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THE IMPLEMENTATION OF AN INDIVIDUALISED CONTINUOUS POSITIVE AIRWAY PRESSURE PROGRAMME IN PREPARATION OF THE INTUBATED ADULT PATIENT FOR EXTUBATION

CANDIDATE
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A dissertation submitted to the Faculty of Health Sciences, University of Witwatersrand, Johannesburg, in fulfilment of requirements for the degree of Masters of Science.
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DECLARATION

I, Wilma A Erasmus, declare that this dissertation is my own work and is submitted for the degree of Masters of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.



Signature

07.day of March 2012

ABSTRACT

Background

The detrimental effects of prolonged mechanical ventilation (MV) on the respiratory muscles, especially the diaphragm, are well documented and it is crucial that MV should be discontinued as soon as possible to prevent added complications and additional risks to patients with critical illness. The spontaneous breathing stage of MV can be managed as a rehabilitation and conditioning phase for the respiratory muscles due to the fact that the respiratory muscles are more active during this stage of MV. Weaning strategies that provide insufficient respiratory work, too high a respiratory muscle load or insufficient respiratory muscle rest may lead to respiratory muscle fatigue and consequently failed weaning and extubation. The aim of this research project was to develop an individualised continuous positive airway pressure (CPAP) weaning programme and test its effects on the outcomes of extubation in the adult ventilated patient.

Method

An experimental, prospective, non-randomised, sequential study of two groups of subjects was performed. Forty eight subjects [group one: n =24 (control) and group two: n = 24 (intervention)], who were mechanically ventilated for longer than 48 hours, in an open adult, general intensive care unit were recruited. Subjects in the control group were weaned according to the standard weaning programme of the test setting at the time; and those in the intervention group were weaned according to an individualised CPAP programme. This weaning programme was developed utilising three principles of muscle rehabilitation namely; daily stepwise progression, sufficient rest and recovery periods and adapted to the individual needs and progression of each subject. Objective measurements such as the rapid shallow breathing index (RSBI), RSBI rate and the maximum inspiratory pressure (MIP) were used to determine the subjects in group two's readiness for a spontaneous breathing trial. The primary outcomes assessed were time spent in the different stages of MV, rate of failure to sustain spontaneous breathing in stage 3 of MV, successful extubation and mortality rate.

Results and Discussion

The difference in rate of failure to sustain spontaneous breathing between the two groups was statistically significant ($p = 0.01$) with 10 events of failure in group one and three in group two. The rate of successful extubation from MV between groups one and two was 70.8% and 91.7%

respectively (p=0.52). The mortality rate was 33.3% for group one and 8.3% for group two (p = 0.02).

The difference in the total time spent on MV (days) did not differ significantly (group one = 8.6 (± 0.40) days; group two = 9.3 (±0.32) days; p = 0.75).

The results yielded from this study suggest that the use of a multidisciplinary team model and an individualised CPAP programme aids successful extubation from MV as the success rate was much higher in the intervention group than in the control group without adding additional time on MV.

Conclusion

Results from this study showed that the implementation of an individualised CPAP programme during the spontaneous breathing stage of MV may improve the outcomes of extubation in adult ventilated patients.

Keywords: prolonged mechanical ventilation, continuous positive airway pressure, respiratory muscle testing, extubation, rapid shallow breathing index, rapid shallow breathing index rate, maximum inspiratory pressure, low frequency fatigue.

DEDICATION

This dissertation is dedicated to my mother: **Annetjie van Rooyen** (02/01/1928 – 16/10/1988) who believed that education and knowledge is the only inheritance that nobody can ever take away from anyone.

"Dankie, Mamma dat jy altyd in my geglo en my altyd ondersteun het."

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TABLE OF CONTENTS

		Page
	Declaration	ii
	Abstract	iii
	Dedication	v
	Acknowledgements	vi
	Funding	vii
	Table of Contents	viii
	List of Tables	xi
	List of Figures	xii
	List of Abbreviations	xiii
	List of Normal Values	xv
	Definitions	xvi
1.	**Chapter 1: Introduction**	1
1.1	Background	1
1.2	Problem Statement and Justification for Research	5
1.3	Significance of Research	6
1.4	Research Question	7
1.5	Research Aim	7
1.6	Research Objectives	7
1.7	Type of Study	8
1.8	Summary	8
2.	**Chapter 2: Literature Review**	10
2.1	Indications for Mechanical Ventilation in Adult Patients	10
2.2	Complications of Mechanical Ventilation	10
2.3	The Effect of Mechanical Ventilation on Respiratory Muscles	12
2.3.1	Classification of Skeletal Muscle Fibre Types	12
2.3.2	Physiological Properties of Respiratory Muscles	13
2.3.3	Muscle Fibre Atrophy	13
2.3.4	Muscle Fibre Remodelling	14
2.3.5	Sub Cellular Structural Abnormalities	14
2.3.6	Reduced Inspiratory Muscle Endurance	16
2.3.7	Respiratory Muscle Fatigue	16
2.4	Weaning Strategies in Adult Mechanically Ventilated Patients	18
2.4.1	Predictors of Weaning Success and Extubation Failure in Weaning Strategies	19
2.4.2	Assessment of Respiratory Muscle Function	20
2.4.2.1	Respiratory Muscle Strength and Function	20
2.4.2.2	Respiratory Muscle Endurance	23
2.4.2.3	Respiratory Muscle Fatigue	23

2.4.3	Spontaneous Breathing Trial	23
2.4.4	Weaning Protocols	26
2.4.5	Multi-Disciplinary Team Model in the Weaning Strategies of Patients on Mechanical Ventilation in ICU	28
2.5	Principles of Muscle Rehabilitation	29
2.5.1	Specific Adaptation to Imposed Demand	29
2.5.2	Overload	30
2.5.3	Individual Differences Principal	30
2.6	Muscle Conditioning	31
2.6.1	Muscle Activation and Motor Re-Education	31
2.6.2	Muscle Strength Training	31
2.6.3	Muscle Power Training	32
2.6.4	Muscle Endurance Training	33
2.6.5	Recovery and Rest	37
2.7	Exercise Prescription for Acutely Ill Patients	34
2.8	Respiratory Muscle Training in Mechanically Ventilated Patients	34
2.9	Summary	35
3.	**Chapter 3: Methodology**	37
3.1	Study Design	37
3.2	Subjects	37
3.2.1	Sample Selection and Demographics	37
3.2.2	Inclusion Criteria	38
3.2.3	Exclusion Criteria	38
3.2.4	Sample Size Calculations	39
3.3	Hypothesis	39
3.4	Null Hypothesis	39
3.5	Outcome Measures	39
3.6	Variables	40
3.7	Study Procedures	41
3.7.1	Instruments	41
3.7.1.1	Standard Procedure	41
3.7.1.2	Intervention Procedure	41
3.8	Data Collection Procedure	46
3.9	Ethical Considerations	49
3.10	Approaches to Data Analysis	50
4.	**Chapter 4: Results**	52
4.1	Demographic Information and Confounding Variables	52
4.2	Primary Outcomes	54
4.2.1	Hours Spent in the Different Stages of Mechanical Ventilation	54

4.2.2	Failure to Sustain Spontaneous Breathing in Stage Three of Mechanical Ventilation, Success rate of Extubation and the Mortality Rate within 48 Hours of Extubation……	56
4.2.3	Reasons for Failure of Stage three of Mechanical Ventilation and for Extubation Failure	58
4.3	Rapid Shallow Breathing Index Distribution for Group Two.....	59
4.4	Maximum Inspiratory Pressure for Group Two.....	60
4.5	Summary of Statistical Results	60
5.	**Chapter 5: Discussion**…….....	62
5.1	Challenges Pertaining to the Multi-Disciplinary Team in the Current Study…….....	67
5.2	Significance of Findings.....	68
5.3	Limitations of the Study and Recommendations for Future Trials.....	70
6.	**Chapter 6: Conclusion**…….....	72
7.	**References**.....	74
Appendix 1	: Figure 1.1: Krebs's Cycle…..…….....	85
Appendix 2	: Baseline Data Collection Sheet.....	87
Appendix 3	: Screening Forms 1-3…….....	89
Appendix 4	: Rapid Shallow Breathing Index Protocol ….....	93
Appendix 5	: Maximum Inspiratory Pressure Measurement Protocol.....	95
Appendix 6	: Individualised Continuous Positive Airway Pressure Program…….....	97
Appendix 7	: Weaning Flow Chart.....	99
Appendix 8	: Patient Information Sheet.....	101
Appendix 9	: Individual Continuous Positive Airway Pressure Schedule.....	106
Appendix 10	: Data Capture Sheets A and B.....	108
Appendix 11	: Ethical Clearance Certificate.....	111
Appendix 12	: Permission Letters from Cosmos Life Hospital, ICU Steering Committee and Management to Perform Study.....	113
Appendix 13	: Research Assistant: Letter of Appointment…….....	116
Appendix 14	: Subject Informed Consent Letter.....	118
Appendix 15	: Richmond Agitation Sedation Scale……..……	121

LIST OF TABLES

			Page
Table 3.1	:	Individualised Continuous Positive Airway Pressure Programme……..	45
Table 4.1	:	Comparison of Combined Demographic and Confounding Variables Distribution by Group…….	53
Table 4.2	:	Comparison of Study Groups with Respect to Time Variables ……..	54
Table 4.3	:	Comparison of Study Groups with Respect to Failed Stage Three of Mechanical Ventilation, Successful Extubation and Mortality During or After Stage Two of Mechanical Ventilation.....	57
Table 4.4	:	Number of Failed Spontaneous Breathing and Extubation Events in Stage Thee by Group. …….....	58
Table 4.5	:	Reasons for Failed Spontaneous Breathing in Stage Three by Group	58
Table 4.6	:	Reasons for Failed Extubation by Group	59

LIST OF FIGURES

			Page
Figure 1.1	:	Krebs' Cycle (Appendix 1)…….....	86
Figure 4.1	:	Kaplan-Meier Curves for Time in Stage Three of Mechanical Ventilation where the Event of Interest was Extubation Failure…….....	55
Figure 4.2	:	Kaplan-Meier Curves for Time in Stage Two Plus Stage Three of Mechanical Ventilation where the Event of Interest was Extubation Failure……..	56
Figure 4.3	:	Rapid Shallow Breathing Index Distribution for Group Two…….	59
Figure 4.4	:	First Maximum Inspiratory Pressure Measurement for Group Two.....	60

LIST OF ABBREVIATIONS

10RM	-	Ten Repetition Maximum
ABG	-	Arterial Blood Gases
AHCPR	-	Agency for Health Care Policy and Research
ARDS	-	Acute Respiratory Distress Syndrome
ARV	-	Anti Retroviral
ATC	-	Automatic Tube Compensation
ATP	-	Adenosine Triphosphate
ATPase	-	Myosin Adenosine Triphosphate
b/min	-	Breaths per Minute
b/min/ℓ	-	Breaths per Minute per Litre
BP	-	Blood Pressure
CI	-	Confidence Interval
CIM	-	Critical Illness Myopathy
CIP	-	Critical Illness Polyneuropathy
cmH_2O	-	Centimetre of Water
CMV	-	Controlled Mechanical Ventilation
COPD	-	Chronic Obstructive Pulmonary Disease
CPAP	-	Continuous Positive Airway Pressure
DAPRE	-	Daily Adjustable Progressive Resistive Training
DNA	-	Deoxyribonucleic Acid
ELISA Test	-	Enzyme-Linked Immunosorbent Assay Test
f/V_T	-	Frequency to Tidal Volume
FiO_2	-	Fraction of Inspired Oxygen
FT	-	Fast Twitch
H_2O	-	Water
HAP	-	Hospital Acquired Pneumonia
HFF	-	High Frequency Fatigue
HIV/AIDS	-	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
HR	-	Heart Rate
ICU	-	Intensive Care Unit
IMST	-	Inspiratory Muscle Strength Training
Krebs's Cycle	-	Tricarboxylic Acid Cycle

ℓ/minute	-	Litres per Minute
M	-	Mean
MIP	-	Maximum Inspiratory Pressure
mmHg	-	Millimetre Mercury
MSV	-	Maximum Sustainable Ventilation
MV	-	Mechanical Ventilation
MVV	-	Maximum Voluntary Ventilation
n	-	Number of Subjects
O_2	-	Oxygen
$PaCO_2$	-	Partial Pressure of Carbon Dioxide in Arterial Blood
PaO_2	-	Partial Pressure of oxygen in Arterial Blood
Pdi	-	Transdiaphragmatic Pressure
PEEP	-	Positive End Expiratory Pressure
Pemax	-	Maximum Expiratory Pressure
Pes	-	Oesophageal Pressure
Pga	-	Gastric Pressure
Pimax	-	Maximum Static Inspiratory Pressure
REM	-	Rapid Eye Movement
RR	-	Respiratory Rate
RSBI	-	Rapid Shallow Breathing Index
RV	-	Residual Volume
S_aO_2	-	Saturation of Haemoglobin with Oxygen in Arterial Blood
SBT	-	Spontaneous Breathing Trial
SD	-	Standard Deviation
ST	-	Slow Twitch
VAP	-	Ventilator Associated Pneumonia
VC	-	Vital Capacity
VO_{2max}	-	Oxygen Consumption and Maximum Exertion
Vti	-	Inspiratory Tidal Volume
WOB	-	Workload of Breathing

LIST OF NORMAL VALUES

Heart Rate	:	60 - 100/min
Maximum Expiratory Pressure	:	100 cm/H_2O
Maximum Inspiratory Pressure	:	-100 to - 70 cmH_2O
Partial Pressure of Carbon Dioxide in Arterial Blood	:	35 - 45mmHg
Partial Pressure of Oxygen in Arterial Blood	:	80 - 100mmHg
Respiratory Rate	:	10 - 20/min
Rapid Shallow Breathing Index	:	< 100b/min/l
Rapid Shallow Breathing Index Rate	:	< - 20% of RSBI
Saturation of Haemoglobin with Oxygen in Arterial Blood	:	95%-98%
Oxygen Consumption and Maximum Exertion	:	> 25ml/kg/min
Inspiratory Tidal Volume	:	10ml/kg
Workload of Breathing	:	0.3 - 0.5kg.m/min

DEFINITIONS

Stages of Mechanical Ventilation Weaning Used in This Study

Stage 1: Maximum mechanical ventilation support stage: Starts from the time of intubation, with maximum mechanical ventilation support, according to the needs and symptoms of the patient.

Stage 2: Weaning stage: Starts with the progressive weaning of the level of assisted breathing support provided, by gradually decreasing pressure support, ventilator rate, fraction of inspired oxygen, trigger flow and/or positive end expiratory pressure and redirecting the work to the patient.

Stage 3: Spontaneous breathing stage: Spontaneous breathing can be achieved by putting the patient on a T-piece with oxygen flow-by (without the support of airway pressure) or a T-piece with oxygen flow-by with a PEEP valve attached to the end of the oxygen tubing or on continuous positive airway pressure (CPAP) mode on the ventilator, alternated with periods of assisted mechanical ventilation.

Stage 4: Extubation or liberation from mechanical ventilation: Extubation from mechanical ventilation is done by either extubation or by continuous tracheal oxygen mask and/or T-piece without any mechanical ventilatory support