policy (Ministry of Health, Malaysia, 2011).

i. IS is routinely used to improve lung volumes in the early postoperative period for OHS patients in Hospital Sultanah Aminah, Johor Bahru (HSAJB), Malaysia. However, information on serial relative ISIC volume changes occurring after OHS, to be used as a guideline for ascertaining IS target volumes for each postoperative day, is not available. Additionally, factors and predictors of postoperative ISIC volume outcomes in a local OHS has not been investigated before.

ii. IS prescription used in HSAJB also comprises these two parameters, namely frequencies of usage and inspiratory volumes and therapy is performed with the goal of recovering postoperative ISIC volumes to preoperative values prior to discharge. However, the association between these two parameters and ISIC volume outcomes has not been investigated before.

iii. To address the above-mentioned issues, IS performance needs to be objectively monitored and tracked through the course of intervention to obtain precise data on patients' compliance to the prescribed IS

parameters. However, the single-use disposable VIS devices used in this hospital lack the necessary features. Electronic technologies may be used for collecting such data but implications of cost has to be considered as any upgrade to the IS device itself is bound to increase its cost. Thus, an appropriate electronic technology capable of tracking and collecting such data, and at the same time does not increase the cost of the IS device, needs to be developed before these endeavors can be undertaken.

1.3 Study Objectives

The objectives of this study are as follows:

i. To identify relative changes in ISIC volumes from preoperative period to POD 5 and the IS compliance of an OHS study sample in HSAJB.

ii. To determine the relationship and predictive strength of age, gender, body mass index (BMI), smoking status, preoperative ISIC (preop ISIC), cardiopulmonary bypass (CPB) time, pain, IS frequency (ISf) and IS inspiration volumes (ISv) on postoperative ISIC outcomes in order to formulate and propose evidence-based IS prescription for this patient population.

iii. To develop and validate an appropriate IS data acquisition device capable of collecting and storing IS performance data which can be used to investigate relationship between IS performance and postoperative ISIC volume outcomes in these patients.

1.4 Research Questions and Hypothesis

i. What are the relative changes that occur in ISIC volumes from the preoperative period to POD 5 and the IS performance compliance of a sample of OHS patients in HSAJB?

ii. What evidence-based IS prescription can be formulated for these patients, based on the findings from the relationship and predictive strength of their age, gender, BMI, smoking status, preop ISIC, CPB time, pain, IS performance frequency and volumes on their postoperative ISIC volume outcomes?

iii. Is the newly-developed IS data collection device valid and reliable in collecting IS performance data?

For this study, a null hypothesis was postulated that there is no relationship between any factors or predictors which were studied on postoperative ISIC volume outcomes.

1.5 Scope of Study

To achieve the research objectives, this study was conducted in a cohort of OHS patients in HSAJB. The scope of the study was focused on the aspects outlined below:

i. Conduct power analysis to determine the sample size needed for the study.

ii. Collect data:
    a. Using manual methods for:
        – Sample characteristics and preop ISIC
        – Postoperative ISIC
    b. Using the newly developed IS data collection device for IS performance from POD 1 to POD 5.

iii. Conduct data analysis to:
    a. Examine and describe the relative changes in ISIC volumes from the preoperative period to POD 5.
    b. Examine and describe the IS performance compliance of these patients.
    c. Examine the relationship and test the predictive strength of pain, IS performance frequency and volumes on POD 1, 2, 3 and 4 on ISIC volume outcomes on POD 2, 3, 4 and 5 respectively.
    d. Examine the relationship and test the predictive strength of age, gender, BMI, smoking status, preop ISIC, CPB time, IS performance frequency and volumes on ISIC volume outcomes on POD 5.

iv. Formulate and propose IS therapy prescription for this patient population, based on the findings from this research.

v. Develop a suitable device capable of tracking, recording and storing IS-related data.

vi. Test the device in these following aspects:
    a. Electrical safety
    b. Functionality of the various features of the device
    c. Performance of the device in accurately tracking, recording and storing IS-related data.

1.6 Significance of Study

This study helps to:

i. Provide evidence on the relationship between age, gender, BMI, smoking status, preop ISIC, CPB time, pain, IS performance frequency and volumes on postoperative ISIC volume outcomes after OHS to formulate and propose suitable IS therapy prescription that can be potentially used for OHS patients in HSAJB.

ii. Provide insights on the clinical validity of IS therapy and facilitate care strategies that may improve outcomes for these patients.

iii. Provide a suitable technology option for fellow researchers in this field to conduct similar studies in different clinical populations.

iv. Catalyze a new direction in IS research by highlighting the need for including comprehensive and objective evaluation of IS performance frequency and volumes to determine best practices in IS therapy.

REFERENCES

Agostini, P. & Singh, S. (2009). Incentive spirometry following thoracic surgery: What should we be doing? *Physiotherapy*, 95(2), 76-82.

Agostini, P., Naidu, B., Cieslik, H., Steyn, R., Rajesh, P. B., Bishay, E., Kalkat, M. S. & Singh, S. (2013). Effectiveness of incentive spirometry in patients following thoracotomy and lung resection including those at high risk for developing pulmonary complications. *Thorax*, 68(6),580-585.

Al-Ruzzeh, S. & Kurup, V. (2012). Respiratory diseases. In R. L. Hines & K. E. Marschall (Eds.), *Stoelting's anesthesia and co-existing disease* (6th ed., pp.181-217). Philadelphia, PA: Elsevier Saunders.

Ambrosino, N. & Gabbrielli, L. (2010). Physiotherapy in the perioperative period. *Best Pract Res ClinAnaesthesiol*, 24(2), 283-289.

Antunes, P. E., de Oliveira, J. F. & Antunes, M. J. (2009). Risk-prediction for postoperative major morbidity in coronary artery surgery. *Eur J Cardiothorac Surg*, 35(5), 760-766.

Bach, J. R. & Mehta, A. D. (2014). Respiratory muscle aids to avert respiratory failure and tracheostomy: A new patient management paradigm. *Journal of Neurorestoratology*, 2, 25-35.

Badenes, R., Lozano, A. & Belda, F. J. (2015). Postoperative pulmonary dysfunction and mechanical ventilation in cardiac surgery. *Crit Care Res Pract*, 420513, 1+. doi:10.1155/2015/420513

Bartlett, R. H., Gazzaniga, A. B. & Geraghty, T. R. (1973). Respiratory manoeuvres to prevent postoperative pulmonary complications: A critical review. *JAMA*, 224(7), 1017-1021.

Bastin, R., Moraine, J. J., Bardocsky, G., Kahn, R. J. & Melot, C. (1997). Incentive spirometry performance: A reliable indicator of pulmonary function in the early postoperative period after lobectomy? *Chest,* 111(3), 559-563.

Baumgarten, M. C. S., Garcia, G. K., Frantzeski, M. H., Giacomazzi, C. M., Lagni, V. B., Dias, A. S. & Monteiro, M. B. (2009). Pain and pulmonary function in patients submitted to heart surgery via sternotomy. *Rev Bras Cir Cardiovasc,* 24(4), 497-505.

Branson, R. D. (2013). The scientific basis for postoperative respiratory care. *Respir Care,* 58(11), 1974-1984.

Brazzale, D., Hall, G. & Swanney, M. P. (2016). Reference values for spirometry and their use in test interpretation: A position statement from the Australian and New Zealand Society of Respiratory Science. *Respirology,* 21(7), 1202-1209.

Breivik, H., Borchgrevink, P. C., Allen, S. M., Rosseland, L. A., Romundstad, L., Breivik Hals, E. K., Kvarstein, G. & Stubhaug, G. (2008). Assessment of pain. *Br J Anaesth,* 101(1), 17-24.

Brown, S. D. & Walters, M. R. (2012). Patients with rib fractures – Use of incentive spirometry volumes to guide care. *J Trauma Nursing,* 19(2), 89-91.

Bryant, T. K. (2012). *U.S. Patent No. 2012/0089043 A1*. Washington DC: U.S. Patent and Trademark Office.

Bursac, Z., Gauss, C. H., Williams, D. K. & Hosmer, D. W. (2008). Purposeful selection of variables in logistic regression. *Source Code Biol Med*, 3(17), 1+. doi:10.1186/1751-0473-3-17.

Cairo, J. M. (2014). Lung expansion therapy devices. In Cairo, J. M., *Mosby's Respiratory Care Equipment* (9th ed., pp.213-236). Missouri, U.S.: Elsevier Mosby.

Cardiothoracic Surgery HSAJB (2015). *Cardiothoracic surgery annual statistics 2001-2015*. Unpublished report of patient statistics. Department of Cardiothoracic Surgery, Hospital SultanahAminah, Johor Bahru, Johor.

Carvalho, C. R. F., Paisani, D. M. & Lunardi, A. C. (2011). Incentive spirometry in major surgeries: A systematic review. *Rev Bras Fisioter*, 15(5), 343-350.

Casutt, C., Pancherz, H., Gawora, M. & Ruf, S. (2007). Success rate and efficiency of activator treatment. *Eur J Orthod,* 29(6), 614-621.

Cattano, D., Altamirano, A., Vannucci, A., Melnikov, V., Cone, C. & Hagberg, C. A. (2010). Preoperative use of incentive spirometry does not affect postoperative lung function in bariatric surgery. *Transl Res*, 156, 265-272.

Caza, N., Taha, R., Qi, Y. & Blaise, G. (2008). The effects of surgery and anaesthesia on memory and cognition. *Prog Brain Res*, 169, 409-422.

Celli, B. R., Rodriguez, K. S. & Snider, G. L. (1984). A controlled trial of intermittent positive pressure breathing, incentive spirometry and deep breathing exercises in preventing pulmonary complications after abdominal surgery. *Am Rev Respir Dis*, 130(1), 12-15.

Chapman, K. R. (2000). Reality–based medicine. *Chest*, 118(2), 281-283.

Chan, A. W., Tetzlaff, J. M., Gøtzsche, P. C.,Altman, D. G., Mann, H., Berlin, J. A., Dickersin, K., Hróbjartsson, A., Schulz, K. F., Parulekar, W. R., Krleža-Jerić, K., Laupacis, A. & Moher, D. (2013). SPIRIT 2013 explanation and elaboration: Guidance for protocols of clinical trials. *BMJ*. 346:e7586. doi:10.1136/bmj.e7586

Cochrane, M. G., Bala, M. V., Downs, K. E., Mauskopf, J. & Ben-Joseph, R. H. (2000). Inhaled corticosteroids for asthma therapy: Patient compliance, devices, and inhalation technique. *Chest*, 117(2), 542-550.

Cohen, J. (1992). A power primer. *Psychol. Bull*, 112(1), 155-159.

Cooper, B. G. (2011). An update on contraindications for lung function testing. *Thorax*, 66(8), 714-723.

Corn, S. B. (2010). *U.S. Patent No. 2010/0305466 A1*. Washington DC: U.S. Patent and Trademark Office.

Crowe, J. M. & Bradley, C. A. (1997). The effectiveness of incentive spirometry with physical therapy for high-risk patients after coronary artery bypass surgery. *Phys Ther*, 77(3), 260-268.

Csifesz, N. G. & Gartman, E. J. (2014). New developments in the assessment of COPD: Early diagnosis in key. *Int J Chron Obstruct Pulmon Dis*, 9, 277-286.

Daniel, W. W. (1999). *Biostatistics: A foundation for analysis in the health sciences* (7th ed.). New York: John Wiley & Sons.

de Mello, L. C., Rosatti, S. F. C. & Hortense, P. (2014). Assessment of pain during rest and during activities in the postoperative period of cardiac surgery. *Rev. Latino-Am. Enfermagem*, 22(1), 136-43.

de Souza, V. E., de Oliveira Lopes, M. V., de Arauio, T. L., Rolim, I. L., do Nascimento, R. V. & Oliveira, T. F. (2014). Clinical indicators of ineffective airway clearance for patients in the cardiac postoperative period. *Eur J Cardiovascular Nurs*, 12(2), 193-200.

Dias, C. M., Vieira, R. O., Oliveira, J. F., Lopes, A. J., Menexes, S. L. & Guimaraes, F. S. (2011). Three physiotherapy protocols: Effects on pulmonary volumes after cardiac surgery. *J Bras Pneumol*, 37(1), 54-60.

Dodd, S., White, I. R. & Williamson, P. (2012). Nonadherence to treatment protocol in published randomised controlled trials: A review. *Trials*, 13:84. doi:10.1186/1745-6215-13-84

Duggan, M. & Kavanagh, B. P. (2005). Pulmonaryatelectasis – apathogenic perioperative entity. *Anesthesiology*, 102(4), 838-854.

Dull, J. L. & Dull, W. L. (1983). Are maximal inspiratory breathing exercises or incentive spirometry better than early mobilization after cardiopulmonary bypass? *Phys Ther*, 63(5), 655-659.

El- Kader, S. M. A. (2011). Blood gases response to different breathing modalities in phase I of cardiac rehabilitation program after coronary artery bypass graft. *European Journal of General Medicine*, 8(2), 85-91.

Elliott, A. C. & Woodward, W. A. (2007). *Statistical analysis quick reference guidebook with SPSS examples*. London: Sage Publications Limited.

El-Sobkey, S. B. & Gomaa, M. (2011). Assessment of pulmonary function tests in cardiac patients. *J Saudi Heart Assoc*, 23(2), 81-86.

Etikan, I., Musa, S. A. & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), 1- 4.

Faria, I. D. B., Freire, L. M. S. & Sampaio, W. N. O. (2013). Inspiration boosters: Technical updates in incentive spirometers and breath-stacking. *Rev Med Minas Gerais*, 23(2), 222-228.

Faul, F., Erdfelder, E., Lang, A. G. & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*, 39(2), 175–191.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed.). London: Sage Publications Limited.

Fisher, D.F. (2013). Lung expansion therapy. In R. M. Kacmarek, J. K. Stoller & A. J. Heuer (Eds.), *Egan's Fundamentals of Respiratory Care* (10th ed.). St. Louis, Missouri: Elsevier.

Fisher, M. J. & Marshall, A. P. (2009). Understanding descriptive statistics. *Aust Crit Care,* 22, 93-97.

Forster, R. E., DuBois, A. B., Briscoe, W. A. & Fisher, A. B. (1986). *The lung: Physiological basis of pulmonary function tests* (3rd ed.). Chicago: Year Book Medical Publishers.

Freitas, E. R. F. S., Soares, B. G. O., Cardoso, J. R. & Atallah, A. N. (2012). Incentive spirometry for preventing pulmonary complications after coronary artery bypass graft (review). *Cochrane Database Syst Rev,* 9:CD004466. doi:10.1002/14651858.CD004466.pub2

Ghasemi, A. & Zahedias, S. (2012). Normality tests for statistical analysis: A guide for non-statisticians. *Int J Endocrinol Metab,* 10(2), 486-489.

Glaziou, P. & Haynes, B. (2005). The paths from research to improved health outcomes. *Evid Based Nurs*, 8(2), 36-38.

Glover, D. W. (2010). *The history of respiratory therapy: Discovery and evolution*. Bloomington, I. N.: Author House.

Gois, C. F. L., Aguillar, O. M., dos Santos, V. & Rodriguez, E. O. L. (2012). Stress factors for patients undergoing cardiac surgery. *Invest Educ Enferm,* 30(3), 321-319.

Gosselink, R., Schrever, K., Cops, P., Witvrouwen, H., De Levn, P., Troosters, T., Deneffe, G. & Decramer, M. (2000). Incentive spirometry does not enhance recovery after thoracic surgery. *Crit Care Med*, 28(3), 679-683.

Haeffener, M. P., Ferreira, G. M., Barreto, S. S. M., Arena, R. & Dall'Ago, P. (2008). Incentive spirometry with expiratory positive pressure reduces pulmonary complications improves pulmonary function and 6-minute walk distance in patients undergoing coronary artery bypass surgery. *Am Heart J,* 156(5), 900.e1-900.e8. doi:10.1016/j.ahj.2008.08.006

Harton, S. C., Grap, M. J., Savage, L. & Elswick, R. K. (2007). Frequency and predictors of return to incentive spirometry baseline volume after cardiac surgery. *Prog Cardiovasc Nurs,* 22(1), 7-12.

Hess, D. R. (2012). Sputum collection, airway clearance, and lung expansion therapy. In Hess, D. R., MacIntyre, N. R., Mishoe, S. C., Galvin, W. F. &

Adams, A. B. (Eds.), *Respiratory Care: Principles and Practices* (2nd ed., pp. 342-418). Sudbury, MA: Jones and Bartlett Learning.

Hedenstierna, G. & Rothen, H. U. (2012). Respiratory function during anesthesia: Effects on gas exchange. *Compr Physiol*, 2(1), 69-96.

Hough, A. (2014). *Physiotherapy in respiratory and cardiac care: An evidence-based approach* (4th ed.). Hampshire, U.K.: Cengage Learning EMEA.

Hulzebos, E. H., Van Meeteren, N. L., De Bie, R. A., Dagnelie, P. C. & Helders, P. J. (2003). Prediction of postoperative pulmonary complications on the basis of preoperative risk factors in patients who had undergone coronary artery bypass graft surgery. *PhysTher*, 83(1), 8-16.

Irwin, R. S. & Widdicombe, J. (2000). Cough. In Murray J. F. & Nadel J. A. (Eds.), *Textbook of Respiratory Medicine* (3rd ed., pp. 553-566). Philadelphia: W.B. Saunders.

Jenkins, S. C., Soutar, S. A., Forsyth, A., Keates, J. R. W. & Moxham, J. (1989). Lung function after coronary artery surgery using the internal mammary artery and the saphenous vein. *Thorax*, 44(3), 209–211.

Ji, Q., Zhao, H., Mei, Y. Q., Shi, Y. Q., Ma, R. H. & Ding, W. J. (2015). Impact of smoking on early clinical outcomes in patients undergoing coronary artery bypass grafting surgery. *J Cardiothorac Surg*, 10:16.doi:10.1186/s13019-015-0216-y

Jordan, R. E., Cheng, K. K., Miller, M. R. & Adab, P. (2011). Passive smoking and chronic obstructive pulmonary disease: Cross-sectional analysis of data from the health survey for England. *BMJ Open*, 1:e000153. doi:10.1136/bmjopen-2011-000153

Kailash, R. L., Daley, J., Duncan, C. C., Davis, R. B., Coffman, G. A. & Iezzoni, L. I. (1995). Costs of potential complications of care for major surgery patients. *Am J Med Qual*, 10(1), 48-54.

Karanicolas, P. L., Farrofhyar, F. & Bhandari, M. (2010). Blinding: Who, what, when, why, how? *Can J Surg*, 53(5), 345-348.

Kehlet, H. & Wilmore, D. W. (2002). Multimodal strategies to improve surgical outcome. *Am J Surg*, 183(6), 630-641.

Ko, F. W. & Hui, D. S. (2012). Air pollution and chronic obstructive pulmonary disease. *Respirology*, 17(3), 395-401.

Kucklick, T. R. (2012). Materials for medical device R&D: Introduction to medical plastics. In T. R. Kucklick (Ed.), *The Medical Device R&D Handbook* (2nd ed., pp. 3-27). Boca Raton, Florida: CRC Press, Taylor & Francis Group.

Kulkarni, S., Fletcher, E., McConnell, A., Poskitt, K. R. & Whyman, M. R. (2010). Pre-operative inspiratory muscle training preserves postoperative inspiratory muscle strength following major abdominal surgery – a randomised pilot study. *Ann R Coll Surg Eng*, 92, 700-705.

Kundra, P., Vitheeswaran, M., Nagappa, M. & Sistla, S. (2010). Effect of preoperative and postoperative incentive spirometry on lung functions after laparoscopic choecystectomy. *Surg Laparosc Endosc Percutan Tech*, 20, 170-172.

LaFluer, J. & Oderda, G.M.(2004). Methods to measure patient compliance with medication regimens. *J Pain Pall Care Pharmacother*, 18(3), 81-87.

Lakens, D. (2013).Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Front. Psychol*, 4(863), 1-12.

Leeper, B. (2009). Impact of obesity on care of postoperative coronary bypass patients. *Crit Care Nurs Clin North Am*, 21(3), 369-375.

Limanthe, J., Kurt, M., Feindt, P., Gams, E. & Boeken, U. (2009). Predictors and outcomes of ICU admission after cardiac surgery. *Thorac Cardiovasc Surg*, 57(7), 391-394.

Li, P., Janczewski, W. A., Yackle, K., Kam, K., Pagliardini, S., Krasnow, M. A. & Feldman, J. L. (2016). The peptidergiccontrol circuit for sighing. *Nature*, 530(7590), 293-297.

Lomi, C. & Westerdahl, E. (2013). Physical therapy treatment after cardiac surgery: A national survey of practice in Greece. *J Clin Exp Cardiolog*, S7: 004. doi:10.4172/2155-9880.S7-004

Magnusson, L. & Spahn, D. R. (2003). New concepts of atelectasis during general anaesthesia. *Br J Anaesth*, 91(1): 61-72.

Marshall, G. & Jonker, L. (2011). An introduction to inferential statistics: A review and practical guide. *Radiography*, 17, e1- e6.

Martin, L. R., Williams, S. L., Haskard, K. B. & DiMatteo, M. R. (2005). The challenge of patient adherence. *Ther Clin Risk Manag*, 1(13), 189-199.

Massard, G. & Wihlm, J. M. (1998). Postoperative atelectasis. *Chest Surg Clin N Am*, 8(3),503-528.

Massoudy, P., Zahler, S., Becket, B. F., Braun, S. L., Barankay, A. & Meisner, H. (2001). Evidence for inflammatory responses of the lungs during coronary artery bypass grafting with cardiopulmonary bypass. *Chest*, 119(1), 1–36.

Matsuo, M., Hashimoto, N., Usami, N., Imaizumi, K., Wakai, K., Kawabe, T., Yokoi, K. & Hasegawa, Y. (2012). Inspiratory capacity as a preoperative assessment of patients undergoing thoracic surgery. *Interact Cardiovasc Thorac Surg*, 14(5), 560-564.

Matte, P., Jacquet, L., Van Dyck, M. &Goenen, M. (2000). Effects of conventional physiotherapy, continuous positive airway pressure and non-invasive ventilator support with bilevel positive airway pressure after coronary artery bypass grafting. *Acta Anaesthesiol Scand*, 44(1), 75–81.

Meier, T., Lange, A., Papenberg, H., Ziemann, M., Fentrop, C., Uhlig, U., Schmucker, P., Uhlig, S. & Stamme, C. (2008). Pulmonary cytokine responses during mechanical ventilation of noninjuredlungs with and without end-expiratory pressure. *Anesth Analg*, 107(4), 1265–1275.

Meyer, W. J. (2004). *Concepts of mathematical modelling*. Mineola, N. Y.: Dover Publications.

Milgrom, L. B., Brooks, J. A., Qi, R., Bummel, K., Wuestfeld, S. & Beckman, D. (2004). Pain levels experienced with activities after cardiac surgery. *Am J Crit Care*, 13(4), 116-125.

Ministry of Health Malaysia (2011). *Cardiothoracic surgery services operational policy*. Putrajaya, MY: Medical Development Division, Ministry of Health Malaysia.

Miranda, R. D., Gommers, D., Struiis, A., Dekker, R., Mekel, J., Feelders, R., Lachmann, B. & Bogers, A. J. (2005). Ventilation according to the open lung concept attenuates pulmonary inflammatory response in cardiac surgery. *Eur J Cardiothorac Surg*, 28(6), 889-895.

Moreno, A. M., Castro, R. R. T., Sorares, P. P. S., Anna, M. S., Cravo, S. L. D. & Nóbrega, A. C. L. (2011). Longitudinal evaluation of the pulmonary function of the pre and postoperative periods in the coronary artery bypass graft surgery of patients treated with a physiotherapy protocol. *J Cardiothorac Surg*, 6:62. doi:10.1186/1749-8090-6-62

Müller, A. P., Olandoski, M., Macedo, R., Costantini, C. & Guarita-Souza, L. C. (2006). Comparative study between intermittent (Müller Reanimator) and continuous positive airway pressure in the postoperative period of coronary artery bypass grafting. *Arq Bras Cardiol*, 86(3), 232-239.

Myles, P. S., Daly, D. J., Djaiani, G., Lee, A. & Cheng, D. C. (2003). A systematic review of the safety and effectiveness of fast-track cardiac anesthesia. *Anesthesiology*, 99(4), 982-987.

Neves, F. H., Carmona1, M. J., Auler, J. O. Jr., Rodrigues1, R. R., Rouby, J. J. & Malbouisson, L. M. S. (2013). Cardiac compression of lung lower lobes after coronary artery bypass graft with cardiopulmonary bypass. *PLoS One*, 8(11):e78643. doi:10.1371/journal.pone.0078643

Ng, C. S. H., Arifi, A. A., Wan, S., Ho, A.M., Wan, I. Y., Wong, E. M. & Yim, A. P. (2008). Ventilation during cardiopulmonary bypass: Impact on cytokine response and cardiopulmonary function. *Ann Thorac Surg*, 85(1), 154–162.

Nicholson, D. J., Kowalski, S. E., Hamilton, G. A., Meyers, M. P., Serrette, C. & Duke, P. C. (2002). Postoperative pulmonary function in coronary artery bypass graft surgery patients undergoing early tracheal extubation: A comparison between short-term mechanical ventilation and early extubation. *J Cardiothorac Vasc Anesth*, 16(1), 27-31.

O'Donahue, W. J. Jr. (1992). Postoperative pulmonary complications. When are preventive and therapeutic measures necessary? *Postgrad Med*, 91(3), 167-170.

O'Donnell, D. E., Webb, K. A. & Neder, J. A. (2015). Lung hyperinflation in COPD: Applying physiology to clinical practice. *COPD Research and Practice*, 1:4. doi:10.1186/s40749-015-0008-8

Overend, T. J., Anderson, C. M., Lucy, S. D., Bhatia, C., Jonsson, B. I. & Timmermans, C. (2001). The effect of incentive spirometry on postoperative complications: A systematic review. *Chest*, 120(3), 971-8.

Page, S. J. & Persch, A. C. (2013). Recruitment, retention, and blinding in clinical trials. *Am J Occup Ther*, 67(2), 154-161.

Paisani, D., de M., Lunardi, A. C., da Silva, C. C., Porras, D. C., Tanaka, C. & Carvalho, C. R. (2013). Volume rather than flow incentive spirometry is effective in improving chest wall expansion and abdominal displacement using optoelectronic plethysmography. *Respir Care*, 58(8), 1360-1366.

Parreira, V. F., Tomich, G. M., Britto, R. R. & Sampaio, R. F. (2005). Assessment of tidal volume and thoracoabdominalmotion using volume and flow-oriented incentive spirometers in healthy subjects. *Braz J Med Biol Res*, 38(7), 1105-1112.

Pasquina, P., Tramer, M. R. & Walder, B. (2003). Prophylactic respiratory physiotherapy after cardiac surgery: Systematic review. *BMJ*, 3(327), 1-6.

Pasquina, P., Merlani, P., Granier, J. M. & Ricou, B. (2004). Continuous positive airway pressure versus noninvasive pressure support ventilation to treat atelectasis after cardiac surgery. *Anesth Analg*, 99(4), 1001-1008.

Peruzzi, W. T. & Candido, K. D. (2007). Respiratory care. In W. C. Wilson, C. M. Grande & Hoyt, D. B. (Eds.), *Trauma: Critical care volume 2* (pp. 485-504). New York: Informa Healthcare.

Petersson, J. & Glenny, R. B. (2014). Gas exchange and ventilation-perfusion relationship in the lung. *Eur Respir J*, 44(4), 1023-1041.

Pinheiro, A. C., Novais, M. C. M., Neto, M. G., Rodrigues, M. V. H., Rodrigues, Jr., E. D. S., Aras, Jr., R. & Carvalho, V. O. (2011). Estimation of lung vital capacity before and after coronary artery bypass grafting surgery: A comparison of incentive spirometer and ventilometry. *J Cardiothorac Surg*, 6:70. doi:10.1186/1749-8090-6-70

Piotto R. F., Ferreira, F. B., Colósimo, F. C., da Silva, G. S., de Sousa A. G. & Braile, D. M. (2012). Independent predictors of prolonged mechanical ventilation after coronary artery bypass surgery. *Braz J Cardiovasc Surg*, 27(4), 20–528.

Portney, L. G. & Watkins, M. P. (2015). *Foundations of clinical research: Applications to practice* (3rd ed.). Philadelphia, PA: F.A. Davis Company.

Quanjer, Ph. H., Tommelin, G. J., Cotes, J. E., Pedersen, O. F., Peslin, R. & Yernault, J. C.(1993). Lung volumes and forced ventilatory flows. *Eur Respir J*, 6(Suppl 16), 5-14.

Rau, J. L., Thomas, L. & Haynes, L. H.(1988). The effect of method of administering incentive spirometry on postoperative pulmonary complications in coronary artery bypass patients. *Respir Care*, 33, 771-8.

Reddy, S. L., Grayson, A. D., Griffiths, E. M., Pullan, D. M. & Rashid, A. (2007). Logistic risk model for prolonged ventilation after adult cardiac surgery. *Ann Thorac Surg*, 84(2), 528-536.

Reimer–Kent, J. (2003). From theory to practice: Preventing pain after cardiac surgery. *Am J Crit Care*, 12(2), 136-143.

Renault, J. A., Costa-Val, R. & Rossetti, M. B. (2008). Respiratory physiotherapy in the pulmonary dysfunction after cardiac surgery. *Braz J Cardiovasc Surg*, 23(4), 562–569.

Renault, J. A., Costa-Val, R., Rossetti, M. B. & Houri Neto, M. (2009).Comparison between deep breathing exercises and incentive spirometry after CABG surgery. *Rev Bras Cir Cardiovasc*, 24(2),165-172.

Restrepo, R. D., Wettstein, R., Wittnebel, L. & Tracy, M. (2011). AARC (American Association for Respiratory Care) clinical practice guideline. Incentive spirometry: 2011. *Respir Care*, 56(10), 1600-4.

Restrepo, R. D. & Braverman, J. (2014). Current challenges in the recognition, prevention and treatment of perioperative pulmonary atelectasis. *Respir Med*, 9(1), 97-107.

Romanini, W., Muller, A. P., Carvalho, K. A. T., Olandoski, M., Faria-Neto, J. R., Mendes, F. L., Sardetto, E. A., Costa, F. D. & Guarita-Souza, L. C. (2007). The effects of intermittent positive pressure and incentive spirometry in the postoperative of myocardial revascularization. *Arq Bras Cardiol*, 89(2), 94-99.

Rosenthal, R. (1991). *Meta-analytic procedures for social research volume 6*. Newbury Park, CA: Sage Publication Limited.

Rosnow, R. L. & Rosenthal, R.(2005). *Beginning behavioural research: A conceptual primer* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Rouhi-Boroujeni, H., Rouhi-Boroujeni, H., Rouhi-Boroujeni, P. & Sedehi., M. (2015). Long-term pulmonary functional status following coronary artery bypass grafting surgery. *ARYA Atheroscler*, 11(2), 163-166.

Saski, N., Meyer, M. J. & Eikermann, M. (2013). Postoperative respiratory muscle dysfunction. *Anesthesiology*, 118(4), 961-978.

Savci, S., Sakinç, S., İnce, D. I., Arikan. H., Can, Z., Buran, Y. & Kuralay, E. (2006). Active cycle of breathing techniques and incentive spirometer in coronary artery bypass graft surgery. *Fizyoterap Rehabilitasyon*, 17(2), 61-69.

Schreiber, J. U., Lancé, M. D., deKorte, M., Artmann, T., Aleksic, I. & Kranke, P. (2012). The effect of different lung-protective strategies in patients during

cardiopulmonary bypass: A meta-analysis and semi quantitative review of randomized trials. *J Cardiothorac Vasc Anesth*, 26(3), 448–454.

Shander, A., Fleisher, L. A., Barie, P. S., Bigatello, L. M., Sladen, R. N. & Watson, C.B. (2011). Clinical and economic burden of postoperative pulmonary complications: Patient safety summit on definition, risk-reducing interventions, and preventive strategies. *Crit Care Med*, 39(9), 2163-2172.

Shelledy, O. C. & Mikles, S. P. (2003). Patient assessment and respiratory care plan development. In S. C. Mishoe & M. A. Welch Jr. (Eds.), *Critical thinking in respiratory care – a problem-based learning approach* (pp. 181-234). Singapore: McGraw- Hill Education (Asia).

Shenkman, Z., Shir, Y., Weiss, Y. G., Bleiberg, B. & Gross, D. (1997). The effects of cardiac surgery on early and late pulmonary functions. *Acta Anaesthesiol Scand*, 41(9),1193–1199.

Sterne, J. A. & Davey Smith, G. (2001). Sifting the evidence- what's wrong with significance tests? *BMJ*, 322(7280), 226-231.

Stock, M. C., Downs, J. B., Cooper, R. B., Lebenson, I. M., Cleveland, J., Weaver, D. E., Alster, J. M. & Imrey, P. B. (1984). Comparison of continuous positive airway pressure, incentive spirometry and conservative therapy after cardiac operations. *Crit Care Med*, 12(11), 969-972.

Sullivan, G. M. & Feinn, R. (2012). Using effect size – or why the p value is not enough. *J Grad Med Educ*, 4(3), 279-282.

Szumilas, M. (2010). Explaining odds ratios. *J Can Acad Child Adolesc Psychiatry*, 19(3), 227-229.

Tabachnik, B. G. & Fidell, L. S. (2014). *Using multivariate statistics* (6th ed.). Essex, England: Pearson Education Limited.

Taggart, D. P. (2000). Respiratory dysfunction after cardiac surgery: Effects of avoiding cardiopulmonary bypass and the use of bilateral internal mammary arteries. *Eur J Cardiothorac Surg*, 18(1):31–37.

Tantucci, C., Donati, P., Nicosia, F., Bertella, E., Redolfi, S. & De Vecc, M. (2008). Inspiratory capacity predicts mortality in patients with chronic obstructive pulmonary disease. *Respir Med*, 102(4), 613-619.

Teddlie, C. & Yu, F. (2007). Mixed methods sampling: A typology with examples. *J Mix Methods Res*, 1(1), 77-100.

Tenling, A., Hachenberg, T., Tyden, H., Thelin, S. & Hedensternia G. (1998). Atelectasis and gas exchange after cardiac surgery. *Anesthesiology*, 89(2), 1153-1163.

Thode, H. J. (2002). *Testing for normality*. New York: Marcel Dekker.

Thomas, J. A. & McIntosh, J. M. (1994). 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,* 74(1), 3-10.

Thoren, L. (1954). Postoperative pulmonary complications: Observations on their prevention by means of physiotherapy. *Acta Chir Scand*, 107, 193-205.

Tomich, G. M., França, D. C., Diório, A. C., Britto, R. R., Sampaio, R. F., Parreira, V. F. (2007). Breathing pattern, thoracoabdominal motion and muscular activity during three breathing exercises. *Braz J Med Biol Res*, 40(10), 1409-1417.

Toraman, F., Senay, S., Gullu, U., Karabulut, H. & Alhan, C. (2010). Readmission to the intensive care unit after fast-track cardiac surgery: An analysis of risk factors and outcome according to the type of operation. *Heart Surg Forum*, 13(4), E212-17.

Tung, H. H., Jan, M. S., Huang, C. M., Shih, C. C., Chang, C. Y., Liau, C. Y. (2011). Using the theory of planned behaviour to predict the use of incentive spirometryamong cardiac surgery patients in taiwan. *Heart Lung*, 40(5), 440-447.

Twardellaa, D., Kupper-Nybelena, J., Rothenbachera, D., Hahmannb, H., Wustenc, B. & Brennera, H. (2004). Short-term benefit of smoking cessation in patients with coronary heart disease: Estimates based on self-reported smoking data and serum cotinine measurements. *Eur. Heart J*, 25(23), 2101–2108.

Urell C., Emtner, M., Hedenstrom, H., Tenling, A., Breidenskog, M. & Westerdahl, E. (2011). Deep breathing exercises with positive expiratory pressure at a higher rate improve oxygenation in the early period after cardiac surgery-a randomised controlled trial. *Eur J Cardiothorac Surg*, 40(1), 162–167.

Urell, C., Westerdahl, E., Hedenström, H., Janson, C. & Emtner, M. (2012). Lung function before and two days after open-heart surgery. *Crit Care Res Pract*, 2012:291628, 1-7. doi:10.1155/2012/291628

VanDulmen, S., Sluijs, E., van Dijk, L., de Ridder, D., Heerdink, R. & Bensing, J. (2007). Patient adherence to medical treatment: A review of reviews. *BMC Health Serv Res*, 7:55. doi:10.1186/1472-6963-7-55

Vermeire, E., Hearnshaw, H., Van Royen, P. & Denekens, J. (2001). Patient adherence to treatment: Three decades of research. A comprehensive review. *J Clin Pharm Ther*, 26(5), 331-342.

Vargas, F. S., Terra-Filho, M., Hueb, W., Teixeira, L. R., Cukier, A. & Light, R. W. (1997). Pulmonary function after coronary artery bypass surgery. *Respir Med*, 91(10), 629-633.

Warner, D. O. (2000). Preventing postoperative pulmonary complications: The role of anaesthesiologist. *Anesthesiology*, 92(5), 1467-72.

Weaver, T. E. & Grunstein, R. R. (2008). Adherence to continuous positive airway pressure therapy: The challenge to effective treatment. *Proc Am Thorac Soc*, 5(2), 173-178.

Weinstein, L. A., Richards, F. M., Wickstead, J. C., Forbes, B. & Keating, M. J. (2001). *U.S. Patent No. 6,238,353 BI*. Washington DC: U.S. Patent and Trademark Office.

Weismann, C. (2004). Pulmonary complications after cardiac surgery. *Semin Cardiothorac Vasc Anesth*, 8(3), 185-211.

Westerdahl, E., Lindmark, B., Bryngelsson, I. & Tenling, A. (2003). Pulmonary function 4 months after coronary artery bypass graft surgery. *Respir Med*, 97(4), 317–322.

Westerdahl, E., Lindmark, B., Eriksson, T., Friberg, O., Hedenstierna, G. & Tenling, A. (2005). Deep-breathing exercises reduce atelectasis and improve pulmonary function after coronary artery bypass surgery. *Chest*, 128(5), 3482-3488.

Westerdahl, E. & FagevikOlsén, M. (2011). Chest physiotherapy and breathing exercises for cardiac surgery patients in Sweden - A national survey of practice. *Monaldi Arch Chest Dis*,75(2), 112-119.

Westerdahl, E. (2015). Optimal technique for deep breathing exercises after cardiac surgery. *Minerva Anesthesiol*, 81(6), 678-683.

Wickstead, J. C., Forbes, B. & Keating, M. J. (2001). *U.S. Patent No. 6,191,497 B1*. Washington DC: U.S. Patent and Trademark Office.

Wu, C.L. & Raja, S.N. (2011). Treatment of acute postoperative pain. *Lancet*, 377(9784), 2215-2225.

Wynne, R. & Botti, M. (2004).Postoperative pulmonary dysfunction in adults after cardiac surgery with cardiopulmonary bypass: Clinical significance and implications for practice. *Am J Crit Care,*13(5), 384-393.

Yazdannik, A., Bollbanabad, H. M., Mirmohammadsadeghi, M. & Khalifezade, A. (2016). The effect of incentive spirometry on arterial blood gases after coronary artery bypass surgery (CABG). *Iran J Nurs Midwifery Res*, 21(1), 89-92.

Zarbock, A., Mueller, E., Gabriel, A., Feindt, P. & Kindgen-Milles, D. (2009). Prophylactic nasal continuous positive airway pressure following cardiac surgery protects from postoperative pulmonary complications: A prospective, randomized, controlled trial in 500 patients. *Chest*, 135(5), 1252-1259.