

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

Massey University Library

Thesis Copyright Form

Title of thesis:

Vagal Modulation of Recurrent  
Laryngeal Motoneurone Discharge

- (1) (a) I give permission for my thesis to be made available to readers in the Massey University Library under conditions determined by the Librarian.
- (b) I do not wish my thesis to be made available to readers without my written consent for 9 months.
- (2) (a) I agree that my thesis, or a copy, may be sent to another institution under conditions determined by the Librarian.
- (b) I do not wish my thesis, or a copy, to be sent to another institution without my written consent for 9 months.
- (3) (a) I agree that my thesis may be copied for Library use.
- (b) I do not wish my thesis to be copied for Library use for 9 months.

Signed

  
WILLIAM KIAN MENG TAN

Date

24.3.86

The copyright of this thesis belongs to the author. Readers must sign their name in the space below to show that they recognise this. They are asked to add their permanent address.

NAME AND ADDRESS

DATE

Vagal Modulation of Recurrent  
Laryngeal Motoneurone  
Discharge

A thesis presented in partial fulfilment of the  
requirements for the degree of Master  
of Science in Physiology at Massey  
University, New Zealand

William Kian Meng Tan

1986

---

Vagal Modulation of Recurrent  
Laryngeal Motoneurone  
Discharge

Volume I

To Mum and Dad

and all in my family  
for all of the richness of life

and love they have shared with me

" .....the Lord God formed man of dust from the ground,  
and breathed into his nostrils the *breath of life* and man  
became a living being."

Genesis 2:7

# Vagal Modulation of Recurrent Laryngeal Motoneurone Discharge

## Abstract

The larynx has considerable influence on the rate of respiratory airflow, particularly during expiration. The laryngeal muscles are largely controlled by the recurrent laryngeal nerve (RLN) which exhibits respiratory periodicity in its discharge. The effects of the Hering-Breuer inflation reflex, on this periodicity has been studied, but there is little information on the role of the various groups of lung receptors in modulating the patterns of recurrent laryngeal motoneurone (RLM) discharge during eupnoeic breathing.

The purpose of this investigation was to examine the effects of changes in volume-related feedback and other vagal afferent inputs on the activity of RLMs. The discharge patterns of single fibres in the recurrent laryngeal nerve were classified and their responses to pulmonary inflation and deflation before and during pulmonary stretch receptor (PSR) block by sulphur dioxide were compared, using anaesthetized, spontaneously breathing rabbits. On the basis of observations in this study, RLMs were classified into:

- a) phasic-inspiratory (P-ILMs)
- b) tonic-inspiratory (T-ILMs)
- c) phasic-expiratory (P-ELMs)
- d) tonic-expiratory (T-ELMs)

and their firing patterns were described.

It was found that the frequency and duration of P-ILM discharge in inspiration increased after the inhibition of PSR activity. During lung inflation, some RLMs were inhibited whereas others showed either a low-frequency or a high frequency tonic discharge when PSR were intact. During PSR block, lung inflation failed to inhibit phasic P-ILM discharge. While ILM activity was increased during lung deflation, that of ELM was decreased. These responses persisted in a modified form during PSR block. Breathing through an added dead space increased the frequency of P-ILM discharge during inspiration. During augmented breaths, the frequency and duration of P-ILM activity greatly exceeded P-ILM activity during normal breaths, whereas the activity of T-ELM was reduced.

Further experiments were carried out on rabbits during neuromuscular junction block and artificial ventilation. With stretch receptors functioning, simultaneous recordings of the recurrent laryngeal nerve (RLN) and phrenic nerve (PN) showed that the onset of the activities of both nerves occurred during the deflation phase of ventilation. Changing the tidal volume to 50% or 100% of eupnoeic value could not unlink the recurrent laryngeal and phrenic bursts from the deflation phase of the pump cycle. During PSR block, RLN and PN discharges occurred with no set relation to ventilation at spontaneous

---

resting tidal volume. At 100% higher tidal volume, RLN and PN bursts were initiated more frequently by the deflation phase. These timings were changed into a "free-running" pattern by decreasing the tidal volume to half eupnoeic value.

These results suggested that vagal afferents modulate RLM discharge during eupnoeic breathing: PSR inputs terminate ILM discharge whereas RAR activity, which occurs at functional residual capacity, initiates the onset of ILM discharge and extends its activity. The role of RAR is compatible with its effects in shortening ELM activity if the initiation of ILM discharge is considered as a termination of ELM activity. That RLN and PN responded in almost identical manner to changes in vagal afferent inputs suggests that PSR and RAR may operate through similar central pathways to modulate both neural outputs. The discharge patterns of RLMs and their responses to changes of pulmonary afferent inputs, are probably related to the role of the larynx in regulating upper airway resistance.

## Acknowledgments

"If I have seen further than the rest, it is because I have stood on the shoulders of giants."

Sir Isaac Newton

Thanks is such an insufficient word to express my appreciation to all those persons who have helped me to make this undertaking possible.

I owe a special debt of gratitude to my supervisor, Dr. Andrew Davies for his invaluable guidance, encouragement and help throughout the whole course of this work. I am also indebted to Mrs. Carolyn Davies for her excellent help with my experiments. I am very grateful to Professor R. E. Munford for permission to use the facilities in the Physiology Department and also for his advice on statistics. My appreciation also goes to Dr. Alex Davies for his help with translation from French of important journal articles.

My thanks are also due to Messrs. Mervyn Birtles and K. Korndorffer for their assistance with photomicrographs and artwork respectively. To Miss Irena Madjar and Dr. Rodger Pack my gratitude for their very helpful comments on my final manuscript. Last but not the least, I would also like to acknowledge the meticulous assistance of Miss Irene Koh and many of my other fellow students in the typing and preparation of this thesis.

卷之三

## "Sola Dei Gloriam"

## **Lehrbuch Sebastian Bach**

## Table of Contents

	<b>Page</b>
<b>Abstract</b>	iv
<b>Acknowledgements</b>	vii
<b>Table of Contents</b>	viii
<b>List of Tables</b>	xiii
<b>List of Figures</b>	xv
<b>List of Plates</b>	xxii
<b>Chapter One : Introduction</b>	1
1.1. A Brief History of Ideas About the Larynx	1
1.2 Anatomy of the Larynx	3
1.3 Respiratory Function of the Larynx	7
1.31 Respiratory Movements of the Vocal Cords	9
1.32 Respiratory Activity of the Intrinsic Laryngeal Muscles	11
1.33 Vertical Respiratory Movements of the Larynx	13
1.34 Glottic Resistance to Airflow	14
1.35 Role of the Larynx in Ventilatory Control	17
1.36 Advantages of Expiratory Braking	21
1.4 Pulmonary Receptors and Their Effects on Laryngeal Function	22
1.41 J-Receptors	23
1.42 Rapidly Adapting Receptors	26
1.43 Pulmonary Stretch Receptors	31
1.5 The Present Study	39
1.51 Aim of the Study	41

<b>Chapter Two : Materials and Methods</b>	<b>43</b>
2.1 Surgical Preparation	43
2.11 Anaesthesia	43
2.12 Femoral Vein Catheterisation	44
2.13 Tracheal Cannulation	45
2.14 Exposure of Recurrent Laryngeal and Phrenic Nerves	45
2.141 Recurrent Laryngeal Nerve Isolation	45
2.142 Phrenic Nerve Isolation	46
2.2 Recording Procedures	48
2.21 Respiration Recordings	48
2.22 Neural Recordings	48
2.3 Inflation and Deflation Tests	49
2.4 Stretch Receptor Block	50
2.5 Experimental Protocol	51
2.51 Spontaneously Breathing Rabbits	51
2.52 Neuromuscular Junction Block Series	53
2.6 Validation of Study	54
2.61 Histological Examination of the Recurrent Laryngeal Nerve	54
2.62 Tests of Recording Equipment	55
2.63 Bilateral Vagotomy	55
2.7 Data Analysis	55
2.71 Spontaneously Breathing Rabbits	55
2.72 Neuromuscular Junction Block Series	57
2.721 Analysis of Phase Relationship Between Pump Cycle and Recurrent Laryngeal/Phrenic Bursts	57
<b>Chapter Three : Results</b>	<b>59</b>
3.1 Tests on Spontaneously Breathing Rabbits	59
3.11 Motoneurone Discharge Patterns with Pulmonary Stretch Receptor Intact	59
3.111 Characterization of Spontaneous Laryngeal	

	Page
Motoneurone Discharge	59
3.112 Details of Patterns of Discharge	61
3.113 Effects of Breathing Through An Added Dead Space on Laryngeal Discharge	64
3.114 Discharge Patterns of Laryngeal Motoneurones During Hering-Breuer Reflex	65
3.1141 Responses to Lung Inflation	65
3.11411 Transient Effects	66
3.11412 Initial Effects	67
3.11413 Subsequent Effects	70
3.1142 Responses to Lung Deflation	71
3.11421 Transient Effects	72
3.11422 Initial Effects	73
3.11423 Subsequent Effects	75
3.12 Motoneurone Discharge Patterns During Pulmonary Stretch Receptor Block	77
3.121 Degree of Stretch Receptor Block	77
3.122 Spontaneous Laryngeal Motoneurone Activity	77
3.123 Patterns of Laryngeal Motoneurone Discharge During Hering-Breuer Reflex	78
3.1231 Responses to Lung Inflation	78
3.12311 Transient Effects	78
3.12312 Initial Effects	79
3.12313 Subsequent Effects	80
3.1232 Responses to Lung Deflation	81
3.12321 Transient Effects	82
3.12322 Initial Effects	82
3.12323 Subsequent Effects	84
3.124 Effects of Added Dead Space	85
3.13 Laryngeal Activity During Augmented Breaths	86
3.14 Spontaneous Laryngeal and Phrenic Discharge Patterns	88
3.2 Tests on Artificially Ventilated Rabbits	88
3.21 Discharge Patterns of Phrenic and Recurrent Laryngeal Nerves with Pulmonary Stretch Receptor Intact	89
3.211 Laryngeal and Phrenic Discharge at Spontaneous Resting Tidal Volume	89

3.212 Responses of Phrenic and Laryngeal Nerves to Different Ventilating Volumes	91
3.22 Discharge Patterns of Phrenic and Recurrent Laryngeal Nerves During Pulmonary Stretch Receptor Block	93
3.221 Laryngeal and Phrenic Discharge During Eupnoeic Tidal Volume	93
3.222 Responses of Phrenic and Laryngeal Nerves to Different Tidal Volumes	95
3.23 Laryngeal and Phrenic Activity During Cough	97
3.3 Validation of Results	98
3.31 Histological Findings	98
3.32 Tests of Recording Equipment	100
3.33 Bilateral Vagotomy above Origin of Recurrent Laryngeal Nerves	100
<b>Chapter Four : Discussion</b>	<b>101</b>
4.1 Efferent Activity in the Recurrent Laryngeal Nerve	101
4.2 Vagal Modulation of Recurrent Laryngeal Motoneurone Activity: Evidence from Laryngeal Discharge Patterns	108
4.21 During Spontaneous Breathing	108
4.22 During Lung Inflation	112
4.23 During Artificial Ventilation	115
4.24 During Imposition of Added Dead Space	117
4.25 During Augmented Breaths	119
4.26 During Lung Deflation	122
4.27 During Transient Changes in Lung Volume	125
4.3 Role of J-Receptors	127
4.4 Role of other Modulating Factors other than Vagal Inputs	128
4.5 Functional Advantage of Vagal Modulation	131
4.6 Laryngeal Discharge Pattern During Cough	131
4.7 Role of Recurrent Laryngeal Nerve in Respiration	135

---

4.8 Evaluation of Method	137
4.81 Data Collection and Processing	137
4.82 Histological Findings	138
4.83 Difficulties Encountered in Obtaining A Satisfactory Record	139
4.84 Effect of Anaesthesia and other Chemicals	140
4.85 Effect of Tracheostomy	143
4.9 Conclusions and Implications	145
<b>Summary of Findings</b>	149
<b>References</b>	152
<b>Appendix</b>	

## List of Tables

	Between Page
<b>Table 1</b> Effect of breathing through an added dead space on phasic-inspiratory laryngeal motoneurone discharge	64-65
<b>Table 2</b> Transient response of recurrent laryngeal motoneurones to inflation of the lungs	66-67
<b>Table 3</b> Response of recurrent laryngeal motoneurones during the first breath after lung inflation	70-71
<b>Table 4</b> Data on recurrent laryngeal motoneurone activity after lung inflation	70-71
<b>Table 5</b> Transient response of recurrent laryngeal motoneurones to deflation of the lungs	72-73
<b>Table 6</b> Response of recurrent laryngeal motoneurones during the first breath following lung deflation	74-75
<b>Table 7</b> Effect of lung deflation on recurrent laryngeal motoneurone discharge	74-75
<b>Table 8</b> Response of recurrent laryngeal motoneurones during the first breath after lung deflation	76-77
<b>Table 9</b> Data on recurrent laryngeal motoneurone activity after lung deflation	76-77
<b>Table 10</b> Assessment of the degree of pulmonary stretch receptor block after sulphur dioxide administration	77-78
<b>Table 11</b> Effect of pulmonary stretch receptor block on recurrent laryngeal motoneurone discharge	77-78
<b>Table 12</b> Effect of lung inflation before and during stretch receptor block on the first inspiratory and expiratory discharge after lung inflation	81-82
<b>Table 13</b> Data on recurrent laryngeal motoneurone activity after lung inflation before and during stretch receptor block	81-82
<b>Table 14</b> Response of recurrent laryngeal motoneurones during the first breath following lung deflation before and during PSR block	83-84
<b>Table 15</b> Effect of lung deflation on recurrent laryngeal motoneurone discharge before and during stretch receptor block	83-84
<b>Table 16</b> Response of recurrent laryngeal motoneurones during the first breath after lung deflation	84-85

	Between Page
<b>Table 17</b> Data on recurrent laryngeal motoneurone activity after lung deflation before and during stretch receptor block	84-85
<b>Table 18</b> Changes in recurrent laryngeal motoneurone discharge in inspiration and expiration during augmented breath	87-88
<b>Table 19</b> Evaluation of the degree of pulmonary stretch receptor block after sulphur dioxide inhalation	93-94

## List of figures

xv

- Figure 1** The cartilages of the rabbit's larynx (after Barone, 1976).
- Figure 2** The intrinsic laryngeal muscles of the rabbit (after Barone, 1976).
- Figure 3** Scheme of action of laryngeal muscles on vocal cords.
- Figure 4** A schematic diagram of a frontal section of composite mammalian larynx to show the main features.
- Figure 5** Schematic drawing demonstrating course of right and left recurrent laryngeal nerves.
- Figure 6** Distribution of the recurrent laryngeal and cranial laryngeal nerves.
- Figure 7** Main functional components of the control system and the breathing apparatus.
- Figure 8** Receptor influence on the phases of breathing.
- Figure 9** Schematic outline of experimental set-up.
- Figure 10** Experimental protocol.
- Figure 11** Neuromuscular junction block series. Diagram of experimental set-up.
- Figure 12** Experimental Protocol (Neuromuscular junction block series).
- Figure 13** Schematic diagram showing how the duration of inspiration and expiration, number of spikes within each quartile of both respiratory phases and duration of firing were measured from the airflow signal and recurrent laryngeal motoneurone neurogram records.
- Figure 14** Schematic classification of major discharge patterns of recurrent laryngeal motoneurones.
- Figure 15** Spontaneous activity of recurrent laryngeal motoneurones with different patterns of discharge.
- Figure 16** Histogram showing correlation between impulse frequency of a phasic-inspiratory laryngeal motoneurone and the inspiratory and expiratory phases of the respiratory cycle.
- Figure 17** Histogram showing correlation between the impulse frequency of a tonic-inspiratory laryngeal motoneurone and the inspiratory and expiratory phases of the respiratory cycle.

- Figure 18** Histogram showing correlation between impulse frequency of a phasic-expiratory laryngeal motoneurone and the inspiratory and expiratory phases of the respiratory cycle.
- Figure 19** Histogram showing correlation between the impulse frequency of a tonic-expiratory laryngeal motoneurone and the inspiratory and expiratory phases of the respiratory cycle.
- Figure 20** Fibre types in the recurrent laryngeal nerve samples.
- Figure 21** Record showing the change in discharge pattern of a phasic-inspiratory laryngeal motoneurone during eupnoeic breathing; from a phasic-inspiratory pattern of discharge into a tonic-inspiratory pattern and back to phasic-inspiratory again.
- Figure 22** Records from 3 phasic-inspiratory laryngeal motoneurones showing different times of onset of motoneurone discharge during eupnoeic breathing.
- Figure 23** Mean frequency of P-ILM discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle during eupnoeic breathing.
- Figure 24** Mean frequency of T-ILM discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle during eupnoeic breathing.
- Figure 25** Mean frequency of tonic-expiratory laryngeal motoneurone discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle during eupnoeic breathing.
- Figure 26** Mean frequency of P-ELM discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle during eupnoeic breathing.
- Figure 27** Effect of breathing through an added dead space on phasic-inspiratory laryngeal motoneurone discharge.
- Figure 28** Instantaneous frequency plot of the phasic-inspiratory laryngeal motoneurone in Fig. 27, showing how the impulse frequency changed during hypercapnia (caused by breathing through an added dead space).
- Figure 29** Effect of breathing through an added dead space on the mean frequency of phasic-inspiratory laryngeal motoneurone discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle.
- Figure 30** Responses of phasic-inspiratory laryngeal motoneurones to lung inflation.

- Figure 31** Responses of recurrent laryngeal motoneurones to inflation of the lungs.
- Figure 32** Typical transient response of a phasic-inspiratory laryngeal motoneurone to lung inflation.
- Figure 33** Changes in frequency of inspiratory laryngeal motoneurone discharge relative to control inspiratory discharge elicited by lung inflation and deflation at different positions of the inspiratory phase of the respiratory cycle.
- Figure 34** Changes in frequency of inspiratory laryngeal motoneurone discharge relative to control inspiratory discharge elicited by lung inflation and deflation at different positions of the expiratory phase of the respiratory cycle.
- Figure 35** Changes in the frequency of inspiratory laryngeal motoneurone discharge relative to control inspiratory discharge following the release of lung inflation or deflation.
- Figure 36** Changes in frequency of expiratory laryngeal motoneurone discharge relative to control expiratory discharge elicited by lung inflation and deflation at different positions of the inspiratory phase of the respiratory cycle.
- Figure 37** Changes in frequency of expiratory laryngeal motoneurone discharge relative to control expiratory discharge elicited by lung inflation and deflation at different positions of the expiratory phase of the respiratory cycle.
- Figure 38** Changes in the frequency of expiratory laryngeal motoneurone discharge relative to control expiratory discharge following the release of lung inflation or deflation.
- Figure 39** Types of response of recurrent laryngeal motoneurones to lung inflation.
- Figure 40a,b,c** Histogram showing changes in discharge frequency during various responses to lung inflation.
- Figure 41** Records showing response of recurrent laryngeal motoneurones to lung deflation.
- Figure 42** Typical transient response of a phasic-inspiratory laryngeal motoneurone to lung deflation.
- Figure 43** Instantaneous frequency plot of the phasic-inspiratory laryngeal motoneurone in Fig. 41 (record A), showing how the impulse frequency changed during lung deflation.

- Figure 44** Effect of lung deflation on the mean frequency of recurrent laryngeal motoneurone discharge during the inspiratory and expiratory phases of the respiratory cycle.
- Figure 45** Instantaneous frequency plot of the tonic-expiratory laryngeal motoneurone in Fig. 41 (record D), showing how the impulse frequency changed during lung deflation.
- Figure 46a** Spontaneous discharge of three recurrent laryngeal motoneurones before pulmonary stretch receptor block.
- Figure 46b** Effect of pulmonary stretch receptor block with sulphur dioxide on the spontaneous discharge of the three motoneurones in Fig. 46a.
- Figure 47** Instantaneous frequency plot of the phasic-inspiratory laryngeal motoneurone in Figs. 46a,b (records A), showing how the impulse frequency changed when pulmonary stretch receptors were blocked.
- Figure 48** Effect of pulmonary stretch receptor block by exposure to 200 ppm sulphur dioxide on the frequency of P-ELM discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle during eupnoeic breathing.
- Figure 49** Effect of pulmonary stretch receptor block by 20 minutes exposure to 200 ppm sulphur dioxide on the mean frequency of tonic-expiratory laryngeal motoneurone discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle.
- Figure 50a** Response to lung inflation before stretch receptor block.
- Figure 50b** Response of the three motoneurones in Fig. 50a to lung inflation during stretch receptor block.
- Figure 51a** Response to lung deflation before stretch receptor block.
- Figure 51b** Response of the three motoneurones in Fig. 51a to lung deflation during stretch receptor block.
- Figure 52** Mean percentage changes in frequency and duration of recurrent laryngeal motoneurone discharge in inspiration and expiration caused by lung deflation before and during stretch receptor block.
- Figure 53** Effect of breathing through an added dead space on the discharge patterns of a phasic-inspiratory laryngeal motoneurone before and during stretch receptor block.
- Figure 54** Changes in mean frequency of P-ILM discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle during stretch receptor block.

- Figure 55** Discharge patterns of recurrent laryngeal motoneurones during spontaneous augmented breaths.
- Figure 56** Record showing the discharge patterns of phasic-inspiratory laryngeal motoneurones during augmented breaths induced by various stimuli.
- Figure 57** Various stimuli causing augmented breaths.
- Figure 58** Discharge patterns of phasic-inspiratory laryngeal motoneurones during augmented breaths when stretch receptors were blocked by sulphur dioxide.
- Figure 59** Record showing sudden acceleration in impulse frequency of a phasic-inspiratory laryngeal motoneurone in the second half of inspiration during an augmented breath.
- Figure 60** Instantaneous frequency plot of the phasic-inspiratory laryngeal motoneurone in Fig. 59, showing how the impulse frequency changed during an augmented breath.
- Figure 61** Changes in mean frequency of phasic-inspiratory laryngeal motoneurone discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle during augmented breaths.
- Figure 62** Frequency of P-ILM discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle during an augmented breath after 20 minutes exposure to 200 ppm sulphur dioxide.
- Figure 63** Record of an augmented breath showing a lessening of phasic-inspiratory laryngeal motoneurone activity before the augmented half of the breath began.
- Figure 64** Discharge patterns of a tonic-expiratory laryngeal motoneurone during a spontaneous augmented breath.
- Figure 65** Instantaneous frequency plot of the tonic-expiratory laryngeal motoneurone in Fig. 64, showing how the impulse frequency changed during an augmented breath.
- Figure 66** Spontaneous activity of the recurrent laryngeal and phrenic nerves in relation to tidal volume.
- Figure 67a,b** Records showing activity of recurrent laryngeal and phrenic nerves in relation to the inflation and deflation phases of the ventilator.
- Figure 68** The time of onset of the recurrent laryngeal and phrenic bursts in relation to the inflation and deflation phases of the ventilator at spontaneous resting tidal volume.

- figure 68** Effect of decreasing tidal volume to half of eupnoeic level on the phase relationship between RLN/PN discharge and pump cycle.
- figure 70** The time of onset of the recurrent laryngeal and phrenic bursts in relation to the inflation and deflation phases of the ventilator when the tidal volume was at half eupnoeic level.
- figure 71** Phase relationship between RLN/PN discharge and pump cycle when tidal volume was 100% greater than eupnoeic level.
- figure 72** The time of onset of the recurrent laryngeal and phrenic bursts in relation to the inflation and deflation phases of the ventilator when the tidal volume was 100% greater than eupnoeic level.
- figure 73** Effect of the Hering-Breuer inflation test with 10 cm H<sub>2</sub>O positive pressure on the recurrent laryngeal and phrenic activity before and during stretch receptor block.
- figure 74** Effect of pulmonary stretch receptor block on the discharge patterns of recurrent laryngeal and phrenic nerves in relation to inflation and deflation phases of the ventilator.
- figure 75** Two typical records of the changes in the activity of recurrent laryngeal and phrenic nerves when stretch receptors were blocked and the tidal volume was 100% greater than eupnoeic level.
- figure 76** Effect of decreasing tidal volume to half the spontaneous eupnoeic value on the phase relationship between recurrent laryngeal and phrenic nerves and pump cycle during stretch receptor block.
- figure 77** Onset of RLN and PN bursts during pump inflation stroke at different ventilating tidal volumes.
- figure 78** Records showing the discharge patterns of recurrent laryngeal and phrenic nerves during cough following sulphur dioxide administration.
- figure 79** Record showing the disappearance of recurrent laryngeal nerve activity consequent on bilateral cervical vagotomy.
- figure 80** Schematic representation of the functional organization of the basic inspiratory 'off-switch' mechanism.
- figure 81** Mean percentage changes in frequency and duration of phasic-inspiratory laryngeal motoneurone discharge during the inspiratory phase caused by various interventions.
- figure 82** Mean percentage changes in frequency and duration of phasic-inspiratory laryngeal motoneurone discharge during the expiratory phase caused by various interventions.

- figure 83** Mean percentage changes in frequency and duration of tonic-expiratory laryngeal motoneurone discharge during the inspiratory phase caused by various interventions.
- figure 84** Mean percentage changes in frequency and duration of tonic-expiratory laryngeal motoneurone discharge during the expiratory phase caused by various interventions.
- figure 85** Effect of pulmonary stretch receptor block by 20 minutes exposure to 200 ppm sulphur dioxide on the mean frequency of phasic-inspiratory laryngeal motoneurone discharge in different quartiles of the inspiratory and expiratory phases of the respiratory cycle.
- figure 86** Schematic diagram of brainstem structures involved in breathing.

### List of Plates

- Plate 1** A transverse section of the right recurrent laryngeal nerve at the level of the clavicle. The sections were stained with Masson's blue trichrome.
- Plate 2** A transverse section of the left recurrent laryngeal nerve at the level of the clavicle. The sections were stained with Masson's blue trichrome.
- Plate 3** A transverse section of the right recurrent laryngeal nerve near its entry into the larynx. The sections were stained with Masson's blue trichrome.
- Plate 4** A transverse section of the left recurrent laryngeal nerve near its entry into the larynx. The sections were stained with Masson's blue trichrome.

## **Chapter One : Introduction**

- 1.1 A Brief History of Ideas About the Larynx*
- 1.2 Anatomy of the Larynx*
- 1.3 Respiratory Function of the Larynx*
  - 1.31 Respiratory Movements of the Vocal Cords*
  - 1.32 Respiratory Activity of the Intrinsic Laryngeal Muscles*
  - 1.33 Vertical Respiratory Movements of the Larynx*
  - 1.34 Glottic Resistance to Airflow*
  - 1.35 Role of Larynx in Ventilatory Control*
  - 1.36 Advantages of Expiratory Braking*
- 1.4 Pulmonary Receptors and Their Effects on Laryngeal Function*
  - 1.41 J - Receptors*
  - 1.42 Rapidly Adapting Receptors*
  - 1.43 Pulmonary Stretch Receptors*
- 1.5 The Present Study*
  - 1.51 Aim of the Study*