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.
AN EVALUATION OF THE EFFECTIVENESS OF CASTELLATED LARYNGOFLISSURE AND BILATERAL ARYTMENOID LATERALISATION FOR THE RELIEF OF LARYNGEAL PARALYSIS IN DOGS

A Thesis presented for The Degree of Master of Veterinary Science at Massey University by Hilary M. Burbidge BVSc., DVR., MACVSc., MRCVS. 1989
ACKNOWLEDGEMENTS

Funds for this work were provided by the Massey University Research Fund, Auckland Veterinary Society and New Zealand Veterinary Association.

Thanks are due to many people for their assistance during this study.

The technicians of the Department of Veterinary Clinical Science for their help in caring for the dogs during their stay at Massey University.
Dr A.M. Alexander for providing accommodation for the dogs.
Mr J. Pedley for his technical assistance.
Mr T. Law for the photographs.
Mr K. Korndorffer for the graphic work.
Mrs L.K. Fecser for typing the drafts and final manuscript.

I am especially grateful to my supervisors:

Mr B. Jones for his help with funds, literature and interest.
Dr D.H. Carr for his assistance in obtaining the tidal breathing flow-volume loop data.
and in particular:
Dr B.E. Goulden for his support throughout this project and his persistence in channelling my enthusiasm down the path of logical thought.

The help of all these people I acknowledge with gratitude.
ABSTRACT

In recent years, laryngeal paralysis in dogs, has become a frequently recognised disorder. Various surgical procedures have been advocated to relieve the consequential laryngeal obstruction, but few critical examinations of the effectiveness of these procedures have been attempted. The aim of this study was to determine and compare the efficacy of two of the more commonly used surgical methods (i) castellated laryngofissure with vocal fold resection and (ii) bilateral arytenoid lateralisation in providing an adequate laryngeal airway in dogs after surgically induced laryngeal paralysis.

The laryngeal function of ten adult healthy experimental dogs was assessed by clinical examination, laryngoscopy, blood gas and tidal breathing flow-volume loop analyses prior to and after bilateral recurrent laryngeal nerve resection. Five dogs then underwent a castellated laryngofissure with vocal fold resection and the remaining five, bilateral arytenoid lateralisation. Six weeks later, the laryngeal function of the ten dogs was reassessed using the same investigative techniques. Radiographs of the chest were taken at the start and completion of the experiment on the live dogs to help detect the presence of any co-existent lower respiratory tract disease. An autopsy was performed on each dog, six weeks after surgery, and details of visible changes in the laryngeal structure recorded.

After neurectomy, all of the dogs had inspiratory stridor, a hoarse bark and reduced exercise tolerance. Medial displacement of the arytenoid cartilages and vocal cords caused narrowing of the rima glottidis. No abduction of these structures occurred during inspiration. There was a significant fall in arterial oxygen tension and inspiratory airflow recorded on blood gas analyses and tidal breathing flow-volume loop studies, respectively.

The degree of relief from the laryngeal obstruction in the neurectomised dogs after castellated laryngofissure with vocal fold resection was variable. Some of the animals still had signs of respiratory embarrassment. The size of the rima glottidis achieved was either slightly narrower or similar to that seen in the non-abducted, pre-neurectomised larynx of the experimental dogs. No significant improvement in blood gas or tidal breathing flow-volume loop analyses were recorded following the surgical technique.

In contrast, bilateral arytenoid lateralisation consistently alleviated the clinical signs of bilateral recurrent laryngeal neurectomy. The rima glottidis width was increased to either the non-abducted, pre-neurectomised size or greater, depending on the position of the lateralisation suture. Furthermore, blood gas and tidal breathing flow-volume analyses recorded a significant increase in arterial oxygen tension and inspiratory airflow, respectively.
Although bilateral arytenoid lateralisation was more efficient than castellated laryngofissure with vocal fold resection in alleviating the laryngeal obstruction caused by bilateral recurrent laryngeal neurectomy, it did have some inadequacies. The fixed abduction of the arytenoid cartilages destroyed the expiratory braking mechanism of the larynx. Furthermore, execution of the surgical technique requires intimate knowledge of the anatomy of the larynx and the surrounding structures and, since the position of the lateralisation suture is important, best results are likely to be achieved by surgeons experienced with the procedure.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Acknowledgements</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>i</td>
</tr>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>iv</td>
</tr>
<tr>
<td>List of Tables</td>
<td>vii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>viii</td>
</tr>
<tr>
<td><strong>Chapter I.</strong> INTRODUCTION</td>
<td></td>
</tr>
<tr>
<td><strong>L1.</strong> Laryngeal Paralysis - the disease</td>
<td>1</td>
</tr>
<tr>
<td>i) Clinical signs</td>
<td></td>
</tr>
<tr>
<td>ii) Aetiology</td>
<td></td>
</tr>
<tr>
<td><strong>L2.</strong> Anatomy</td>
<td>4</td>
</tr>
<tr>
<td>i) Cartilages</td>
<td></td>
</tr>
<tr>
<td>ii) Laryngeal mucosa and associated structures</td>
<td></td>
</tr>
<tr>
<td>iii) Laryngeal muscles</td>
<td></td>
</tr>
<tr>
<td>iv) Laryngeal nerves</td>
<td></td>
</tr>
<tr>
<td><strong>L3.</strong> Physiology</td>
<td>17</td>
</tr>
<tr>
<td>i) Action during respiration</td>
<td></td>
</tr>
<tr>
<td>ii) Action during swallowing</td>
<td></td>
</tr>
<tr>
<td>iii) Action during phonation</td>
<td></td>
</tr>
<tr>
<td><strong>L3a.</strong> The paralysed larynx</td>
<td>20</td>
</tr>
<tr>
<td><strong>L4.</strong> Laryngeal Paralysis - diagnostic techniques</td>
<td>23</td>
</tr>
<tr>
<td>i) Laryngoscopy</td>
<td></td>
</tr>
<tr>
<td>ii) Blood gas analysis</td>
<td></td>
</tr>
<tr>
<td>iii) Tidal breathing flow-volume loops</td>
<td></td>
</tr>
<tr>
<td>iv) Upper airway pressure flow curves</td>
<td></td>
</tr>
<tr>
<td>v) Electromyography</td>
<td></td>
</tr>
<tr>
<td>vi) Palpation</td>
<td></td>
</tr>
<tr>
<td>vii) Radiography</td>
<td></td>
</tr>
<tr>
<td>viii) Histopathology</td>
<td></td>
</tr>
<tr>
<td>ix) Histochemistry</td>
<td></td>
</tr>
<tr>
<td>x) Nerve transmission studies</td>
<td></td>
</tr>
</tbody>
</table>
Laryngeal Paralysis - a review of surgical techniques

i) Partial laryngectomy
ii) Arytenoid lateralisation
iii) Castellated laryngofissure and vocal fold resection
iv) Modified castellated laryngofissure
v) Neuromuscular pedicle graft

Chapter II. MATERIALS AND METHODS

II.1 Investigative Procedures

i) Radiography
ii) Laryngoscopy
iii) Blood gas analysis
iv) Tidal breathing flow-volume loop analysis

II.2 Surgical Procedures

i) Bilateral recurrent laryngeal nerve resection
ii) Castellated laryngofissure with vocal fold resection
iii) Bilateral arytenoid lateralisation

II.3 Experimental Procedure

II.4 Statistical Analysis

Chapter III. RESULTS

III.1 Clinical Assessment

III.2 Radiography

III.3 Laryngoscopy

III.4 Blood Gas Analysis

III.5 Tidal Breathing Flow-volume Loop Analysis

III.6 Autopsy Examination
Chapter IV. DISCUSSION

IV_1. The effects of bilateral recurrent laryngeal nerve resection

IV_2. The efficacy of castellated laryngofissure with vocal fold resection in alleviating the effects of experimentally induced laryngeal paralysis

IV_3. The efficacy of bilateral arytenoid lateralisation in alleviating the effects of experimentally induced laryngeal paralysis

IV_4. Evaluation of the diagnostic techniques used
   i) Laryngoscopy
   ii) Radiography
   iii) Blood gas Analysis
   iv) Tidal breathing flow-volume loop analysis
   v) Autopsy examination

IV_5. Critical evaluation of the experiment

Chapter V. CONCLUSION

REFERENCES
### LIST OF TABLES

| Table 1. | Result of blood gas analyses from dogs undergoing castellated laryngofissure and vocal fold resection. | Page 70 |
| Table 2. | Result of blood gas analyses from dogs undergoing bilateral arytenoid lateralisation. | Page 71 |
| Table 3. | Mean values for tidal breathing flow-volume loops from dogs after castellated laryngofissure and vocal fold resection. | Page 74 |
| Table 4. | Indices of tidal breathing flow-volume loops from dogs after castellated laryngofissure and vocal fold resection. | Page 75 |
| Table 5. | Mean values for tidal breathing flow-volume loops from dogs after bilateral arytenoid lateralisation. | Page 76 |
| Table 6. | Indices of tidal breathing flow-volume loop from dogs after bilateral arytenoid lateralisation. | Page 77 |
LIST OF FIGURES

Figure 1. Lateral view of the laryngeal cartilages. 5
Figure 2. Sagittal section through the larynx showing cartilages and their associated structures. 7
Figure 3. Cranial view of the normal larynx. 8
Figure 4. Dorsal aspect of the larynx showing the intrinsic laryngeal muscles. 10
Figure 5. Lateral aspect of the larynx with the left lamina of the thyroid cartilage, cut and reflected, to show the intrinsic laryngeal muscles. 11
Figure 6. Schematic drawing of medulla with *nucleus ambiguus* and its efferent neurons, the cervical spinal cord with external branch of accessory nerve and the vagus. 14
Figure 7. Lateral aspect of larynx showing path of cranial laryngeal and recurrent laryngeal nerves. 15
Figure 8. Dorsal aspect of larynx showing path of cranial laryngeal and recurrent laryngeal nerves. 16
Figure 9. Diagrammatic representation of A) the normal larynx, and B) the effects of left recurrent laryngeal nerve paralysis and C) the effects of left cranial laryngeal and recurrent laryngeal nerve paralysis. 21
Figure 10. Maximum flow-volume loop of a healthy adult human showing typical expiratory and inspiratory tracings. 25
Figure 11. Characteristic flow-volume loops produced by major airway lesions A) a fixed lesion B) a variable extrathoracic lesion and C) a variable intrathoracic lesion. 25
Figure 12. Characteristic tidal breathing flow-volume loops of a healthy dog showing peak expiratory flow (PEF), peak inspiratory flow (PIF), midtidal expiratory flow ($EF_{50}$), midtidal inspiratory flow ($IF_{50}$), and expiratory and inspiratory flow at 25% of the tidal volume remaining to be exhaled ($EF_{25}$ and $IF_{25}$ respectively). 26
Figure 13. Photograph of one of the experimental dogs with rubber mask and pneumotachograph placed over the muzzle.

Figure 14. Photograph of multichannel recorder displaying the flow and volume signals.

Figure 15. Photograph of X-Y plotter displaying tidal breathing flow-volume loops.

Figure 16. Experimental arrangement used to obtain tidal breathing flow-volume loops in conscious dogs.

Figures 17 - 24a Sequential views of surgical procedure for castellated laryngofissure and vocal fold resection.

Figures 25 - 35 Diagrams showing surgical procedure of bilateral arytenoid lateralisation.

Figures 36 - 45 Photographs of larynges taken at endoscopic examination of the ten experimental dogs.

Figures 46 - 55 Tidal breathing flow-volume loops of the ten experimental dogs.

Figure 56 Photograph of larynx from cadaver after castellated laryngofissure demonstrating asymmetry of the rima glottidis. The ventral portion of the laryngeal opening is deviated to the left.

Figure 57 Photographs of two trachea rings illustrating the effects of tracheostomy on the tracheal shape. A) the site of the tracheostomy shows narrowing and change in shape when compared to the normal tracheal lumen, B) immediately distal to the tracheostomy site.
Figure 58  Photographs of oral view of larynx from cadaver after bilateral arytenoid lateralisation showing symmetrically positioned arytenoid cartilages.

Figure 59  Photograph of lateral view from cadaver after bilateral arytenoid lateralisation showing caudal position of lateralisation suture (arrow).

Figure 60  Photograph of larynx from cadaver after bilateral arytenoid lateralisation showing asymmetry of the *rima glottidis*.

Figure 61  Photograph of larynx from cadaver after bilateral arytenoid lateralisation showing rostral position of lateralisation suture (arrow).