STUDIES ON LARYNGOPLASTY AND VENTRICULECTOMY FOR LARYNGEAL HEMIPLEGIA IN RACEHORSES

C. YESHWANTH KUMAR

DEPARTMENT OF SURGERY AND RADIOLOGY
VETERINARY COLLEGE, BANGALORE
KARNATAKA VETERINARY, ANIMAL AND FISHERIES
SCIENCES UNIVERSITY, BIDAR
2007

STUDIES ON LARYNGOPLASTY AND VENTRICULECTOMY FOR LARYNGEAL HEMIPLEGIA IN RACEHORSES

C. YESHWANTH KUMAR

Thesis submitted to the
Karnataka Veterinary, Animal
and Fisheries Sciences University, Bidar,
In partial fulfillment of the requirements
For the award of the degree of

Master of Veterinary Science

in

VETERINARY SURGERY AND RADIOLOGY

BANGALORE **AUGUST, 2007**

Affectionately dedicated
to my
Beloved
Parents and Sister

DEPARTMENT OF SURGERY AND RADIOLOGY
VETERINARY COLLEGE, BANGALORE
KARNATAKA VETERINARY, ANIMAL AND FISHERIES SCIENCES UNIVERSITY, BIDAR

CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON LARYNGOPLASTY AND VENTRICULECTOMY FOR LARYNGEAL HEMIPLEGIA IN RACEHORSES"** *by* **C. YESHWANTH KUMAR** *for the award of degree of* **MASTER OF VETERINARY SCIENCE** *in* **VETERINARY SURGERY AND RADIOLOGY** *to the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, is a record of bona-fide research work done by him during the period of his study in this University under my guidance and supervision, and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.*

Bangalore
29th August, 2007

(M.S. VASANTH)
Major advisor and
Professor and Head
Dept. of Surgery and Radiology

Approved by:

Chairperson:- _____
(M.S. VASANTH)

Members: 1. _____
(L. RANGANATH)

2. _____
(B.N. NAGARAJA)

3. _____
(S. YATHIRAJ)

4. _____
(M. NARAYAN BHAT)

ACKNOWLEDGEMENTS

I heartily record my deep sense of gratitude and thanks to my Major Advisor ***Dr.M.S.Vasanth****, Professor and Head, Department of Surgery and Radiology, Veterinary college, Bangalore for his scholarly guidance, constant encouragement, affectionate dealing and moral support throughout the period of research and during the preparation of this thesis.*

I am very much grateful to my Advisory Committee Members, ***Dr.L.Ranganath****, Associate Professor Department of Veterinary Surgery and Radiology,* ***Dr. B.N. Nagaraja,*** *Assistant Professor, Department of Veterinary Surgery and Radiology,* ***Dr. S.Yathiraj,*** *Professor and Head, Department of clinical Medicine,* ***Dr. M. Narayan Bhat****, Professor and Head, Department of Preventive Medicine, Veterinary college, bangalore for their useful suggestions and guidance during the study.*

I am extremely thankful to the managing committee of ***Mysore Race Club Ltd.*** *For sanctioning study leave and financial assistance to pursue my studies.*

My special and unforgettable thanks are extended to ***Dr. Hasyen Mirza,*** *Proprietor, Gallop-in Equine clinic, for providing timely help to conduct the research. work.*

I wish to convey my sincere thanks to ***Dr. R. Nagaraj,*** *Assistant Professor, Head (i/c) Teaching Veterinary Clinical Service Complex, Yelahanka,* ***Dr. Goerge Chandy,*** *Assistant Professor, and* ***Dr. A.M. Mahendra*** *contract teacher, Department of Veterinary Surgery and Radiology for there wholehearted encouragement and support during my post graduation Programme.*

I take this occasion to thank ***Dr.Naveed Ahmed, Dr.Shasikanth, Dr. B.S.Thimmappa, Dr. Mir Aamer Ali, Dr. Mahesh, Dr.Vedi, Dr. Jaishima*** *and* ***Mr. Nataraj.***

I owe special thanks to Drs. ***Mahesh, Gaurav*** *and* ***Nagaraj*** *and my junior PG students Drs.* ***Vishal, Venketgiri Saiprakash and Vani*** *who were always there with their cordial help and cooperation.*

I thank all my non- teaching staff members of our department, ***Mr. Shridar, Mr. Venkataram and Mr. Narayan*** *for their affectionate help rendered by them during my research.*

I sincerely thank very much to my loving friends ***Drs. Nirmala, Ramesh, Pasha, Kachi, Sebastien, Girish,*** *for their cooperation and wellwishness during my stay in the college.*

Finally I express deep cordial gratitude without fail to my dad ***Chikka ThimmeGowda*** *and mom* ***Smt.Rathnamma*** *and my loving sister* ***Nandini.***

I extend my thanks to all those who have knowingly and unknowingly helped me during the course of my study.

Bangalore,

29th August, 2007 **(C. YESHWANTH KUMAR)**

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

1.0 INTRODUCTION

Athletic performance has improved in man and animal as a direct result of better understanding about changes in body function during various types of exercise. The knowledge acquired could further lead to better selection of animals, devising appropriate training methods, and for identification of true racing fitness.

A normal horse at rest breaths 20 times a minute with a tidal volume of five liters and a minute ventilation of 100 liters. As the horse begins to exercise, respiratory rate and tidal volume increase to achieve minute ventilation of approximately 1,500 liters/min (Strand and Staempfli,1993). The upper airway must accommodate this large increase in airflow by undergoing changes in caliber, rigidity and shape. In spite of these adaptations to exercise, evidence suggests that in exercising horses upper airway resistance becomes a large portion of total respiratory resistance resulting in early fatigue thus limiting performance. In strenuously exercising horses, the PO_2 decreases and PCO_2 increases. This perturbation in gas exchange is in part caused by insufficient alveolar ventilation. It is easy to understand that small upper airway lesions may significantly affect upper airway function during exercise and adversely influence performance.

Horse is an obligatory nose breathing animal due to the relative positions of the entrance of the larynx and the nasopharyngeal sphincter (Cook, 1965). Any marked obstruction of the nasopharyngeal airway will result in embarrassment of the respiratory function of the horse.

Poor performance due to various upper respiratory tract disorders has been well documented in the horse. Obstruction of the upper respiratory tract during exercise may result from laryngeal neuropathy

(Duncan and Griffiths, 1973), dorsal displacement of the soft palate (Quinlan *et al.*, 1975), epiglottis entrapment (Cook, 1974), rostral displacement of the palatopharyngeal arch (Cook, 1974) and arytenoid chondritis (Haynes *et al.*, 1980).

The normal function of the equine larynx is dependent upon the action of the intrinsic laryngeal muscles, a group of finely balanced agonists and antagonists, whose major nerve supplys the recurrent laryngeal nerve (RLN). This nerve is frequently affected by a neuropathy that results in the well known clinical disease, idiopathic laryngeal hemiplegia (ILH), which is manifested as paralysis of the left vocal fold.

Abnormal inspiratory noise has been described in exercising horses since the late 17th century. Laryngeal hemiplegia is one of the causes of abnormal inspiratory noise production in exercising horse and the condition is caused by recurrent laryngeal nerve injury. Determining the cause of poor performance in the equine athlete is difficult, because many of the problems that cause poor performance are manifested only at medium or high speed and horses with poor performance may have multiple concurrent problems (Morris and Seeherman, 1991).

The availability of flexible fibreoptic endoscope for veterinary practice has enabled the detection of a variety of upper respiratory tract abnormalities, including idiopathic laryngeal hemiplegia (ILH), dorsal displacement of the soft palate, aryepiglottic entrapment, subepiglottic cyst, arytenoid chondritis, pharyngitis and other affections of the nasal passages, pharynx, larynx and cranial trachea which may cause impairment of airflow. Anecdotally, many of these conditions have been associated with reduced exercise capacity (Stick *et al.*, 1990; Williams *et al.*, 1990b), although data to confirm these assumptions are lacking.

Video endoscopy of the upper airway during exercise provides an opportunity to investigate abnormal respiratory noises and to evaluate the dynamics of upper respiratory function during peak exercise (Stick *et al.*, 1990; Morris, 1991).

Most modern surgical procedures used to correct laryngeal hemiplegia in horses (ventriculectomy, arytenoidectomy and vocal cordectomy) are modifications of techniques used in the 18th century. Surgical therapy remained unchanged until the use of suture prosthesis (prosthetic laryngoplasty) to treat horses with laryngeal hemiplegia was described (Marks *et al.*, 1970a). Ventriculectomy has been performed alone or in conjunction with prosthetic laryngoplasty and vocal cordectomy (Shapell *et al.*, 1988, Hawkins *et al.*, 1997).

The efficacy of surgical procedures used to treat horses with left laryngeal hemiplegia has been evaluated using subjective criteria such as reduction of inspiratory noise during exercise and improved athletic performance.

Prompted by these considerations, the present study was undertaken with the following objectives.

1. To study the occurrence of laryngeal hemiplegia in race horses.
2. To evaluate and grade laryngeal dysfunction by endoscopy in race horses with laryngeal hemiplegia.
3. To study and compare the laryngoplasty and ventriculectomy techniques for correction of laryngeal hemiplegia in race horses.
4. To assess various clinical parameters before and after surgery.
5. To measure certain haematological and biochemical parameters before and after surgery.

Review of Literature

2.0. REVIEW OF LITERATURE

The available literature on laryngeal hemiplegia in horses is reviewed under following headings.

2.1. Occurence of laryngeal hemiplegia

2.2 Etiology and pathogenesis of laryngeal hemiplegia

2.3 Clinical symptoms

2.4 Haematological and biochemical changes in laryngeal hemiplegia

2.5 Diagnosis and grading

2.6 Treatment of laryngeal hemiplegia

2.7 Post operative care

2.8 Post operative complications

2.1. OCCURENCE OF LARYNGEAL HEMIPLEGIA

The incidence of laryngeal hemiplegia has been reported to range from three to eight percent (Cook 1974, Raphel 1982 and Hillidge, 1986) and may be as high as nine percent in draft horses (Goulden *et al.*, 1985). In addition, it is now widely accepted that many horses without idiopathic laryngeal hemiplegia had marked evidence of neurogenic atrophy of the laryngeal muscles (Cole, 1946 Gunn, 1972, and Quinlan *et al.*, 1975). It has been reported that this sub clinical laryngeal disease may be present on endoscopic examination as paresis of the left vocal fold Endoscopy can show a number of abnormalities including asymmetry, asynchronous movements, trembling or a preferential loss of adduction (Duncan *et al.*, 1977).

Haynes *et al.* (1984) reported that up to fifty-three percent of large breed horses had some degrees of laryngeal asynchrony and asymmetry

at rest. However, the effects of such changes are noticed particularly when a degree of laryngeal movement was retained.

Goulden and Anderson (1981) studied clinical features of laryngeal hemiplegia in 127 horses and noticed that in all cases, the left arytenoid was affected, although in 3 animals, a bilateral laryngeal dysfunction was noted.

Pascoe *et al.* (1981) suggested that atleast forty percent of thoroughbred horses had some degree of laryngeal asymmetry and reported incidence of neuropathy in horses to ranged from 2.6 percent to 8.3 percent.

Hillidge (1986) noticed idiopathic left-sided laryngeal paralysis in 14 of 169 thoroughbred horses (8.3 percent). In nine animals, it was evident only after exercise with arytenoid abduction and adduction, being normal at rest.

Tullners *et al.* (1988) observed among 58 cases of horses with arytenoid cartilage abnormalities, that 22 cases had left sided, 19 cases right sided and 17 cases bilateral involvement. They reported that arytenoid chondropathy was generally seen in young horses that performed at high speed, particularly racing thoroughbreds.

Hall *et al.* (1990) reported that laryngeal hemiplegia was a common problem in thoroughbred horses and in the vast majority it was left-sided. It occurred mainly in horses between 5-9 years old and produced a typical roaring or whistling noise at exercise.

King *et al.* (1994) examined 13 horses with upper airway conditions. From their resting evaluations, 9 had idiopathic laryngeal hemiplegia. Of the horses with idiopathic laryngeal hemiplegia, 7 were geldings and 2 were mares. Their mean age was 3.9 ± 0.4 years and the

mean weight was 495 ± 18 kg. Most of these horses were presented because an abnormal respiratory noise was noticed on cantering or galloping. On endoscopic examination, all horses with idiopathic laryngeal hemiplegia showed asymmetry of the larynx at rest with failure of abductor function of the arytenoid cartilage. All horses had palpable atrophy of the left dorsal cricoarytenoid muscle and were either graded III or IV on the laryngeal grading system used by Hackett *et al* (1991).

Russell and Slone (1994) screened medical records of 70 horses diagnosed with left laryngeal hemiplegia treated by prosthetic laryngoplasty combined with bilateral ventriculectomy. They reported that thoroughbred race horses had a much lower success rate (19 of 40 horses, 48 percent) with younger thoroughbred race horses showing better success rate (14 0f 20 horses, 70 percent) than those ≥ 3years old (5 of 20 horses, 25 percent). The degree of arytenoid abduction had little effect on outcome, except that horses with maximal abduction (grade 5) of the arytenoid cartilage had a higher prevalence of complication of poor correction. The two most prevalent complications were exercise intolerance (42 percent, 23 of 55 horses) and continuing noise when exercising (47 percent, 26 of 55 horses).

Christley *et al.* (1997) evaluated the effect of different grades of laryngeal dysfunction in 149 horses using treadmill exercise tests. The animals examined comprised of 103 thoroughbreds and 46 standard breeds. 20 of the horses were intact males, 95 geldings and 34 females. The age of horses was 1-7 years (Mean ± SD 3.9 ± 1.2 years). Grade-V idiopathic laryngeal hemiplegia was noticed in 5 out of 149 (3.4 percent) cases, while 10 out of 149 (6.7 percent) were Grade IV. Grade II was noticed in 41 out of 149 (27.5 percent) of horses.

Hawkins *et al.* (1997) reported the frequency of idiopathic laryngeal hemiplegia based on age and sex in 230 horses, of which 174 were

thoroughbreds (76 percent) and 56 were standardbreds (24 percent) with the mean age of 3.3 ± 1 years (range 1-6 years) and 4.1 ± 1.6 years (range 1-8 years) respectively. Out of 230 horses examined, 96 were stallions, 66 were geldings and 68 were females. Based on subjective evaluation of left arytenoid function at rest, 2 horses (1 percent) were classified as Grade II, 109 horses (47 percent) as Grade III and 119 horses (52 percent) as Grade IV.

Hammer *et al.* (1998) evaluated videoendoscopically 369 horses before and during high speed treadmill exercise, of which 26 (7 percent) horses were found to have Grade III left laryngeal hemiparesis at rest. Out of the 26 horses with idiopathic laryngeal hemiplegia, 19 were thoroughbreds and 7 standardbreds, 9 were sexually intact males, 9 were geldings and 8 were sexually intact females. Ages ranged from 2-8 years (mean 4.1 years).

Strand *et al.,* (2000) reported the median age at time of surgery was 3 years and sexually intact males and geldings represented 83 percent of horses treated with prosthetic laryngoplasty. Two year old horses most commonly had paresis of the left arytenoid cartilage (8 of 14 horses), whereas horses ≥ 3 years old more commonly had arytenoid paralysis (27of 38 horses).

Dixon *et al.* (2001) screened 375 cases of laryngeal paralysis from a mixed breed equine population. Of the animals examined, 351 (94 percent) cases had recurrent laryngeal neuropathy (RLN) and 24 cases (6 percent) of laryngeal paralysis from causes other than RLN. Laryngeal movements were classified endoscopically into one of 6 grades. In contrast to the usual 4 grades, the RLN cases had a median Grade 4 laryngeal paralysis of which 96 percent were left-sided, 2 percent right sided and 2 percent bilaterally affected. RLN cases included 204 (58 percent) thoroughbred, 96 (27 percent) thoroughbred-cross, 23 (7

percent) draft, 16 (5 percent) warm bloods and 10 (3 percent) other breeds, including 4 (1 percent) ponies. The median age of RLN was 7 years (range 2-12 years).

Kidd and Slone (2002) reported that among the 80 horses examined for laryngeal hemiplegia, which were treated by laryngoplasty, ventriculectomy and vocal cordectomy, 42 were males (53%), 25 were geldings (31 percent) and 14 were females (18 percent).

Kraus *et al.* (2002) documented preoperative endoscopic examination of 104 draft horses and found that 93 cases (84 percent) were diagnosed with grade IV left laryngeal hemiplegia, 17 cases (15 percent) were grade III and one case was grade II.

Lane *et al* (2006b) based on video-endoscopic examinations, reported dynamic collapse within the nasopharynx or larynx in 471 of the 600 horses. Dorsal displacement of soft-palate (50 percent) and palatal instability (33 percent) were the disorders most frequently identified. It was concluded that deglutition was not a significant event in the triggering of dorsal displacement of soft-palate. Complex forms of dynamic collapse were present in 30 percent of the horses with upper respiratory tract obstructions. There was an increased risk of dorsal displacement of soft-palate in younger horses and of laryngeal collapse in older horses. No association with grades or format of racing was identified.

2.2 ETIOLOGY AND PATHOGENESIS

Duncan and Griffith (1973) reported that idiopathic laryngeal hemiplegia was caused by the abnormal function of the left recurrent laryngeal nerve, as a part of peripheral neuropathy, resulting in dysfunction of all of the intrinsic left laryngeal muscles.

Recurrent laryngeal neuropathy caused due to conditions other than damage to recurrent laryngeal nerve such as guttural pouch mycosis, perivascular irritant drug injections in the cervical area, neck trauma and neoplasia (Gilbert, 1972) resulted in unilateral laryngeal paralysis. Bilateral laryngeal paralysis has been recorded in horses following organophosphate poisoning, hepatic encephalopathy and following general anesthesia.

Duncan and Brook (1985) reported that idiopathic laryngeal hemiplegia was caused by a distal degeneration of the recurrent laryngeal nerve of unknown etiology. Recurrent laryngeal neuropathy commonly affected horses, usually the left side of the larynx, less frequently the right side or occurs bilaterally.

Riggs *et al.* (1985) reported that laryngeal paralysis associated with tracheal collapse had been described in horses secondary to recurrent laryngeal nerve malfunction and secondary to recurrent laryngeal nerve involvement in a peritracheal abscess.

Derksen *et al.* (1986) reported that laryngeal hemiplegia might be either complete or partial. This resulted from decreased motor activity of the cricoarytenoideus dorsalis muscle.

Duncan *et al.* (1991) examined the laryngeal muscles of 18 horses histologically. The neurogenic changes found in each muscle were scored and the result evaluated statistically. Fifteen of these horses had endoscopic evidence of abnormal laryngeal function, 3 of which were defined as having adductor paralysis.

Baxter *et al.* (1992) reported that idiopathic laryngeal hemiplegia was considered to be the result of a peripheral neuropathy that affected the left recurrent laryngeal nerve distally, resulting in atrophy of the

intrinsic laryngeal muscles. Loss of function of the cricoarytenoideous dorsalis muscle was the major cause of the clinical syndrome because this was the only abductor muscle of the larynx.

Strand and Staempfli (1993) reported dynamic collapse of the roof of the nasopharynx as a cause of poor performance due to obstruction of the upper respiratory tract during exercise in a standard bred 4 year old colt.

Stick and Holcomb (1998) reported that abnormalities of the arytenoid cartilage, the epiglottis and the soft palate comprised the most common upper airway obstructions in performance horses in the form of laryngeal hemiplegia, epiglottic entrapment and dorsal displacement of the soft palate.

Tetens *et al.* (2000) reported that tracheal collapse could limit athletic function by increasing airway impedance and turbulence, thereby increasing the work of breathing leading to exercise intolerance in horses.

Hawe *et al.* (2001) reported that the physical traits such as height or neck length did not correlate with the incidence or severity of recurrent laryngeal neuropathy (RLN).

Dixon *et al.* (2001) reported that in 24 horses with non-idiopathic laryngeal neuropathy cases, 12 had bilateral laryngeal paralysis, 11 (92 percent) of which were ponies. Bilateral laryngeal paralysis occurred with hepatic encephalopathy in 7 cases and following general anesthesia in 2 cases. The 12 cases of acquired unilateral laryngeal paralysis included 7 caused by guttural pouch mycosis.

2.3 CLINICAL SYMPTOMS

Marks *et al.* (1970a) reported that laryngeal hemiplegia caused exercise intolerance and noise production on inhalation rendering affected horses unsuitable for athletic or show performance.

Goulden and Anderson (1981) studied some clinical features of laryngeal hemiplegia in 127 horses and noticed that the onset of clinical signs was either sudden or unridiculous. The majority of cases were presented with abnormal respiratory noise made at exercise.

Bayly *et al.* (1989) noticed that exercise intolerance seen with laryngeal paralysis could adversely affect performance of the race horses. This could be related to an increased oxygen demand during exercise, with concurrent increased oxygen requirement for the respiratory muscles function. Any further increase in the work of breathing, caused by laryngeal paralysis caused redistribution of blood flow from locomotory muscles to the respiratory muscles and adversely affected the performance.

Hillidge (1986) noticed abnormal inspiratory noise during exercise in 11 of the 14 horses that were diagnosed as laryngeal paralysis, but not in the remainders. An abnormal noise on inspiration was also produced by 9 horses in which laryngeal hemiplegia was not diagnosed.

Tulleners *et al.* (1988) observed that exercise intolerance was subjectively more severe in horses with arytenoid chondropathy, compared with horses with laryngeal hemiplegia.

Stick and Derksen (1989) observed exercise intolerance and respiratory noise during exercise in a horses with arytenoid cartilage abnormalities.

Dixon *et al.* (2001) reported presenting signs in recurrent laryngeal neuropathy affected horses like abnormal exercise related respiratory sounds in 98 percent of horses and reduced exercise tolerance in 64 percent. However, many horses were referred before their exercise tolerance could be fully assessed. 40 percent of the RLN cases had intercurrent disorders, including 10 percent with additional upper respiratory and 7 percent with lower respiratory tract diseases.

Brown *et al.* (2003) reported that show and performance horses with laryngeal hemiplegia were often presented for exercise respiratory noise rather than significant exercise intolerance.

2.4 HAEMATOLOGICAL AND BIOCHEMICAL PARAMETERS.

Goulden *et al.* (1981) reported that electrocardiographic examination of 48 horses affected with ILH did not reveal any significantly higher incidence of haematological or biochemical abnormalities than that observed in the racing population. Majority of haemograms taken from affected animals were also within normal limits.

Bayly *et al.* (1989) observed there was no significant difference on acid-base or blood gas measurement before and after surgery in a horse with laryngeal hemiplegia and also noticed that the horses with laryngeal hemiplegia developed a severe hypercapnia-hypoxemia and mixed acidemia during strenuous exercise.

Derksen *et al.* (1986) observed that increasing treadmill speed lead to progressively increased heart rate, respiratory rate, respiratory frequency, peak inspiratory flow and peak expiratory flow, but inspiratory resistance and expiratory resistance remained unchanged. They also noticed that neither left recurrent laryngeal neurectomy nor prosthetic laryngoplasty affected heart rate, respiratory frequency, peak expiratory flow or expiratory resistance.

King *et al.* (1994) reported that measurement of PCO_2 and cardio respiratory measurements during tread mill exercise were useful in determining which conditions of the upper airway contributed to reduced exercise capacity in race horses. Of the conditions assessed, idiopathic laryngeal hemiplegia caused the greatest aberration in PCO_2 and peak VO_2 (velocity of oxygen). They suggested that the degree of hypercapnia during exercise might be used as an index of the degree of functional obstruction in the upper airway

Ehrlich *et al.* (1995) reported that peak velocity of oxygen (VO2) was significantly decreased by left recurrent laryngeal neuropathy.

Christley *et al.* (1997) reported that endoscopic assessment of laryngeal function at rest, using a simple grading system provided an indication of dynamic changes in ventilation and the effects on the blood gases during exercise and they suggested that horses that had some movements of the left arytenoid cartilage but were unable to achieve full abduction (Grade 4) had similar ventilatory effects and blood gas response during maximal exercise to those with complete paralysis. Some horses with Grade 3 laryngeal function had blood gas results similar to those of horses with Grade 4 and 5 laryngeal functions, indicating that discrepancies might occur between the resting assessment and laryngeal function during strenuous exercise.

2.5 DIAGNOSIS AND GRADING

Duncan *et al.* (1977) correlated endoscopic abnormalities in horses with various degrees of idiopathic laryngeal hemiplegia with the degree of neurogenic atrophy seen in the laryngeal muscles.

Attenburrow (1978a) reported use of radiostethoscope for recording and studying the respiratory sounds generated during rest and during exercise.

Attenburrow (1978b) reported graphic representation of respiratory sounds recorded by a radio stethoscope from normal horses exercised at walk, trot, canter and gallop. Inspiratory and expiratory sounds were distinguished, and sounds were recorded at different gaits and compared.

Greet *et al.* (1979) used fluoroscopic techniques and video tape recording to study pharyngeal function after laryngoplasty on two clinical cases of laryngeal paralysis. They also performed post operative endoscopy to check the position of the left arytenoid cartilage in fixed position after laryngoplasty for laryngeal hemiplegia in horses.

Heffron and Baker (1979) reported use of fibreoptic endoscope to study the movements of the larynx and pharynx during nasal occlusion in 10 horses which showed signs consistent with functional pharyngeal obstruction on exercise.

Greet *et al.* (1980), suggested that thoracolaryngeal reflex (TLR) test or "Slap test" be performed with the examiners fingers located over the dorsal aspect of both sides of larynx. The TLR had to be performed on both sides by slapping the rostrodorsal thorax with the hand. The strength and briskness of the resultant laryngeal movements were assessed by palpation as good, reduced, absent or unknown.

Goulden *et al.* (1985) suggested that sub-clinical laryngeal disease might be present on endoscopic examination as paresis of the left vocal fold which could show a number of abnormalities including asymmetry, asynchronous movements, trembling or a preferential loss of adduction.

Hillidge (1986) reported asynchronous movement of arytenoid cartilage in 94 horses at rest (55.6 percent), 86 of which were considered to be normal after exercise. Conversely, synchronous movement of the

arytenoid was noted when at rest in 6 of the 14 animals diagnosed as having laryngeal hemiplegia after exercise.

Derksen *et al.* (1986) examined the effect of left laryngeal hemiplegia on airway flow mechanics in 5 exercising horses and the efficacy of surgical repair by laryngoplasty was evaluated using treadmill. They used pneumatochographs for measurement of inspiratory and expiratory flow rates in exercising horses to study upper airway mechanics.

Tullners *et al.* (1988) used endoscopy in 75 horses with respiratory noise or exercise intolerance and they observed structural arytenoid cartilage abnormalities or failed laryngoplasty in cases of laryngeal hemiplegia.

Stick and Derksen (1989) used videoendoscopy and flow mechanics studies to examine exercising horses with complicated upper airway obstructions. They suggested that evaluation of upper airway function in resting horses was incomplete and that the dynamics of upper airway function in performance horses could only be adequately studied during exercise using treadmill.

Hall *et al.* (1990) carried out investigations to determine whether measurements of total respiratory resistance (TRR) made in resting animals could detect changes due to laryngeal hemiplegia. Control values of TRR were obtained in 8 ponies and in 6 of these the measurements were repeated after division of left recurrent laryngeal nerve in the mid cervical region. Two were retained as controls. A further set of measurements were made before 2 of the operated animals were subjected to left ventriculectomy (Hobday operation). A laryngoplasty (Tie-back operation) was performed on two other animals. They concluded that the measurement technique was capable of

demonstrating changes in upper airway resistance due to partial obstruction of the laryngeal lumen in quietly standing ponies.

Williams *et al.* (1990b), reported use of nasotracheal catheter and a portable pressure transducer in 10 normal horses to measure upper airway pressure during maximal exercise before and after left recurrent laryngeal neurectomy.

Archer *et al.* (1991) evaluated laryngeal function in 7 horses using four techniques designed to stimulate laryngeal movements, nasal occlusion, exercise swallowing and administration of a respiratory stimulant. In addition, the effects of sedation and twitching on endoscopic examination were also examined. The cross sectional area of the rima glottis was measured in each horse at rest and after each technique was performed. There was no statistically significant difference in the increase in area seen after nasal occlusion or exercise. Doxapram hydrochloride increased the cross-sectional area of the rima-glottis, whereas xylazine caused a decrease. Neither of these pharmacological agents exaggerated or decreased the amount of asynchronous movements or tremoring of the arytenoid cartilages. Manual occlusion of the external nares during endoscopy was a simple, yet effective method of stimulating arytenoid function and hence diagnosing idiopathic laryngeal hemiplegia.

Hackett *et al.* (1991) reported endoscopic examination as the primary method of determining laryngeal function in horses and results could be used to grade horses as having Grade-I, II, III or IV laryngeal hemiparesis.

Rakestraw *et al.* (1991) reported endoscopic examination of the larynx of 49 horses at rest and while exercising. Subjective laryngeal function scores at rest and while exercising were made based on the

degree and synchrony of arytenoid abduction. Arytenoid abduction was expressed as a left:right ratio of rima-glottis measurements. 42 horses with a resting left:right arytenoid abduction ratio greater than or equal to 0.71, consistently had complete arytenoid abduction at exercise. 7 horses with a left:right ratio less than 0.71 consistently showed dynamic collapse at exercise. There was no significant difference in the exercising left:right ratio between normal horses (Grade I) and Grade II or Grade III horses.

King *et al.* (1994) used flexible fibreoptic endoscopes for detection of a variety of upper respiratory tract abnormalities, including idiopathic laryngeal hemiplegia, dorsal displacement of soft palate, aryepiglottic entrapment, subepiglottic cysts, arytenoid chondritis, pharyngitis and other conditions of the nasal passages, pharynx, larynx and cranial trachea which might cause impairment of airflow. Anecdotally, many of these conditions had been associated with reduced exercise capacity although data to confirm these assumptions were lacking.

Russell and Slone (1994) endoscopically examined the degree of arytenoid cartilage abduction graded on a 5 point grading system. A grade of 5 was given if the stabilized arytenoids were maximally abducted, sufficient to cause a depression in the pharyngeal wall, a grade of IV, if there was full abduction of the arytenoids with contact of the pharyngeal wall. If the arytenoids were abducted just beyond an intermediate position, but not touching the pharyngeal wall, the condition was graded III. A grade of II was given if the arytenoids were positioned at an intermediate (resting) position, including lack of abduction. If the cartilage crossed the midline of the rima glottis the condition was classified as Grade I. The surgeon's impression prior to conducting this study was that a Grade 4 arytenoid abduction would result in the best possible post surgical outcome for each horse. The

degree of arytenoid retraction observed immediately after surgery was not assumed to be maintained throughout a horse's career.

Christely *et al.* (1997) reported that despite the increased use of endoscopy in equine practice and advances in the evaluation of respiratory function in the horse, there was wide variation in the interpretation of the effects of laryngeal function in cases of asynchrony or paresis.

Tetens *et al.* (2000) reported that the causes of exercise intolerance could not be determined in horses from endoscopic evaluation of the nasopharynx during rest and exercise. They recommended that tracheal videoendoscopy should be performed during exercise.

Strand *et al.* (2000) developed performance index to compare the number of top 3 finishers in races before and after prosthetic laryngoplasty. First place was assigned 3 points, second place was assigned 2 points, and third place was assigned 1 point. To create the performance index, the total number of points for a given period were added together and divided by the total number of races run during that period.

Derksen *et al.* (2001) reported spectrum analysis of respiratory sounds from exercising horses after experimental induction of laryngeal hemiplegia or dorsal displacement of soft palate. The study revealed unique sound patterns in these conditions causing airway obstruction. They suggested that spectrum analysis of respiratory sounds might prove to be useful in the diagnosis of airway abnormalities in horses.

Hawe *et al.* (2001) performed electro diagnostic measurement of the thorocolaryngeal reflex (TLR) latency in horses and was compared to other diagnostic techniques used for evaluation of laryngeal function.

The diagnostic tests studied were laryngeal muscle palpation, resting and immediately post exercise endoscopic examinations and palpable endoscopic responses to the thoracolaryngeal reflex. Compared to resting endoscopy, the electro diagnostic measurement of thoracolaryngeal reflex latency was not an accurate test for the evaluation of recurrent laryngeal neuropathy (RLN). Physical traits such as height or neck length did not correlate with the incidence or severity of recurrent laryngeal neuropathy.

Dixon *et al.* (2001) performed initial endoscopic examinations in horses for reasons other than those suspected for laryngeal dysfunction. Pulmonary disorders were common in race horses. Respiratory tract endoscopy was therefore, performed during the investigation of all such cases with intercurrent laryngeal findings being contemporarily documented.

Kraus *et al.* (2002) recorded the assignment of performance scores for horses to evaluate the efficacy of laryngoplasty and ventriculectomy or ventriculocordectomy for the treatment of laryngeal hemiplegia and found 57 horses (66 %) with score 3 , 16 horses (19 percent) with score 2 and 13 horses (15 percent) with score 1.

Dixon *et al.* (2003) evaluated endoscopically the degree of arytenoid abduction achieved following surgery using a 5-grade system at 1 day, 7 days and 6 weeks after surgery. They noticed on the day following laryngoplasty that 62 percent of horses had good (Grade II), 10 percent had excessive (Grade I) and 5 percent had minimal (Grade IV) arytenoid abduction due to progressive loss of abduction. Moderate (Grade III, range I-V) abduction was present overall at 1 and 6 weeks after laryngoplasty. Further surgery was required to re tighten prostheses in 10 percent of cases with excessive loss of abduction, or to loosen

prostheses in 7 percent of horses which had continuing high levels of laryngoplasty abduction and significant post operative dysphagia.

Franklin *et al.* (2003) suggested that spectral analysis of respiratory sounds in horses had potential as a diagnostic technique for field use especially when facilities for high speed treadmill were not practicable. Concurrent use of endoscopy and audio spectroscopy provided invaluable visual confirmation of dynamic events occurring during exercise.

Kraus *et al.* (2003) reviewed 104 horses treated with laryngoplasty and ventriculectomy or ventriculocordectomy and performance score of 1-3 were assigned. All horses had preoperative performance score of 1. Improvement in postoperative performance was reported in 92 percent of horses. Respiratory noise was eliminated in 72 percent (57 horses) of horses. Postoperative performance scores of 3 in 57 (72 percent) horses, 2 in 16 (20 percent) horses and 1 in 16 (8 percent). There was no significant difference in postoperative performance based on preoperative grade of laryngeal hemiplegia.

Franklin *et al.* (2004) reported that vibrations of the soft palate were the probable source of expiratory sounds recorded in horses with dorsal displacement of soft palate and suggested that respiratory sound analysis can be applied for diagnosis of dorsal displacement of soft palate.

Brown *et al.* (2005) performed rhinolaryngoscopy once on each of 744 horses over 3.5 months. 55 abnormalities of the upper airway were detected in 47 horses (6.3 percent). Epiglottic entrapment was detected in 7 horses (0.9 percent) and was significantly associated with superior performance. Grade 2 asymmetry of the left arytenoid cartilage was detected in 9 horses (1.2 percent) and was also associated with superior

performance. Ulceration or erosion of the mucosa of the axial surface of one or both arytenoids was detected in 18 horses (2.4 percent) and was not associated with alterations in exercise performance.

Lane *et al.* (2006b) reported endoscopic findings of 600 thoroughbred racehorses during quiet breathing and these were compared with findings during high-speed treadmill exercise. Endoscopy of the resting horse showed low sensitivity in the diagnosis of dorsal displacement of soft palate and palatal instability. When endoscopy and reported noises were taken together there was still a 35 percent misdiagnosis rate. Sensitivity of the diagnostic model was greatly increased (80 percent) when a history of inspiratory noise and palpable intrinsic muscle atrophy were included.

2.6 TREATMENT OF LARYNGEAL HEMIPLEGIA

Partial arytenoidectomy, the removal of the arytenoid and corniculate cartilages while leaving the muscular process *in situ*, was first introduced as a treatment for left laryngeal hemiplegia in 1845. This procedure was considered unsatisfactory because it was associated with a high rate of postoperative complications. With the development of ventriculectomy and later prosthetic laryngoplasty (Marks *et al.*, 1970b). This had low morbidity and mortality, the use of arytenoidectomy as a treatment lot favour.

Marks *et al.* (1970b) described a prosthetic device for correction of laryngeal hemiplegia in horses.

Baxter (1983) reported that success rates for laryngoplasty ranged from 48% to 95% depending on the outcome variable evaluated. Evaluating decreased upper-respiratory tract noise as an indicator yielded a 58% success rate. When postoperative racing performance was used to compare horses that had laryngoplasty with an age matched

control group, the success rate was 85%. Thoroughbred race horses had a much lower success rate (48%) compared with breeds not intended for racing (95%).

Spiers *et al.* (1983) evaluated the use of abductor muscle prosthesis for treating laryngeal hemiplegia in 153 horses by questionnaire. In 100 thoroughbred race horses in this group, survival analysis was used to compare their racing performances and earnings with those of 400 control horses. Survival analysis showed that there was no significant difference between the related group of horses and the control horses.

Haynes *et al.* (1984) reported that horses with maximally abducted arytenoid cartilages had a lower success rate and higher incidence of complications, compared with horses with less optimal lateral positioning of the cartilages.

Derksen *et al.* (1986) suggested that stabilization of the arytenoid cartilage by laryngoplasty was necessary to improve upper airway flow mechanics in exercising horses with left laryngeal hemiplegia.

Tullners *et al.* (1988) observed that 45% of the thoroughbred racehorses returned to racing after arytenoidectomy and raced successfully. 20% of the standard bred were able to race. while 75% of the non-racehorses were able to return to their previous use.

Shappell *et al.* (1988) observed in their studies that ventriculectomy failed to improve upper airway flow mechanics in horses with laryngeal hemiplegia, whereas prosthetic laryngoplasty restored upper airway flow mechanics to base-line value.

Bohanon *et al.* (1990) screened 27 draft horses with laryngeal hemiplegia of which 21 horses were treated by ventriculectomy with or

without prosthetic laryngoplasty. Fifteen horses improved after surgery and were able to perform to the owners expectations. Performance improved significantly and hospitalization was shorter after ventriculectomy alone. They reported that the clinical signs of exercise intolerance and excessive inspiratory noise associated with left laryngeal hemiplegia in draft horses could be treated successfully by ventriculectomy with prosthetic laryngoplasty.

Dean *et al.* (1990) reported that clinical success rates for use of laryngoplasty for horses with laryngeal hemiplegia were highly variable depending on the criteria used for evaluation. They compared cartilage retention strengths of laryngoplasty prostheses in larynges of 2, 3, and 4 year old horses and observed that there was no significant effect of age, prosthetic material or side of prosthesis placement on cartilage.

Williams *et al.* (1990a) reported that during maximal exertion, prosthetic laryngoplasty was more effective than subtotal arytenoidectomy in reversing the increase in upper airway pressure that followed left recurrent laryngeal neurectomy.

Fulton *et al.* (1991) suggested the use of nerve muscle pedicle (NMP) graft for laryngeal hemiplegia. Its efficacy in restoring upper airway function was evaluated in exercising horses and it was found that there was no improvement in airway function. But 12 weeks after insertion of the NMP graft, inspiratory impedance and inspiratory air flow were significantly improved.

Rakestraw *et al.* (1991) reported that horses with arytenoid asynchrony at rest will not suffer progressive collapse of the rima glottis during exercise and that incomplete arytenoid abduction at rest was an unreliable predictor of such collapse. Surgical treatment of all Grade II horses and some Grade III horses might be inappropriate.

White (1992) suggested that the grade of laryngeal function might affect outcome after laryngoplasty and that horses treated for Grade III left laryngeal hemiparesis (LLH) have a higher rate of laryngoplasty failure than horses treated for Grade IV LLH.

Hay *et al.* (1993) reported that arytenoidectomy was used as a treatment for arytenoid chondropathy, failed left laryngoplasty and laryngeal hemiplegia. The objective was to restore the cross-sectional area of the larynx and airway function.

Lumsden *et al.* (1994) noticed that partial arytenoidectomy improved upper airway function in exercising horses with surgically induced left laryngeal hemiplegia, although qualitative evaluation suggested that some flow limitation remained at near maximal airflow rates. These results suggested that, although the procedure did not completely restore the upper airway to normal, partial arytenoidectomy was a viable treatment option for failed laryngoplasty and arytenoid chondropathy in horses.

King *et al.* (1994) suggested that the measurement of arterial blood gases and cardio respiratory indexes during treadmill exercise was useful in determining the effect on exercise capacity of various upper airway abnormalities in racehorses.

Russell and Slone (1994) reported that the success rates for correction of laryngeal hemiplegia by use of prosthetic laryngoplasty ranged from 58 to 95 percent. In a study in which racing performance of 106 thoroughbreds that had undergone prosthetic laryngoplasty and ventriculectomy were compared with those of a control group of 400 horses, 85 percent of the operated horses were able to perform up to the standards of clinically normal horses.

Tetens *et al.* (1996) reported that the upper airway function returned to pre-left recurrent laryngeal neurectomy values in horses with experimentally induced idiopathic laryngeal hemiplegia. Exercising at 100 percent of maximal heart rate, 60 and 180 days after prosthetic laryngoplasty or ventriculocordectomy with prosthetic laryngoplasty did not further improve upper airway function in the horses.

Hawkins *et al.* (1997) reported that laryngoplasty with or without ventriculectomy allowed 77 percent of the horses to race at least one time after surgery. Improved racing performance was recorded in 56 percent of the horses that completed three races before and after surgery.

Stick and Holcombe (1998) reported that prosthetic laryngoplasty alone remained the primary treatment option for idiopathic laryngeal hemiplegia, especially when the athletic endeavors of the horses involved speed. Hence race horses, 3 days event horses and other horses that performed at maximum speed should have this surgical procedure performed in preference to others.

Jansson *et al.* (2000) reported that cordopexy alone did not improve airflow in a horse with left laryngeal hemiplegia. Cordopexy with modified laryngoplasty was as efficacious as standard laryngoplasty in alleviating the effects of left laryngeal hemiplegia on air flow mechanics.

Strand *et al.* (2000) suggested a more guarded prognosis for restoration of racing performance in older horses receiving prosthetic laryngoplasty, unless they were especially talented and free of musculoskeletal and other racing related problems. They also reported that many horses might have long successful racing careers after prosthetic laryngoplasty and return to approximately the same racing speed they had before developing laryngeal neuropathy.

Schumacher *et al.* (2000) reported that *in vitro* laryngoplasty performed using a prosthetic composed of a steel cable and stress reducing washers could withstand significantly higher distractive forces than laryngoplasty performed using a single, conventionally placed polyester suture.

Dixon *et al.* (2001) noted that less severe cases of recurrent laryngeal neuropathy, especially in non-race horses, are sometimes treated by ventriculectomy and or vocal cordectomy. However, if such cases appeared to suffer from progressive RLN, it might be more prudent to treat them by laryngoplasty initially, rather than waiting for further possible deterioration in laryngeal function.

Davenport *et al.* (2001) reported that 55 thoroughbred race horses with resting endoscopic Grade III idiopathic laryngeal hemiplegia were treated by laryngoplasty and ventriculocordectomy either with (39 horses) or without (16 horses) recurrent laryngeal neurectomy (RLN). Respondents for 38 horses with RLN believed performance was improved in 19 horses, unchanged in 16 horses and decreased in 3 horses. A respondent for 9 horses without RLN reported that performance was improved in 5 horses, was unchanged in 2 horses and decreased in 2 horses. The authors suggested RLN as an adjunctive procedure to laryngoplasty and that ventriculocordectomy should not be recommended for treatment of horses with Grade III idiopathic laryngeal hemiplegia.

Kraus *et al.* (2002) reported that laryngoplasty with ventriculectomy or ventriculocordectomy was an effective treatment for laryngeal hemiplegia in draft horses. Improvement was seen in 82% of the draft horses in this study compared with a 69% subjective improvement seen in racehorses. The higher success rate in draft horses

might be because of the less strenuous demand on show horses relative to the race horses.

Kidd and Slone (2002) reported that of 67 race horses in which vocal cordectomy was performed, 38 (66%) had a successful surgical outcome, 13 (22 %) had an unsuccessful surgical outcome and 7 could not be classified as either successful or unsuccessful by their owners or trainers. They suggested that vocal cordectomy might be more important in the eradication of post operative respiratory noise than in improving clinical success rate.

Brown *et al.* (2003) reported that ventriculocordectomy effectively reduced inspiratory noise in laryngeal hemiplegia affected horses by 90 days following surgery. Inspiratory trans upper airway pressure was improved 30 days following ventriculocordectomy but did not return to baseline value. They recommended ventriculocordectomy as a surgical treatment of laryngeal hemiplegia affected horses if reduction of respiratory noise was the primary objective of surgery.

Dixon *et al.* (2003b) surveyed horses in which laryngoplasty and ventriculectomy were performed. The owners of 198 horses reported that after a median of 19 months after laryngoplasty 91 percent of cases had returned to full work while 3 percent showed reduced work. 95 percent of horses had good (Grade 2) laryngoplasty abduction at 6 weeks after surgery, 91 percent had moderate (Grade 3) abduction, 88 percent of cases had minimal (Grade 4) abduction while 25 percent of cases had total loss of surgical abduction (Grade 5). Exercise performance following surgery was reported to be markedly increased in 75 percent of cases with 10 percent showing no difference in exercise performance, and owners unsure of any effect on exercise performance in 13 percent of cases. Improved work was reported in 70 percent of sports and pleasure horses and in 67 percent of race horses. Overall, 86 percent of owners

believed laryngoplasty was worthwhile, 7 percent believed it was not worthwhile and 6 percent were unsure of its value. Surgery was reported to be of most benefit to sports horses (100 percent show jumpers) and of least benefit to race horses (long distance).

Kraus *et al.* (2003) reported that laryngoplasty with ventriculectomy or ventriculocordectomy were effective and safe procedures for the treatment of laryngeal hemiplegia in draft horses. They reported that laryngoplasty could be performed successfully, with good performance outcome. Complications associated with general anesthesia and laryngoplasty in draft horses were higher than reported for light breed horses under similar conditions.

Barnes *et al.* (2004) reported that thoroughbred race horses had a fair prognosis for racing successfully after partial arytenoidectomy without mucosal closure and this technique was a practical alternative to primary mucosal closure. This technique would decrease surgical time and avoid some problems reported with primary mucosal closure.

Brown *et al.* (2004) reported that laryngoplasty reduced inspiratory noise in laryngeal hemiplegia affected horses by 30 days following surgery, but the sound did not return to baseline values. Laryngoplasty reduced upper airway noise in horses with laryngeal hemiplegia, but was not as effective as bilateral ventriculocordectomy in this regard, although respiratory noise reduction occurred more rapidly than with bilateral ventriculocordectomy. The degree of arytenoid abduction obtained following surgery did not affect upper airways flow mechanics and suggested that bilateral ventriculocordectomy was less demanding and associated with few serious complications, unlike laryngoplasty. Therefore, in cases where noise reduction was the primary objective of surgery, bilateral ventriculocordectomy was recommended and

laryngoplasty was the treatment of choice for horses where the primary goal of surgery was to relieve airway obstruction.

Brown *et al.* (2005a) reported that unilateral laser vocal cordectomy did not effectively improve upper airway noise in horses with laryngeal hemiplegia. The procedure decreased upper airway obstruction to the same degree as bilateral ventriculocordectomy.

Brown *et al.* (2005b) reported that epiglottic entrapment, Grade II laryngeal asymmetry and mucosal erosions detected in thoroughbred race horses were not associated with impaired performance. Therefore, surgical correction and concern over laryngeal function in horses with Grade II asymmetry might not be necessary in individuals performing to expectation.

Lane *et al.* (2006a) reported that endoscopy of the upper respiratory tract of static horses was unreliable in the diagnosis of dynamic obstructions of the upper respiratory tract and should not be used in isolation in surgical decision making or in the assessment of horses at the time of sale.

Radicliffe *et al.* (2006) reported that airway mechanics and arterial blood gas values were not restored to normal after either laryngoplasty or ventriculectomy or modified partial arytenoidectomy in horses exercising at maximum heart rate. This did not affect ventilation at sub-maximal exercise, but had clinical implications at maximum heart rate. Laryngoplasty, ventriculectomy or modified partial arytenoidectomy restored airway ventilation to normal at maximal exercise. The superiority of laryngoplasty or ventriculectomy over modified partial arytenoidectomy was slight.

Lane *et al.* (2006b) reported that palatal instability and dorsal displacement of soft palate comprised the most frequently encountered forms of dynamic collapse within the upper respiratory tract of the thoroughbred race horses and suggested that those who wanted to correct upper airway dysfunction in the race horse should be aware that complex forms of collapse were common. Remedies that addressed single disorders are inappropriate.

2.7 Post-operative care

Greet *et al.* (1979) suggested laryngoplasty was intended to relieve the airway obstruction that resulted from laryngeal paralysis, although, this might be satisfactory when the horse was at exercise and it might not be acceptable during swallowing.

Tulleners *et al.* (1988) reported the use of phenylbutazone (4 mg/kg b.wt. q 12 h. PO. usually for 3 7 days) and procaine penicillin G (22,000 IU/kg, of 12 h IM. for 3-5 days) for post-operative care. Wound healing was complete after one to two months and horses were returned to work.

Baxter *et al.* (1992) combined oral phenylbutazone at 2.2 mg/kg b.wt. twice daily IV for three days, IV potassium penicillin at 22,000 IU/kg b.wt. four times daily for five days and oral trimethoprim sulphamethoxazole at 3 mg/kg b.wt. three times daily for 10 days in the postoperative period.

Russell and Slone (1994) used injections of procaine penicillin G (22,000 IU/kg of b.wt. q.12 h), IV beginning several hours after surgery. Single injections of flunixin-meglumine (1.1 mg/kg, IV.) and tetanus toxoid (1,500 IU.) IM also were administered after recovery from anesthesia. Clients were asked to resume training of the horse approximately 60 days after surgery.

Tetens et *al.* (1996) used before, during and after surgery, procaine penicillin G (22,000 IU/kg of 24 h) and phenylbutazone (2.2 mg/kg, PO. q.12 h) IV after left recurrent laryngeal neurectomy. Horses were treated for 36 h to 72 hours. The incisions were cleaned daily with dilute povidone solution until healing occured.

Hawkins *et al.* (1997) postoperatively administered antimicrobial and phenylbutazone before surgery and for three to seven days after surgery. Dexamethasone (0.0444 mg/kg, IV. once, then 0.022 mg/kg IV or I/M. every 24 hours) was administered to 29 horses for three to five hours after surgery. The laryngotomy wound was cleaned twice daily until healed and horses were confined to a stall with hand walking for 30 to 45 days after surgery.

Strand *et al.* (2000) performed endoscopy for evaluation of arytenoid abduction several days after surgery and revealed that 45 of 52 horses had good to excellent lateral positioning of the affected arytenoid cartilage. One horse had poor abduction while the remaining four horses had problems associated with prosthesis placement.

Tetens *et al.* (2000) used potassium penicillin G (22,000 IU/kg of b.wt. IV, q 6 h), gentamicin sulfate (6.6 mg/kg IV. q 24 h) and phenylbutazone (2.2 mg/kg PO. q 12 h) preoperatively.

Davenport *et al.* (2001) reported the usc of dexamethasone (0.44 mg/kg) and phenylbutazone (4.4 mg/kg) intravenously. Intra-operatively horses were also administered either procaine penicillin G (22,000 IU/kg of 12 h. IM.) or ceftiofur (0.5 mg/kg IM. once daily) preoperatively and for three to five days postoperatively. Phenylbutazone IV (2.2 mg/kg q 12 h) was continued for three to seven days.

Kidd and Slone (2002) reported the use of 22,000 IU/kg body weight of potassium penicillin IV immediately before surgery and every eight hours after surgery for next 48 hours. Each horse also received a single dose of two grams of phenylbutazone and 1500 IU tetanus toxoid IM immediately after surgery. They recommended that the horses should resume training between 45 to 60 days after surgery.

Brahmosa and Kalpravidh (2003) performed prosthetic laryngoplasty and unilateral ventriculectomy in 13 race horses with idiopathic laryngeal hemiplegia of Grade 4. Two of three horses had right sided laryngeal hemiplegia. Healing was uneventful in all cases, 9 to 18 months postoperatively all horses returned to racing without respiratory disturbances. However, respiratory noise, although markedly decreased was still heard in most horses.

Kraus *et al.* (2003) reported the use of peri-operative administration of antimicrobial and nonsteroidal anti-inflammatory drugs. Horses that had ventriculocordectomy were administered dexamethasone (4.4 mg/kg) IV and one day postoperatively (0.02 mg/kg). Laryngotomy was cleaned with povidone-iodine solution until wound healed. Non-steroidal anti-inflammatory drugs and oral anti-microbial were administered for one week. Post operatively, horses were stall rested with hand grazing for 30 days after which exercise was slowly resumed.

2.8 Postoperative complications

Marks *et al.* (1970a) reported postoperative complications following laryngoplasty technique. Chronic coughing was usually associated with feeding and was occasionally accompanied by the nasal return of food material or water was one of them.

Greet *et al.* (1979) noticed laryngoplasty was intended to relieve the airway obstruction that resulted from laryngeal paralysis and in doing so

produced fixed abduction of the left arytenoid cartilage. Although, this might be satisfactory when the horse was at exercise, it might not be acceptable during swallowing and suggested that pharyngeal dysfunction as well as over-abduction of the arytenoid cartilage might be involved in causing the chronic post-operative cough.

Shappell *et al.* (1988) evaluated the efficacy of surgical procedure used to treat horses with left laryngeal hemiplegia. They used subjective criteria such as reduction of inspiratory noise during exercise and improved athletic performance and noticed ventriculectomy was ineffective in correcting upper airway mechanical impairments in exercising horses with left laryngeal hemiplegia unlike prosthetic laryngoplasty.

Belknap *et al.* (1990) reported coughing and regurgitation to be the primary complications that developed after insertion of a laryngeal prosthetic. Coughing while eating or drinking was one of the most common complications in horses not intended for racing. However the frequency was relatively low at 33 per cent.

Dean *et al.* (1990) observed loosening of prostheses used in the laryngoplasty technique and therefore there was relaxation of arytenoid cartilage leading to failed laryngoplasty.

Lumsden *et al.* (1994) recommended partial arytenoidectomy as the treatment of choice for arytenoid chondropathy and failed prosthetic laryngoplasty, since there was no evidence of coughing or dysphagia. However, in clinical cases, pre-existing laryngeal and peri-laryngeal pathology associated with arytenoid chondropathies and failed prosthetic laryngoplasty might influence the incidence of serious postoperative complications and the efficacy of partial aryteroidectomy.

Russell and Slone (1994) noticed in their study on 70 horses that post-operative arytenoid cartilage abduction were Grade 5 in 7 horses (10 percent), Grade 4 in 47 horses (67 percent), Grade 3 in 10 horses (14 percent), Grade 2 in 1 horses (1 percent), and in 5 horses (7 percent) grades were unrecorded. None of the horses received a grade of 1. Post-operative complications such as incisional infection, prosthesis infection, and excessive drainage from the laryngotomy wound or any other reason for prosthesis removal was not developed in any of the 70 horses. None of the horses had dyspnoea, hemorrhage or pneumonia or died during the 60-day convaluent period.

Tetens *et al.* (1996) observed post-operative complications in two horses. In one horse, a suture sinus developed secondary to suture penetration of the laryngeal mucosa and in another horse, a subcutaneous infection with secondary incisional dehiscence was seen. The latter was treated with procaine penicillin G (22,000 IU/kg, IM q.12 h), gentamicin (5.5 mg/kg IM q.24 h) and daily lavaged with dilute povidone solution until resolution of the infection.

Hawkins *et al.* (1997) observed common post-operative complications like coughing (50 horses, 22 percent), incisional seroma (17 horses, 7 percent), excessive inflammation associated with the laryngotomy (10 horses, 4 percent) incisional infection (5 horses, 2 percent), dysphagia (3 horses), post-operative pleuropneumonia (2 horses), arytenoid chondritis (1 horse) and upper respiratory tract obstruction (1 horse).

Davenport *et al,* (2001) reported that the most common post operative complication was coughing (15 horses). In three horses, coughing was considered performance limiting and another three horses had post-operative incisional infections. However, these resolved with drainage, and antimicrobial and anti-inflammatory therapy without

prosthetic removal. They reported good final cosmetic appearance of the surgical site.

Dixon *et al.* (2003) reported that once the horses performed with laryngoplasty and ventriculocordectomy were back to work, about 73 per cent of cases made no abnormal noises during exercise while 21 per cent of horses were still made abnormal noises during exercise. In other six per cent of cases, owners were unsure regarding noise production.

Kraus *et al.* (2002) reported long term post operative complications like coughing that did not affect performance (8 percent), coughing in horses that had decreased performance (3 percent), prosthetic infection (2 percent), confirmed laryngoplasty failure (10 percent), continued upper respiratory noise (31 percent) and continued exercise intolerance (6 percent).

Dixon *et al* (2003a) noticed laryngoplasty wound problems in nine per cent of cases at last weeks, less than four weeks in four per cent and more than four weeks in four per cent. The discharge from the laryngotomy wounds was observed for less than two weeks in 22 per cent of cases, less than four wecks in seven per cent and for more than four weeks in two per cent. Coughing occurred at some stage post-operatively in 43 per cent of cases and its presence correlated significantly with the degree of surgical arytenoid abduction. Coughing occurred during eating in 24 per cent of cases and was not associated with eating in the other 1.9 per cent of cases. Chronic coughing occurred in 14 per cent of cases, but appeared to be due to intercurrent pulmonary disease in half of these horses.

2.9 SURGICAL ANATOMY

The larynx forms the communicating channel between the pharynx and the trachea and functions during breathing, vocalization and

deglutition. The larynx is composed of cartilage and muscle and is lined with a mucous membrane composed of stratified squamous and pseudo stratified columnar ciliated epithelium (Auer and Stick, 1992).

2.9.1 Cartilages of larynx

The cricoid, thyroid and epiglottis cartilages are unpaired, whereas arytenoid cartilage is paired. The cricoid cartilage in shaped like a signet ring and in positioned rostral to the first tracheal ring and connected to the trachea by the cricotracheal membrane. The thyroid cartilage is the largest of the laryngeal cartilages and in situated just rostral to the cricoid cartilage. The arytenoid cartilages are positioned on either side of the cricoid cartilage and connected to it by the cricoarytenoid articulations (Fig.1). The articulation is a diarthrodial joint that allows the arytenoid cartilage to rotate dorsolaterally during abduction and axially during adduction. Each arytenoid cartilage has a corniculate process that forms part of the dorsal border of the rima glottis, a cuniculate process and a muscular process that serves as origin for the cricoarytenoides dorsalis muscle. The epiglottis runs on the dorsal surface of the body of the thyroid cartilage and is held by the thyroepiglottic ligaments. It consists of elastic cartilage (Fig.2).

2.9.2 Muscles of larynx

The muscles are classified as extrinsic and intrinsic muscles.

Extrinsic muscles: These muscles include the paired cricoarytenoideus dorsalis, thyroarytenoideus (ventricularis and vocalis muscles), cricothyroideus and cricoarytenoideus lateralis muscles and the unpaired transverse arytenoideus muscle

Intrinsic muscles: They include the thyrohyoideus, hyoepigloticus and sternothyrohyoideus muscles (Auer and Stick, 1992).

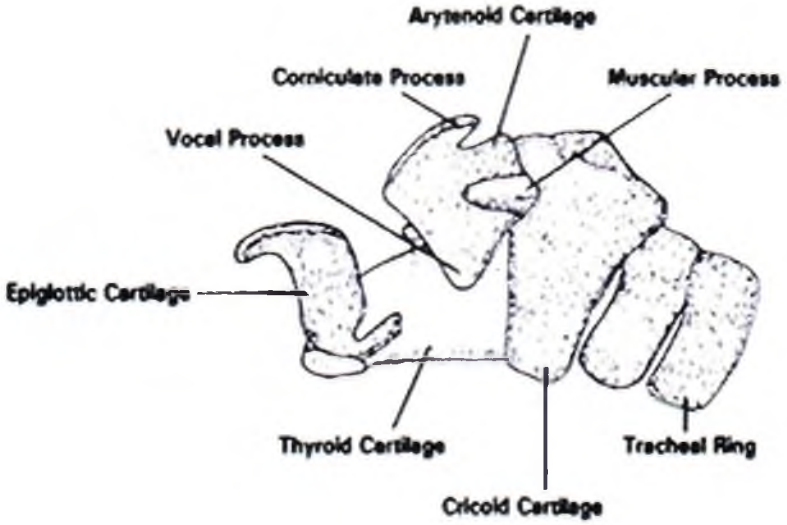


Fig. 1: Lateral view showing cartilages of larynx

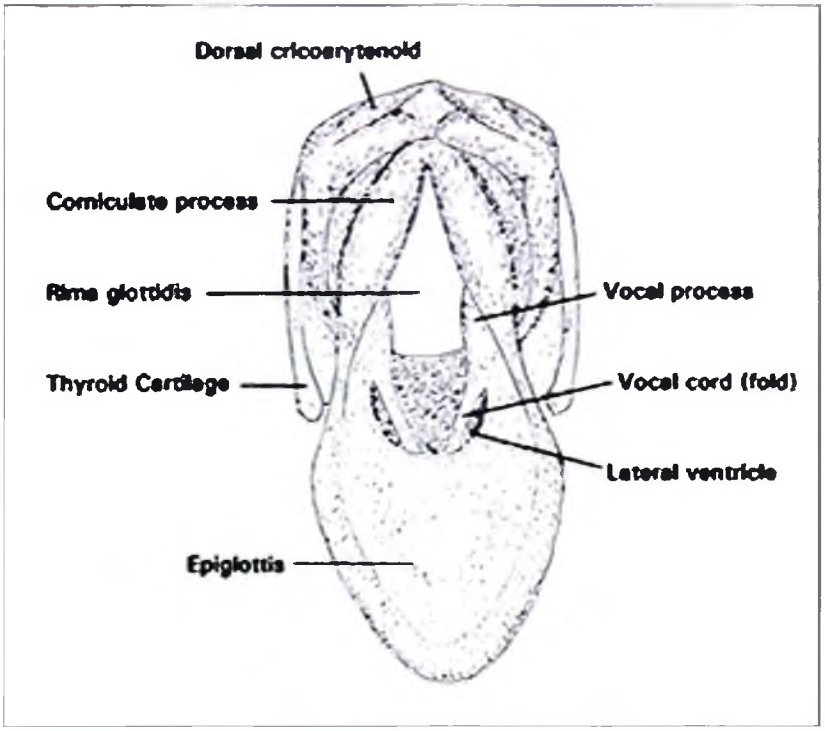


Fig. 2: Anterior view of larynx

2.9.3 Functions of laryngeal muscles

Contraction of the intrinsic laryngeal muscles produces changes in caliber of the rima glottis by abducting and adducting the corniculate processes of the arytenoid cartilage and the vocal folds, there by altering airway resistance. The cricoarytenoideus dorsalis is the principal abductor muscle that widens the laryngeal aperture by abducting the corniculate process of the arytenoid cartilage and tensing the vocal folds. Contraction of the arytenoid transversus muscle also provides arytenoid abduction by drawing the dorsomedial margins of the arytenoid cartilages together. The thyroarytenoideus, arytenoideus transversus and the cricoarytenoideus lateralis muscles adduct the corniculate processes of the arytenoid cartilages, narrowing the rima glottis and protecting the lower airway during swallowing (Auer and Stick, 1992).

The cricothyroideus muscle tenses the vocal folds during vocalization but receives efferent motor innervations from the superior laryngeal branch of the vagus nerve, whereas all other intrinsic laryngeal muscles receives motor innervations from the laryngeal branch of the vagus nerve. The extrinsic laryngeal muscles of the larynx are involved as passive movements of the larynx.

The mucosa of the larynx is closely adhered to the cartilage and contains many different types of afferent receptors. The mucous membrane covering the epiglotic cartilage reflects off the lateral border of the epiglottis and blends with the mucous membrane covering the corniculate processes of the arytenoid cartilages, forming the aryepiglottic folds. The mucous membrane covers the vocal ligament, forms the vocal folds and lines the lateral ventricles forming the laryngeal saccules. There saccules are 2.5 cm deep with a capacity of five to six ml. They extend between the medial surface of the thyroid cartilage and the ventricularis and vocalis muscles. The laryngeal mucosa contains

mechanoreceptors specialized in their sensory modalities for the detection of different stimuli including transmural pressure changes, airflow, temperature and laryngeal motion. These receptors receive afferent neural supply from the superior laryngeal nerve, a branch of the vagus nerve. This rich sensory supply is the main source of many respiratory reflexes that influence upper airway patency and breathing patterns.

2.9.4 Blood, nerve and lymphatic supply

The larynx receives arterial blood supply from the caudal laryngeal and branches of the ascending pharyngeal arteries. Venous drainage is provided by the caudal laryngeal and ascending pharyngeal veins that flow to the external jugular vein *via* the thyroid vein. The lymph chains that serve the laryngeal area include the retropharyngeal and the cranial and deep cervical lymph centre. All laryngeal muscles are supplied by recurrent laryngeal nerve which is a branch of vagus nerve, expect cricothyroid muscle which supplied by cranial laryngeal nerve (Fig.3).

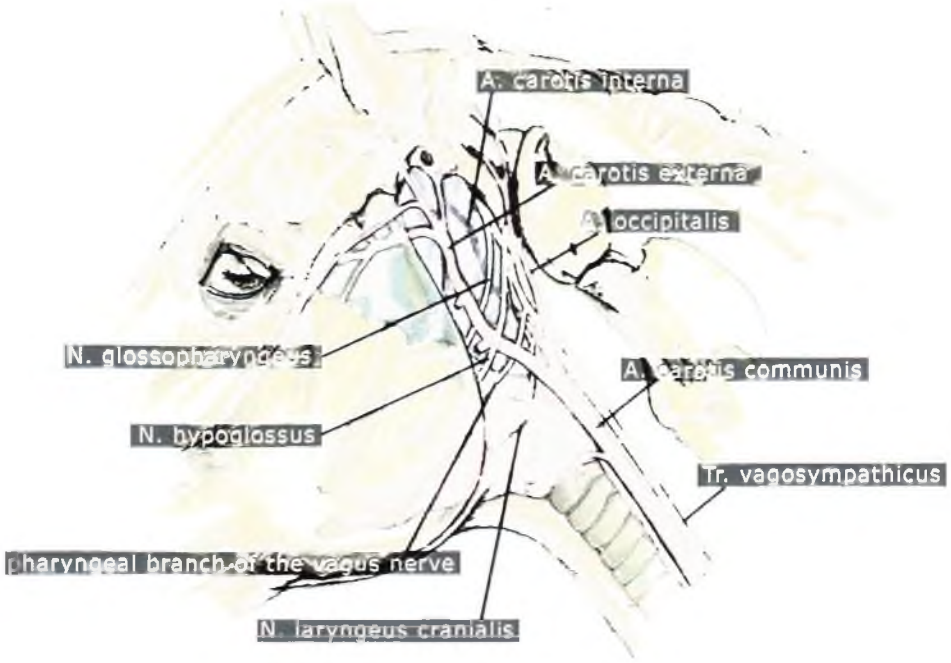


Fig. 3: Photograph showing blood and nerve supply to larynx

Materials and Methods

3.0 MATERIALS AND METHODS

The objective of the present study was to evaluate and compare the efficacy of laryngoplasty and ventriculectomy techniques for laryngeal hemiplegia in race horses. The clinical, hematological and biochemical parameters were studied before and after surgery.

3.1 SOURCE OF ANIMALS

The clinical cases of horses suffering from laryngeal hemiplegia presented to the Veterinary College Teaching Hospital KVAFSU, Bangalore, Equine hospitals of Bangalore Turf Club, Bangalore and Mysore Race Club, Mysore and Gallop-in Equine Clinic, Bangalore were used for the study.

Further, the horses presented for preracing endoscopic examination in the equine hospitals were screened for laryngeal hemiplegia for a period of 12 months.

3.2 GRADING OF LARYNGEAL HEMIPLEGIA

Laryngeal hemiplegia was diagnosed and graded based on subjective laryngeal movement on endoscopic examination of resting horses. Laryngeal hemiplegia was graded to different degrees using four grade grading system as follows.

Grade-I. Symmetrical, synchronous abduction and abduction of the left and right arytenoid cartilages at the resting phase (Fig.4).

Grade-II. Some asynchronous movement (hesitation, flutter or abductor weakness) of the left/right arytenoid cartilage during any phase of respiration, Full abduction of the left arytenoid cartilage can be maintained by swallowing or nasal occlusion (Fig.5).

Fig. 4: Photograph showing endoscopic view of Grade- I laryngeal hemiplegia

Fig. 5: Photograph showing endoscopic view of Grade- II laryngeal hemiplegia

Fig. 6: Photograph showing endoscopic view of Grade- III laryngeal hemiplegia

Fig. 7: photograph showing endoscopic view of Grade- IV laryngeal hemiplegia

Fig. 8: Photograph showing site prepared for aseptic surgery

Fig. 9: Photograph showing induction of anaesthesia

Fig. 10: Horse restrained in lateral recumbancy

Grade-III. Asynchronous movement (hesitation, flutter or abductor weakness) of the left/right arytenoid cartilage during any phase of respiration, full abduction of the left/right arytenoid cartilage cannot be induced and maintained by swallowing or nasal occlusion (Fig.6).

Grade-IV. No substantial movement of the left arytenoid cartilage during any phase of respiration (Fig.7).

3.3 SELECTION OF ANIMALS

The 12 Racehorses with laryngeal hemiplegia of Grade III and IV were selected and randomly divided into two groups *viz* Group A and Group B consisting of six animals each. All the selected Racehorses were thoroughbred and their body weight ranged from 350 to 400 kg. These horses were subjected to two different surgical techniques, *viz*, laryngoplasty and ventriculectomy as follows.

3.3.1 Group A: Laryngoplasty

The horses of this group were subjected to extra laryngeal placement of suture prosthesis between the cricoid cartilage and the muscular process of the arytenoid cartilage. The sutures abducted the collapsed arytenoid cartilages, there by enlarging the area of the rima glottis.

3.3.2 Group B: Ventriculectomy

The horses of this group were subjected to ventriculectomy, which consisted of removing of the ventricles located at the entrance to cul-de-sacs of mucus membrane called saccules. Thus, the saccules of mucous membrane, which resonated and prolapsed into the airway during inspiration were surgically removed.

3.4 PRE-OPERATIVE PREPARATION

The horses were admitted to the hospital, a day before surgery. Horseshoes were removed and the animals were thoroughly groomed and bathed. Feed was withheld for six hours before surgery. However, water was allowed *ad libitum*.

3.4.1 Preparation of surgical site

A wide region around the surgical site was shaved before induction of anaesthesia but not earlier than two hours before surgery (Fig.8).

The area was prepared in anticipation of the contingencies that frequently accompany equine surgery. Skin was surgically prepared at least 12 inches beyond the anticipated margins for draping. The area was scrubbed using povidone-iodine 7.5% (Betadine®). The scrub was vigorously applied to the surgical site for five to seven minutes using 4x4 inch gauge sponges. An unsterile scrub was performed initially followed by a surgical scrub.

3.4.2 Anesthesia and restraint

Surgery was performed under general anesthesia using Xylazine (Xylaze-100®, Parnell lab Pvt Ltd, Australia) at dose of 1.1 mg/kg and Ketamine (Ketamil®, Troy lab Pvt Ltd Australia) at dose of 2.2 mg/kg IV (Fig.9). Further, following medication were administered to horses of both the group as a part of pre-operative procedure. Peri-operative antibiotics using benzylpenicillin (Benzylpenicillin®, Karnataka Antibiotics, Bangalore) at 22,000 IU/kg of body weight, phenylbutazone (Artizone-S®, Alved Pharm, Chennai) at dose rate of 4.4 mg/kg was administered intravenously and tetanus toxoid (Bett®, Biological-E, Ltd, Hyderabad) was given at a dose rate of 1500 IU/kg intra muscularly.

Horses of the Group A, after induction of general anesthesia, were positioned in lateral recumbency (Fig.10), with the affected side of the larynx uppermost. The head and the neck were extended to improve surgical access to the larynx and the neck was elevated with padding (Fig.11).

The Group B horses, after induction of general anaesthesia were positioned in dorsal recumbency with the head and neck extended (Fig.12). The head and neck were held straight, helping to keep the incision midline. The surgical site was draped and kept ready for surgery (Fig.13, Fig.14).

3.4.3 Surgical instrumentation

The special instruments like Endoscope unit (Fig.15 and Fig. 16), half circle trocar point needle (Fig.17), laryngeal burr, Sauerbruch retractor, Weitlaner retractor (Fig.18) and surgical staples (Fig.19) were used to perform the surgical procedures.

3.5 SURGICAL PROCEDURE

3.5.1 Group A: Laryngoplasty

An 8 to 10 cm long skin incision was made immediately ventral and parallel to the linguofacial vein, extending rostrally from the point at which the vein crosses the sternomandibularis muscle (Fig 20).

The subcutaneous tissues were incised in the same plane to expose deeper fascia between the omohyoideus muscle and vein (Fig.21). In the central aspect of the incision, the fascia between the vein and muscle was cut for 5 to 6 cm with scissors, leaving 3 or 4 mm of fascia next to the vein for closure. Care was taken not to damage the linguofacial vein. The vein was pushed dorsally and both index fingers

Fig. 11: Photograph showing position of horse with extended neck and head (Group A)

Fig. 12: Photograph showing restraining horse and povidone scrubbed on surgical site (Group B)

Fig. 13: Photograph showing draping of surgical site (Group A)

Fig. 14: Photograph showing draping of surgical site (Group B)

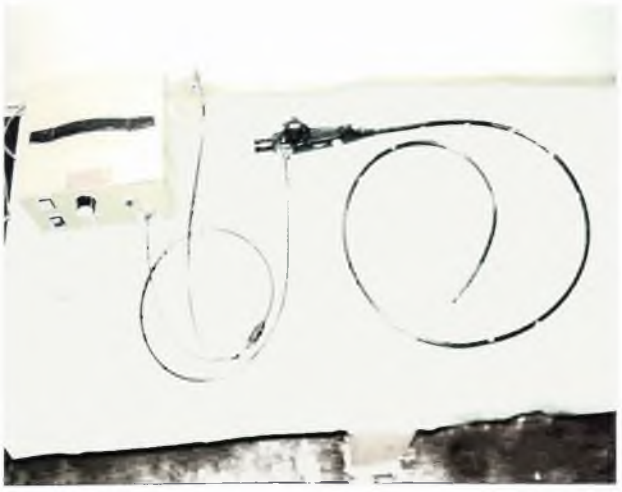


Fig. 15: Endoscopic unit (Schott, Germany)

Fig. 16: Illuminator (light source) for endoscope (Schott, Germany)

Fig. 17: Half circle Trochar point needle, Polyamide suture (Supramid, Germany)

Fig. 18: Laryngeal burr, Sauerbrach retractor and Weitlaner retractor

Fig. 19: Stainless steel staples for skin suture

were inserted into the incision and used to bluntly dissect through the loose fascia around the larynx.

The plane of dissection was expanded by blunt dissection until the muscular processes of the arytenoid cartilage were palpated. Hemorrhage was kept to minimum during the dissection. At this point, the dissection was more extensive in the deeper loose fascia than in the more superficial fascia between the linguofacial vein and the omohyoideus muscle, hence creating a funnel shaped plane of dissection Sauerbruch retractors were placed in the incision underneath the vein and sternomandibularis muscle and these structures were elevated away from the larynx by retracting dorsally and laterally (Fig.22).

The commissaries of the subcutaneous fascia were extended by a combination of blunt and sharp direction to allow visualisation of the cricoid cartilage and the thyropharyngeus and cricopharyngeus muscles that overline the muscular process of the arytenoid cartilage. By first having directed deeper to this fascia, it was easy to identify and preserve the vessels and nerve that supplied the omohydoideus muscles. The fascia around them was transected with scissors to gain mobility. The vessels and nerves usually could be retracted and ligation of vessels was rarely required.

To expose the muscular process of the arytenoid cartilage, a retractor was placed in the cranial aspect of the incision and the septum between the thyropharyngeus and cricopharyngeus muscles were split longitudinally to expose the shiny white cartilage of the apex of the muscular process.

The retractor was now placed in the caudal aspect of the incision. The dorsolateral caudal border of the cricoid cartilage was

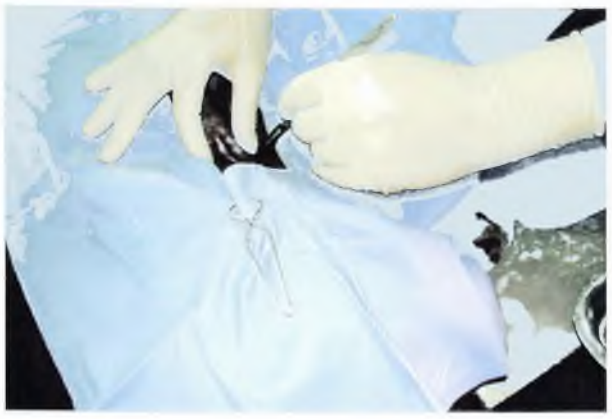


Fig. 20: Photograph showing incision made at the site (Group A)

Fig. 21: Photograph showing dissection of the subcutaneous tissue (Group A)

Fig. 22: Photograph showing placement of Sauerbruch retractor to expose larynx (Group A)

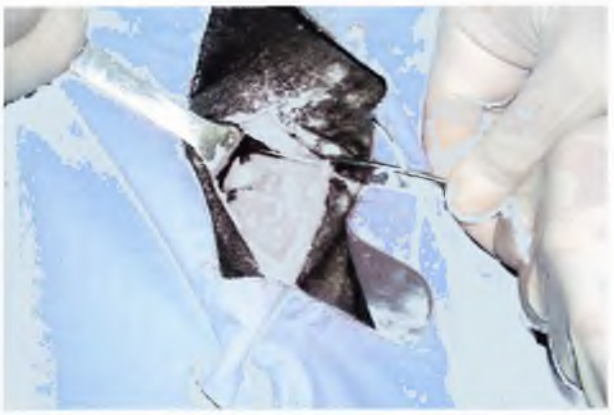


Fig. 23: Photograph Showing placement of half ci trochar point needle into cricoid cartilage (Group

Fig. 24: Photograph showing Placement of half circle trochar point needle into muscular process of arytenoid cartilage (Group A)

exposed by blunt separation of overlying fascia using metazenbaum scissors. Care was taken to preserve the thyrolaryngeal vascular pedicle, which was retracted caudally, during placement of the prosthesis in the cricoid cartilage. Cranial thyroid veins often lie closely opposed to the axial surface of the cricoid cartilage at the point of disection. Hemorrhage was controlled with three to five minutes of gentle counter pressure with gauze/surgical sponges.

The laryngeal suture consisted of single or double stranded nonabsorbable braided polyester material (Supramid® Germany) with strands at least 18 inches long.

A half circle, traumatic needle, which was sturdy enough to penetrate cartilage, was used. The suture was positioned to approximate the normal line of tension of the cricoaryteroideus dorsalis muscle. Tension on the muscular process was in a caudomedial direction to abduct the arytenoid cartilage.

The suture was first placed through the cricoid cartilage. To improve exposure of the dorsal aspect of the cricoid cartilage, the thyroid cartilage was grasped with a towel clamp and rotated downward and outward. The Sauerbruch retractor was placed in the caudal aspect of the incision. The suture was inserted by depressing the soft tissues on the caudal dorsal aspect of the cricoid cartilage with the left index finger and palpating the caudal notch of the cricoid cartilage. The needle was passed at the back of the cricoid cartilage next to the notch just lateral to midline and paired under the cartilage for approximately 1.5 cm (Fig.23). The needle was passed close to the inner surface of the cartilage to avoid penetration of the underlying laryngeal mucosa and inadvertent entrance into the airway.

The needle was then forced through the cricoid cartilage, penetration of the cartilage may be difficult. Taking care to avoid bending or breakage of the needle, the needle was passed in a craniomedial direction, with the point emerging 4 to 5 cm caudal and lateral to the midline ridge of the cricoid cartilage. This ridge was easily palpated as a cartilaginous spine on midline. The needle point was guarded to avoid damage to the esophagus or common carotid artery. Once the suture was anchored to the cricoid cartilage, the ends were brought out of the incision and the needle was removed.

The suture was pulled back and forth gently to ensure that it had engaged the cricoid cartilage and was not restricted from sliding as it was tied. A curved forceps was bluntly introduced from cranial to caudal direction under the cricopharyngeus muscle to separately grasp both ends of the prosthesis and pull them forward so they were adjacent to the muscular process.

A smaller No.5 trocar point needle was put on the end of the suture that emerged from the cricoid cartilage next to the midline ridge. The needle was passed through the muscular process on a medial to lateral direction (Fig.24). Passage of the needle was often difficult and care was taken to avoid breakage. The needle was passed through the muscular process just cranial to the apex to ensure that the suture was placed solidly in the cartilage. Care was taken to avoid placing the suture more than five mm cranial to the apex to avoid inadequate abduction (Fig.25).

The needle was removed and the prosthesis was pulled gently back and forth through the muscular process to ensure that it slide when tension was applied. After ensuring that the suture strands were not twisted, the ends were tied under tension. The amount of tension was subjective. Sutures were tied as tightly as possible using one

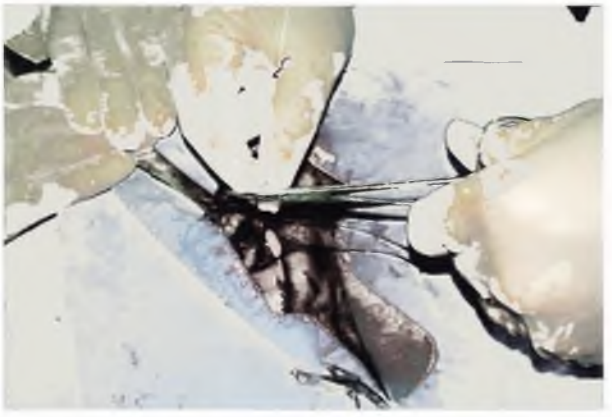


Fig. 25: Photograph showing placement of suture prosthesis into cricoid cartilage and muscular process of arytenoid cartilage (Group A)

Fig. 26: Photograph showing application of kn during surgery (Group A)

Fig. 27: Photograph showing endoscopic assessment of arytenoid cartilage abduction occured during surgery (Group A)

Fig. 28: Photograph showing suturing of cricopharyngeus and thyropharyngeus muscle (Group A)

Fig. 29: Photograph showing application of skin suture with stainless steel staples (Group A)

index finger on each strand (Fig.26). The index fingers were positioned against the larynx so that tension in the prosthetic suture was aligned with the original pull of the cricoarytenoideus dorsalis muscle.

Braided polyester suture material had poor knot security. So clamping the first throw of the knot with hemostat was necessary to avoid slippage while the second throw was placed, followed by four or five throws.

Endoscopic evaluation of the arytenoid cartilage during surgery was done to determine whether abduction had occurred (Fig.27). However it was unreliable in determining the amount of abduction that could be achieved after the horse had recovered from anaesthesia. The cricopharyngeus and thropharyngeus muscle were closed over the muscular process with a simple continuous pattern using 2-0 synthetic absorbable suture material (Fig.28). The fascia adjacent to the linguofascial vein, the omohyoideus muscle and the subcutaneous tissues were closed using catgut. The skin was closed with surgical staples (Royal-35, Auto suture, USA) (Fig.29).

3.5.2 Group B: Ventriculectomy

The horse was restrained in dorsal recumbency. A six cm ventral midline skin incision was made directly over the cricothyroid ligament of the larynx (Fig 30). The correct location was determined by palpation of the cricoid and thyroid cartilages with the neck slightly flexed. In heavily muscled horses, the larynx was difficult to palpate, but the centre of the incision was placed at the level of an imaginary horizontal line between the rami of the mandibles where they meet the muscles of the neck. The skin incision exposed the midline fascia of the sternohyoideus and omohyoideus muscles, which were split with scissors. Cricoid and thyroid cartilages, the cranial thyroid notch and

Fig. 30: Photograph showing incision made at the site (Group B)

Fig. 31: Photograph showing placement of Weitlaner retractor to expose surgical site (Group E

Fig. 32: Photograph showing insertion of laryngeal burr into the ventricle (Group B)

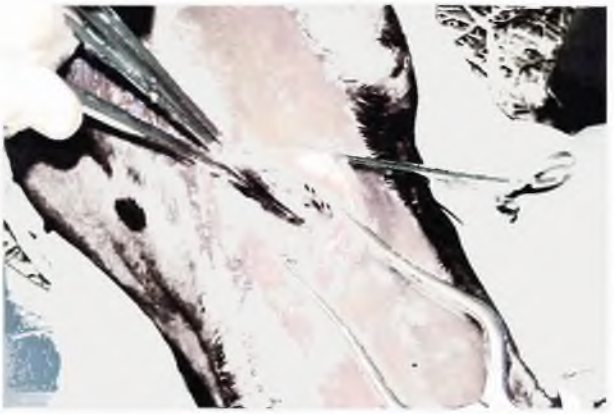


Fig. 33: Photograph showing grasping of saccular mucosa with haemostat (Group B)

the cricothyroid membrane were identified to avoid deeper incision. The ventral aspect of the thyroid cartilage had a laryngeal prominence on the ventral midline which was palpated to demarcate the cranial aspect of the incision.

Self-retaining retractors were used to separate the muscles, loose fascia and fat over the cricothyroid ligament. The ligament was incised in the same direction on the skin incision. A small vein passing horizontally across the ligament near the cricoid cartilage was severed. The cricothyroid membrane was incised by a making a quick stab incision with the scalpel blade into the larynx at the caudal aspect of the ligament immediately adjacent to the cricoid cartilage. The quick stab ensured that the underlying mucous membrane of the larynx was also incised and not pushed away from the ligament. The incision in the cricothyroid ligament was extended to the laryngeal prominence on the thyroid cartilage and the self-retaining retractors were repositioned in the incision to keep the cricothyroid ligament open (Fig.31).

The laryngeal ventricle was identified with the index finger as it lied just cranial to the vocal fold. The finger was inserted into the saccule by moving it laterally and caudo-dorsally toward the base of the ear. The saccule was dried with a gauze sponge using long dressing forceps. The mucous membrane was inserted into the larynx with a footed roaring burr (Fig.32). The burr was inserted into the saccule as deeply as possible in the dorsal and caudal direction and was rotated to engage the mucus membrane while being pushed into the saccule. Rotation of 360^0 to 540^0 was usually sufficient to engage the mucosa. Rotation was stopped when resistance occured, since over rotation could cause the bur to tear through the mucosa and make eversion difficult. Once the mucosa was engaged it was everted and grasped with a curved forceps (Fig.33). The mucosa was unfurled and

Fig. 34: Photograph showing grasping of saccular mucosa with second haemostat (Group B)

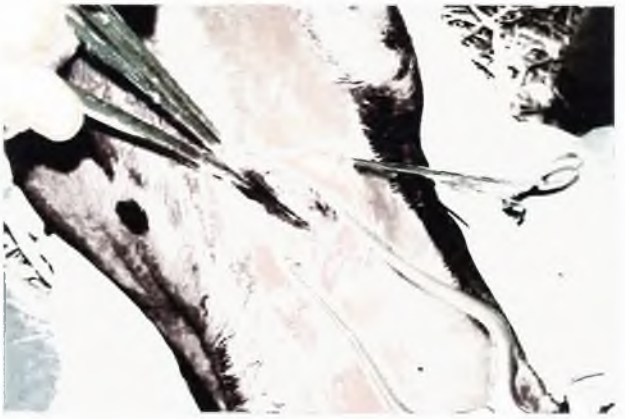


Fig. 35: Photograph showing excision of mucos with scissors (Group B)

Fig. 36: Photograph showing excised saccular mucosa (Group B)

Fig. 37: Photograph showing laryngotomy wound without suturing (Group B)

the burr removed. The mucusmembrane was fully everted by using a second forceps to alternatively cross-clamp and pulls it axially (Fig.34). When full eversion was achieved, no cavities were presented cranial or caudal to the everted cul-de-sac. The mucosa was excised with scissors close to the vocal fold and removed (Fig.35, Fig.36). Bilateral ventriculectomy was preferred when used as the sole procedure for treatment of laryngeal hemiplegia. Laryngotomy incision was left open to heal by second intention (Fig.37).

3.6 POST-OPERATIVE MANAGEMENT

Benzylpenicillin (Benzylpenicillin®, Karnataka Antibiotics, Bangalore) was administered at dose rate of 22,000 IU/kg IV for 7 days along with phenylbutazone (Artizone-S®, Alved Pharm, Chennai) at dose rate of 4.4 mg/kg IV. The operated horses of both groups were confined to a stall rest for four weeks with hand walk of 10-15 minutes daily. Only grass was provided during first post-operative week. The open laryngotomy incision was cleaned twice daily and skin sutures in the laryngoplasty incision were removed on 8th postoperative day. An additional four weeks of rest in a small paddock was given before resumption of training.

3.7 CLINICAL STUDIES

Clinical parameters like rectal temperature, heart rate and respiration rate were recorded prior to surgery and subsequently at weekly intervals.

3.8 HAEMATOLOGICAL STUDIES

Blood samples of five ml were collected from the jugular vein and transferred immediately into sterile vials containing EDTA as anticoagulant. The blood samples were collected on Day 0, 1, 3, 5, 7

and at weekly intervals for eight weeks to study the hematological parameters.

Total erythrocyte count (TEC) and total leucocyte count (TLC) were estimated as per the procedure. Blood smears for differential leucocyte count (DLC) were stained by Giemsa stain and 100 cells were counted using battlement method and percentage obtained. Haemoglobin was estimated using Sahli Haemoglobinometer (Superior Inc., Germany).

3.9 BIOCHEMICAL STUDIES

Blood was collected for serum on Day 0, 1, 3, 5, 7 and at weekly intervals for eight weeks. Alanine amino transferase (ALT), aspartate amino transferase (AST), alkaline phosphatase (ALP) and creatinine were estimated using automatic analyzer by spectrophotometric method.

3.10 POST-OPERATIVE EVALUATION

Endoscopical examination (Schott, Germany) was done on operated horses of both groups to assess wound healing and to assess the post-operative arytenoid abduction. Production of respiratory noise and its performance at training was evaluated subjectively based on trainer and jockey statement.

3.11 STATISTICAL METHODOLOGY

The data obtained with respect to haematological and biochemical values were subjected to statistical analysis by paired and unpaired 't' test with the help of computer based statistical programme (Graph Pad Prism) to test for significance.

Results

4. RESULTS

A comparative evaluation of laryngoplasty and ventriculectomy for corrections of laryngeal hemiplegia in race horses was carried out with reference to clinical improvement, gross evaluation of the surgical site and hematological and biochemical parameters and the results were as follows.

4.1 OCCURENCE OF LARYNGEAL HEMIPLEGIA

Overall occurrence of laryngeal hemiplegia was found to be 12.63 per cent (229 out of 1813). Occurrence of left laryngeal hemiplegia was found to be more (99.12%, 227 out of 229) than right laryngeal hemiplegia (0.88%, 2 out of 229).

Age wise occurrence was found to be more in three year old horses (40.65%, 94 out of 229) followed by four year olds (33.80%, 76 out of 229), five year olds (17.77%, 41 out of 229), six year olds (6.06%, 14 out of 229), seven year olds (1.29%, 3 out of 229) and eight year olds (0.43%, 1 out of 229). Average age of animals with laryngeal hemiplegia was found to be 5.5 years. (Table.1, Fig.38).

Gender wise occurrences, 135 out of 229 cases were males (57.53 %) and the rest females (42.48%, 94 out of 229). Among males, 107 out of 135 were geldings (79.25%) and the rest were intact males (20.75%, 28 out of 130) (Table.1, Fig 39).

Occurrence of different grades of laryngeal hemiplegia was found to be highest in Grade I (69.05 per cent, 158 out of 226) followed by Grade II (20.97 per cent, 48 out of 226), Grade III (8.3 per cent, 19 Out of 226) and Grade IV (1.69 per cent, 5 Out of 226) (Table.1, Fig.40).

Table1 Details of horses affected with various grades of laryngeal hemiplegia

Age	No. of Animals	Gender		Grades of laryngeal hemiplegia			
		Male	Female	I	II	III	IV
3 years	94 (40.65%)	60 (26.2%)	34 (14.84%)	67 (29.25%)	22 (9.60%)	5 (2.18%)	0 (0%)
4 years	76 (33.8%)	41 (17.9%)	35 (15.28%)	56 (24.48%)	15 (6.55%)	6 (2.62%)	1 (0.43%)
5 years	41 (17.77%)	20 (8.73%)	21 (9.17%)	26 (11.35%)	7 (3.05%)	5 (2.18%)	2 (0.87%)
6 years	14 (6.06%)	11 (4.8%)	3 (1.31%)	8 (3.49%)	2 (0.87%)	2 (0.87%)	2 (0.87%)
7 years	3 (1.29%)	2 (0.87%)	1 (0.43%)	1 (0.43%)	1 (0.43%)	1 (0.43%)	0 (0%)
8 years	1 (0.43%)	1 (0.43%)	0 (0%)	0 (0%)	1 (0.43%)	0 (0%)	0 (0%)
Total	229	135 (57.53%)	94 (42.48%)	158 (69.05%)	48 (20.97%)	19 (8.3%)	5 (1.69%)

Fig. 38: Age wise occurence of laryngeal hemiplegia in Race horses

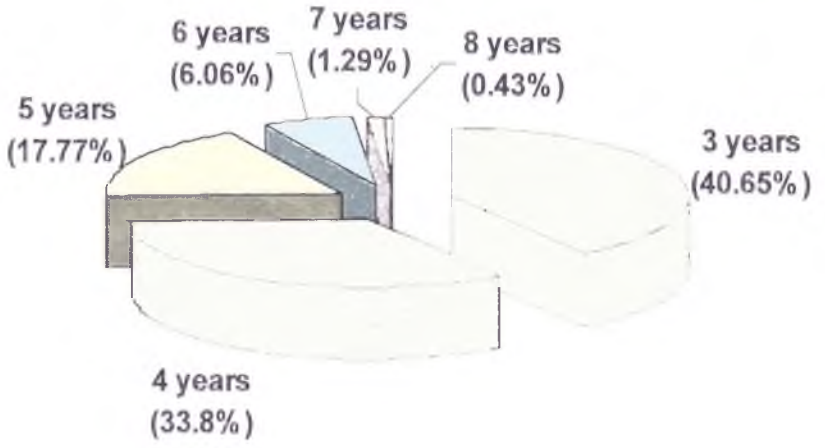


Fig. 39 Sex wise occurence of laryngeal hemiplegia in Race horses

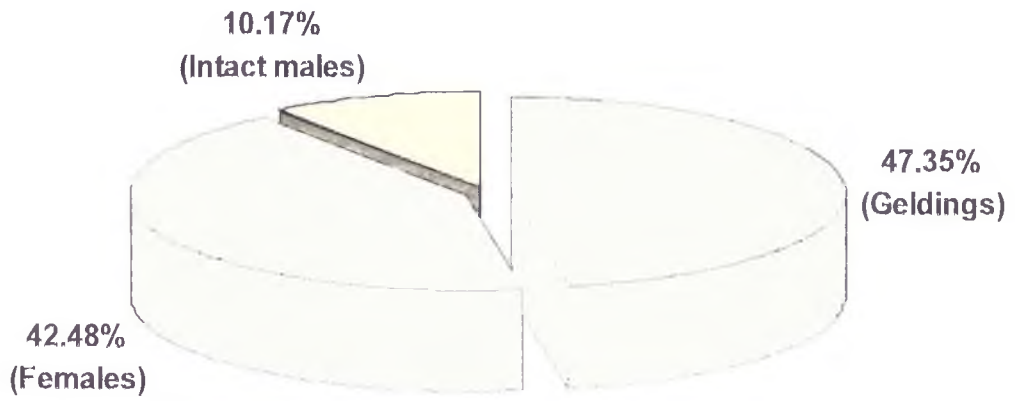
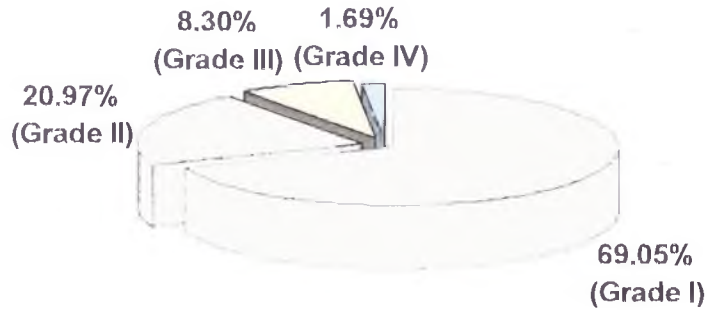


Fig. 40: Incidence of different grades of laryngeal hemiplegia in Race horses



The occurrence with regard to different grades of laryngeal hemiplegia among three year old horses was found to be Grade I - 71.2 per cent (67 out of 94), Grade II – 23.4 per cent (22 out of 94) and Grade III – 5.3 per cent (5 out of 94). Among four year olds, Grade I – 71.29 per cent (54 out of 76), Grade II - 19.23 per cent (15 out of 74), Grade III – 7.69 per cent (6 out of 74) and Grade VI – 1.28 per cent (1 out of 74) were seen. Among five year olds, Grade I – 63.41 per cent (26 out of 41), Grade II - 17.07 per cent (7 out of 41), Grade III – 12.19 per cent (5 out of 41) and Grade VI – 4.87 per cent (2 out of 41) were seen.

Among six year olds, Grade I – 57.17 per cent (8 out of 14), Grade II – 14.20 per cent (2 out of 14), Grade III – 14.20 per cent (2 out of 14) and Grade VI – 14.20 per cent (2 out of 14). Among seven year olds, Grade I – 33.33 per cent (1 out of 3), Grade II – 33.33 per cent (1 out of 3) and Grade III – 33.33 per cent (1 out of 3). Among eight years old only Grade II was found.

4.2 SELECTION OF ANIMALS

Selection of animals with laryngeal hemiplegia of Grade III and Grade IV for the study was carried out based on clinical examination.

4.3 PRE-OPERATIVE PREPARATION

All the horses in the study were admitted to the equine hospital a day prior to surgery for acclimatization. Clinical and haematobiochemical parameters in all the animals were with in the normal range prior to surgery. Shaving of the surgical site and povidone-iodine scrub provided a clean and sterile site for surgery.

4.4 RESTRAINT AND ANAESTHESIA

General anesthesia using xylazine hydrochloride and ketamine hydrochloride was found to be satisfactory. Induction and recovery from anesthesia was smooth without any complication in horses of both groups.

Position of animal in lateral recumbancy with head and neck extended was found to be very convinent in approaching the larynx in animals of Group A. Positioning of animal in dorsal recumbency helped easy approach of the ventricles in animals group B.

4.5 SURGICAL INSTRUMENTATION

The use of special instruments like half circle trocar point needle, sauerbruch retractor, weitlaner retractor, surgical staples and laryngeal burr was found to be effective and useful in performing the surgical procedures.

4.6 SURGICAL PROCEDURE

Six each of 12 horses with laryngeal hemiplegia of Grade III and IV were subjected randomly to either laryngoplasty in Group A or ventriculectomy in Group B.

4.6.1 Group A: Laryngoplasty

During surgery, damage to lingofacial vein was avoided in all cases by careful dissection. The cricopharyngeus and thyropharyngeus muscles were separated without any complication. Application of sauerbruch retractors helped optimal visualization of larynx for performing the surgical procedure.

Placement of suture prostheses through the notch of cricoid cartilage and muscular process of arytenoid cartilage was performed

without difficulty using half circle trocar point needle. Use of surgical staples was more convinent and reduced the time required for closing the skin incision.

4.6.2 Group B: Ventriculectomy

During surgery, weitlaner retractor was found to be effective in keeping sternohyoideus and omohyoideus muscles separated providing an unobstructed view of the ventricles and easy introduction of laryngeal burr.

Entrapment of the saccular mucosa by rotating laryngeal burr was found to be a simple technique, which was performed without any complications. Use of laryngeal burr also helped to remove much of saccular mucosa as possible without any complication.

Minimal bleeding was not clinically significant, which found in all cases. Leaving surgical site without suturing allowed discharge to drain out freely.

4.7 POST-OPERATIVE MANAGEMENT

Benzyl penicillin at a dose of 22,000 IU/kg was found to be effective in preventing post-operative infection except in one horse of Group-A and phenyl butazone at a dose of 4.4 mg/kg found to be satisfactory in controlling post operative inflammation.

Stall rest for four weeks with restricted feeding helped wound healing without any postoperative complications. When animals were put back to training after stall rest, respiratory noise was not observed in any of the horses except in one horse of Group-A.

4.8 POST-OPERATIVE COMPLICATIONS

When subjected to training after 4 weeks of stall rest, one horse of Group A had persistent respiratory noise. This was found to be because of poor abduction of arytenoid and dorsal displacement of soft palate, which was diagnosed subsequently on endoscopic examination

4.9 CLINICAL STUDIES

The results of the gross examination, endoscopic evaluation and clinical evaluation *viz.*, rectal temperature, heart rate and respiratory rate were monitored postoperatively on following days *i.e.*, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56 are presented in Table 2.

4.9.1 Gross examination

The wound was examined for any gross changes at the wound site during the postoperative period.

Group A: One out of six operated horses had wound complication with seroma collection and suppuration on 3rd post-operative day, causing delayed wound healing (Fig.41). This was managed with regular dressing until it healed satisfactory. In rest of the horses, no post-operative complications were noticed and surgical staples were removed on 10th post-operative day (Fig.42). One horse, four weeks after surgery participated in three races winning two.

Group B: All the horses had normal wound healing, without any complications (Fig. 43, Fig.44, Fig.45, Fig.46).

4.9.2 Endoscopic evaluation

The operated horses of both groups were subjected to endoscopic evaluation for assessment of arytenoid abduction in Group A (Fig.47, Fig.48) and for wound healing in Group B.

Fig. 41: Photograph showing wound complication with seroma collection (Group A)

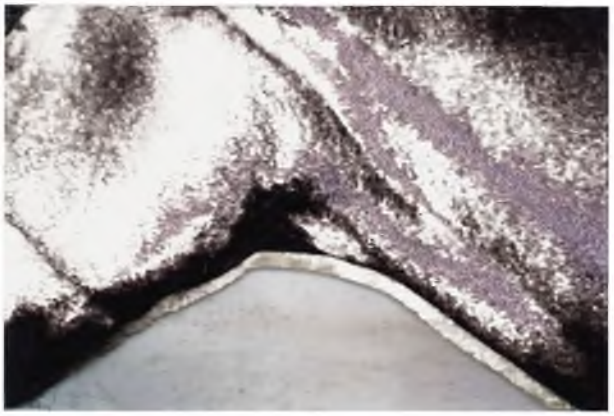


Fig. 42: Photograph showing complete wound healing (Group A)

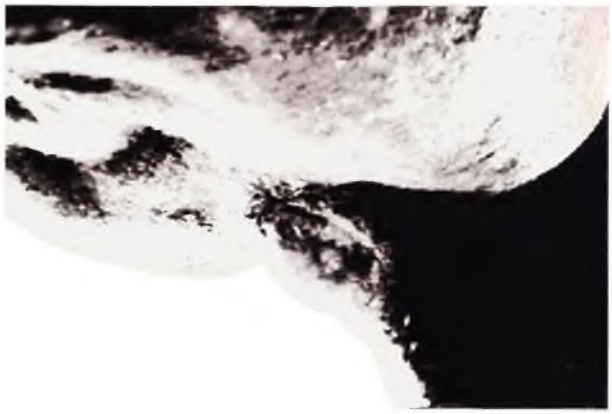


Fig. 43: Photograph showing wound healing by first week (Group B)

Fig. 44: Photograph showing wound healing by second week (Group B)

Fig. 45: Photograph showing wound healing by third week (Group B)

Fig. 46: Photograph showing complete wound healing by fourth week (Group B)

Fig. 47: Photograph showing endoscopic view of Grade III laryngeal hemiplegia before surgery

Fig. 48: Photograph showing arytenoid cartilage abduction after surgery (Group A)

Fig. 49: Photograph showing laryngeal odema on first week (Group A)

Fig. 50: Photograph showing arytenoid cartilage abduction on second week (Group A)

Fig. 51: Photograph showing arytenoid cartilage abduction on third week (Group A)

Fig. 52: Photograph showing endoscopic view of symmetry of arytenoid cartilage during inspiration on fourth week (Group A)

Fig. 53: Photograph showing endoscopic view of symmetry of arytenoid cartilage during inspiration on fifth week (Group A)

Fig. 54: Photograph showing endoscopic view of symmetry of arytenoid cartilage during inspiration on sixth week (Group A)

Group A: The degree of arytenoid abduction was assessed endoscopically in this group at weekly intervals. Laryngeal edema (Fig.49) was observed in all the horses during first postoperative week which was not evident in subsequent weeks. One among the six horses had poor abduction, which was visible endoscopically from first week post-operatively and continued to remain same throughout period of study (Fig.50, Fig.51, Fig.52, Fig. 53 and Fig.54).

Group B: The Wound healing was assessed endoscopically. It was found to be satisfactory without any complications (Fig.55, Fig.56, Fig.57, Fig.58, Fig.59 and Fig.60).

4.9.3 Rectal temperature (°F)

The rectal temperature in Group A animals ranged from 100.4 ± 0.20 (mean± SE) to 101.1 ± 0.13 and in Group B animals ranged from 100.5 ± 0.12 to 101.1 ± 0.12. There were no significant changes in rectal temperature both within and between the groups. (Table 2, Fig 61).

4.9.4 Heart rate (per minute)

The heart rate in Group A animals ranged from 31.33 ± 0.66 to 35.50 ± 1.31 and in Group B animals ranged from 30.33 ± 0.61 to 37.33 ± 0.42.

There were no significant changes in heart rate both within and between the groups (Table 2, Fig 62).

4.9.5 Respiratory rate (per minute)

The respiratory rate in Group A animals ranged from 16.00 ± 0.44 to 19.33 ± 0.95 and in Group B animals ranged from 31.33 ± 0.66 to 35.50 ± 1.31.

Fig. 55: Photograph showing excised vetricle on first week (Group B)

Fig. 56: Photograph showing wound healing on second week (Group B)

Fig. 57: Photograph showing endoscopic view of airway during third week (Group B)

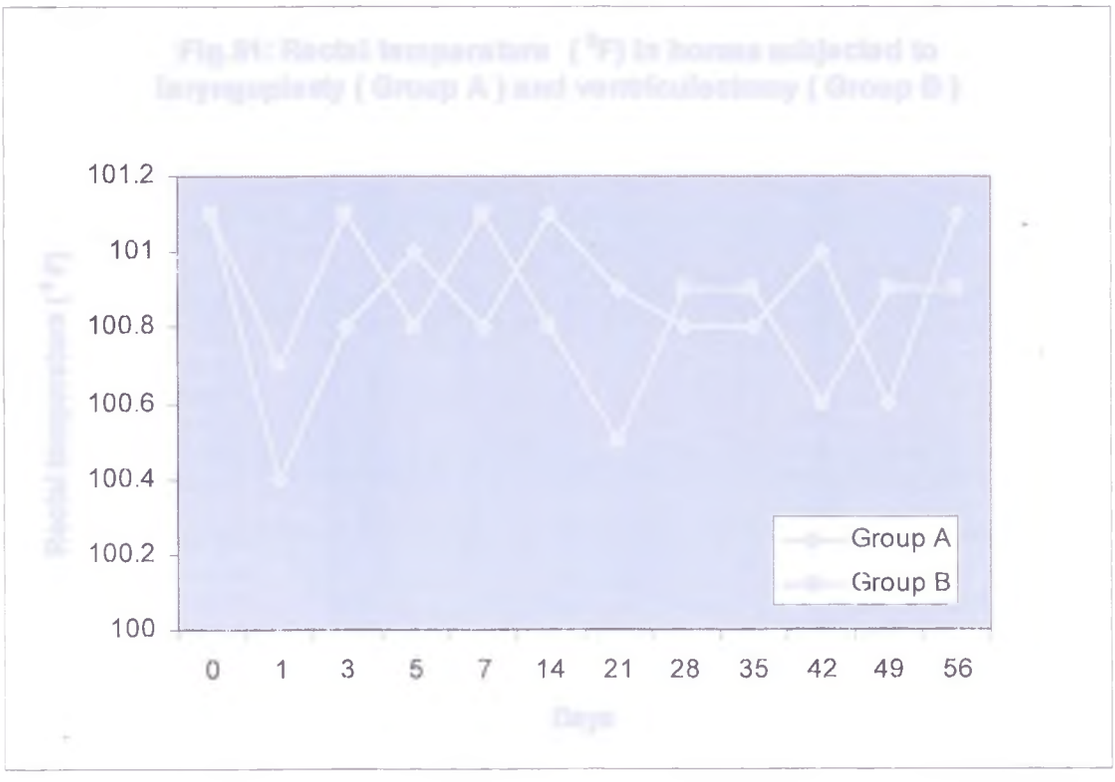
Fig. 58: Photograph showing wound healing on fourth week (Group B)

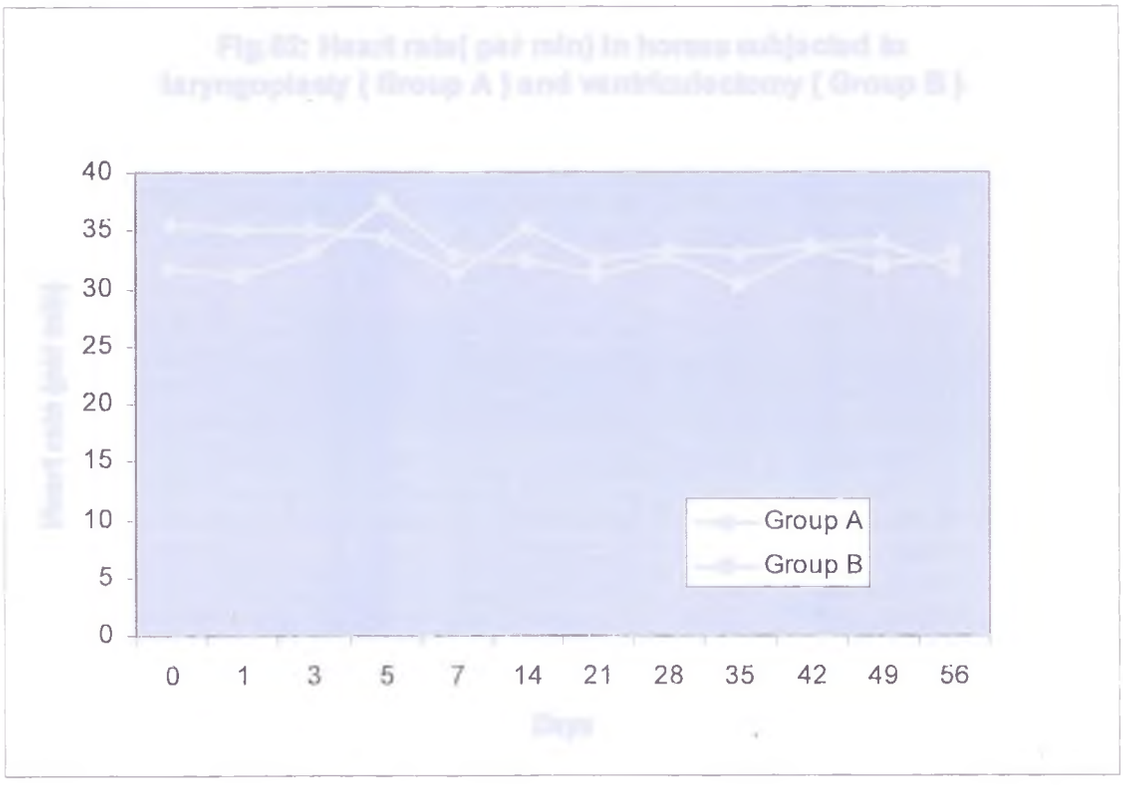
Fig. 59: Photograph showing endoscopic view of larynx and epiglotis on fifth week

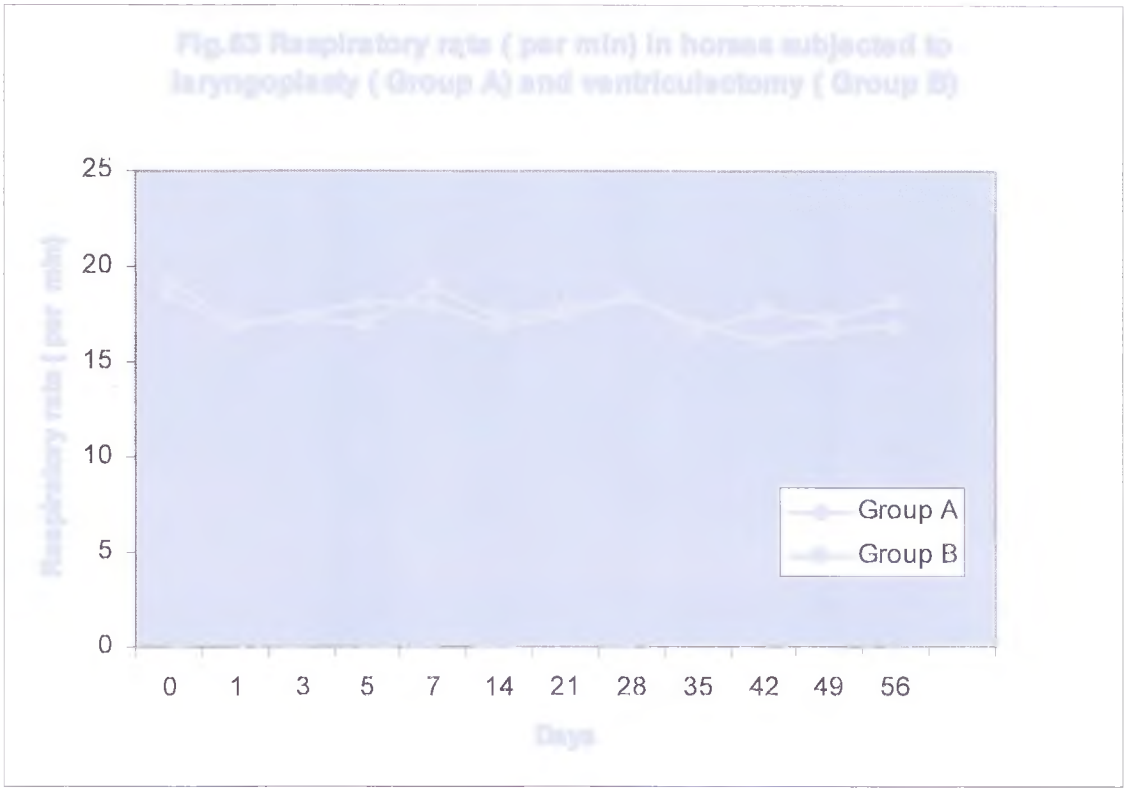
Fig. 60 Photograph showing good airway on sixth week (Group B)

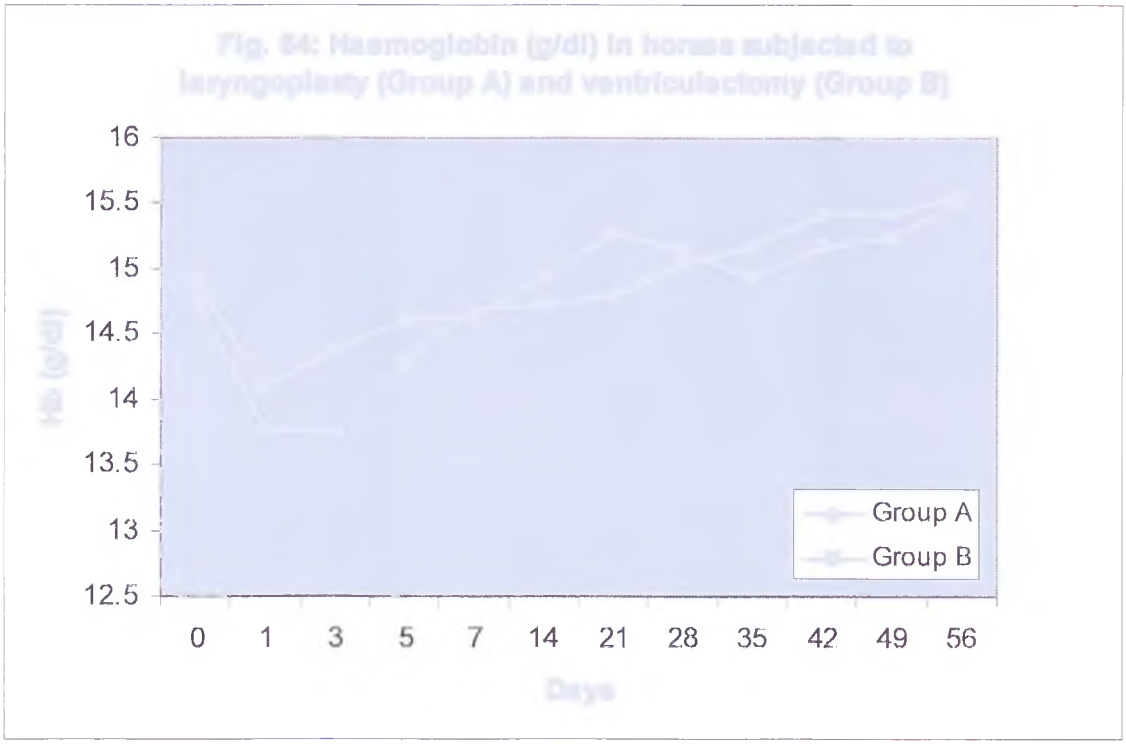
Table 2. Temperature, respiratory rate and heart rate (Mean±SE) in horses subjected to laryngoplasty (Group A) and ventriculectomy (Group B)

Intervals	Temperature (° F)		Respiratory rate (per min)		Heart rate (per min)	
	Group A	Group B	Group A	Group B	Group A	Group B
0 day	101.1 ± 0.13	101.1 ± 0.12	19.33 ± 0.95	18.50 ± 0.718	35.50 ± 1.31	31.67 ± 0.61
1 day	100.4 ± 0.20	100.7 ± 0.15	17.00 ± 0.73	16.83 ± 0.54	35.00 ± 1.61	31.00 ± 1.43
3 days	100.8 ± 0.15	101.1 ± 0.06	17.50 ± 0.56	17.33 ± 0.66	35.00 ± 1.61	33.00 ± 1.34
5 days	101.0 ± 0.09	100.8 ± 0.10	18.17 ± 0.54	17.00 ± 0.44	34.33 ± 1.49	37.33 ± 0.42
7 days	100.8 ± 0.09	101.1 ± 0.08	18.00 ± 0.57	19.00 ± 0.68	31.33 ± 0.66	32.67 ± 1.68
14 days	101.1 ± 0.12	100.8 ± 0.06	16.83 ± 0.54	17.33 ± 0.33	35.17 ± 1.51	32.33 ± 1.20
21 days	100.9 ± 0.17	100.5 ± 0.12	17.50 ± 0.71	17.83 ± 0.60	32.33 ± 0.80	31.00 ± 0.85
28 days	100.8 ± 0.19	100.9 ± 0.13	18.33 ± 0.66	18.50 ± 0.88	33.33 ± 1.52	32.67 ± 2.40
35 days	100.8 ± 0.08	100.9 ± 0.06	17.00 ± 0.81	16.67 ± 0.42	33.00 ± 1.34	30.33 ± 0.61
42 days	101.0 ± 0.14	100.6 ± 0.13	16.00 ± 0.44	17.67 ± 0.33	33.67 ± 1.49	33.33 ± 1.52
49 days	100.6 ± 0.23	100.9 ± 0.08	16.67 ± 0.42	17.17 ± 0.40	34.00 ± 1.54	32.00 ± 1.26
56 days	101.1 ± 0.09	100.9 ± 0.11	16.83 ± 0.79	18.17 ± 0.83	31.67 ± 1.30	33.00 ± 1.61


101.2
101
100.8
100.6
100.4
100.2
100
0 1 3 5 7 14 21 28 35 42 49 56
Group A
Group B


40
35
30
25
20
15
10
5
0
0 1 3 5 7 14 21 28 35 42 49 56
Group A
Group B


25
20
15
10
5
0
Group A
Group B
0 1 3 5 7 14 21 28 35 42 49 56
Days


16
15.5
15
14.5
14
13.5
13
12.5
Group A
Group B
0 1 3 5 7 14 21 28 35 42 49 56
Days

There were no significant changes in respiratory rate both within the groups and in between the groups (Table 2, Fig 63).

4.10 HAEMATOLOGICAL STUDIES

4.10.1 Haemoglobin (g/dl)

In Group A animals, the haemoglobin level prior to surgical procedure was 14.75 ± 0.46. The post-operative hemoglobin level ranged from 13.77 ± 0.40 to 15.43 ± 0.48. No statistically significant variation was found within or between the groups. The values were within the normal range.

In Group B animals, the haemoglobin level prior to surgical procedure was 14.90 ± 0.73. The post-operative hemoglobin level ranged from 14.10 ± 0.66 to 15.53 ± 0.67. No statistically significant variation was found within or between the groups. The values were within the normal range.

The mean values of haemoglobin was determined at 0,1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 3 and graphically depicted in Fig 64.

4.10.2 Total erythrocyte count (millions/cmm)

In Group A, the total erythrocyte count (TEC) prior to surgical procedure was 9.392 ± 0.22 (Mean ± SE). The post-operative mean ± SE values of TEC ranged from 8.990 ± 0.16 to 9.392 ± 0.22. No statistically significant variation was found within or between the groups. The values were within the normal range.

In Group B, the TEC prior to surgical procedure was 8.955 ± 0.32. The post-operative TEC ranged from 8.558 ± 0.24 to 9.330 ± 0.17. No statistically significant variation was found within or between

Table 3. Total erythrocyte count, packed cell volume hemoglobin and total leucocyte count (Mean±SE) in horses subjected to laryngoplasty (Group A) and ventriculectomy (Group B)

Intervals	TEC (million/ cmm)		Packed cell volume (%)		Hemoglobin (g/dl)		Leucocytes (thousand/cmm)	
	Group A	Group B	Group B	Group B	Group A	Group B	Group A	Group B
0 day	9.392 ± 0.22	8.955 ± 0.32	45.68 ± 2.45	44.78 ± 1.61	14.75 ± 0.46	14.90 ± 0.73	8.950 ± 0.43	9.300 ± 0.80
1 day	8.990 ± 0.16	8.558 ± 0.24	42.17 ± 2.31	42.67 ± 1.60	13.77 ± 0.40	14.10 ± 0.66	9.183 ± 0.36	9.833 ± 0.80
3 days	9.010 ± 0.16	8.500 ± 0.23	42.17 ± 2.02	42.83 ± 1.54	13.74 ± 0.36	14.37 ± 0.65	9.153 ± 0.34	9.833 ± 0.82
5 days	9.067 ± 0.16	8.567 ± 0.30	43.67 ± 2.02	43.33 ± 1.70	14.30 ± 0.41	14.60 ± 0.68	9.003 ± 0.35	10.00 ± 0.77
7 days	9.392 ± 0.22	8.633 ± 0.24	45.50 ± 2.46	44.67 ± 1.78	14.70 ± 0.58	14.63 ± 0.76	8.933 ± 0.36	10.07 ± 0.70
14 days	9.300 ± 0.14	9.053 ± 0.19	45.17 ± 2.5	44.27 ± 1.55	14.73 ± 0.48	14.93 ± 0.69	9.133 ± 0.36	9.800 ± 0.58
21 days	9.392 ± 0.22	8.987 ± 0.12	45.00 ± 2.11	44.67 ± 1.60	14.80 ± 0.43	15.27 ± 0.68	9.133 ± 0.37	9.733 ± 0.50
28 days	9.190 ± 0.10	9.133 ± 0.15	46.67 ± 1.98	44.17 ± 2.05	15.03 ± 0.44	15.13 ± 0.63	9.100 ± 0.37	10.07 ± 0.51
35 days	9.253 ± 0.11	8.967 ± 0.21	46.67 ± 1.83	45.17 ± 1.64	15.17 ± 0.47	14.93 ± 0.62	9.067 ± 0.36	9.933 ± 0.56
42 days	9.353 ± 0.06	9.223 ± 0.16	47.50 ± 2.26	44.47 ± 1.37	15.43 ± 0.48	15.17 ± 0.74	9.333 ± 0.34	9.800 ± 0.53
49 days	9.340 ± 0.10	9.330 ± 0.17	48.60 ± 2.55	48.00 ± 2.12	15.43 ± 0.48	15.23 ± 0.67	9.197 ± 0.27	9.833 ± 0.51
56 days	9.337 ± 0.08	9.393 ± 0.15	49.33 ± 2.14	46.83 ± 2.42	15.56 ± 0.48	15.53 ± 0.67	9.233 ± 0.34	9.900 ± 0.56

the groups. The values were within the normal range. The difference between Group A and B was statistically not significant.

The mean values of total erythrocyte count determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 3 and graphically depicted in Fig 65.

4.10.3 Packed cell volume (%).

In Group A, prior to surgical procedure packed cell volume was 45.68 ± 2.45. The post-operative packed cell volume ranged from 42.17 ± 2.31 to 49.33 ± 2.14. No statistically significant variation was found within or between the groups. The values were within the normal range.

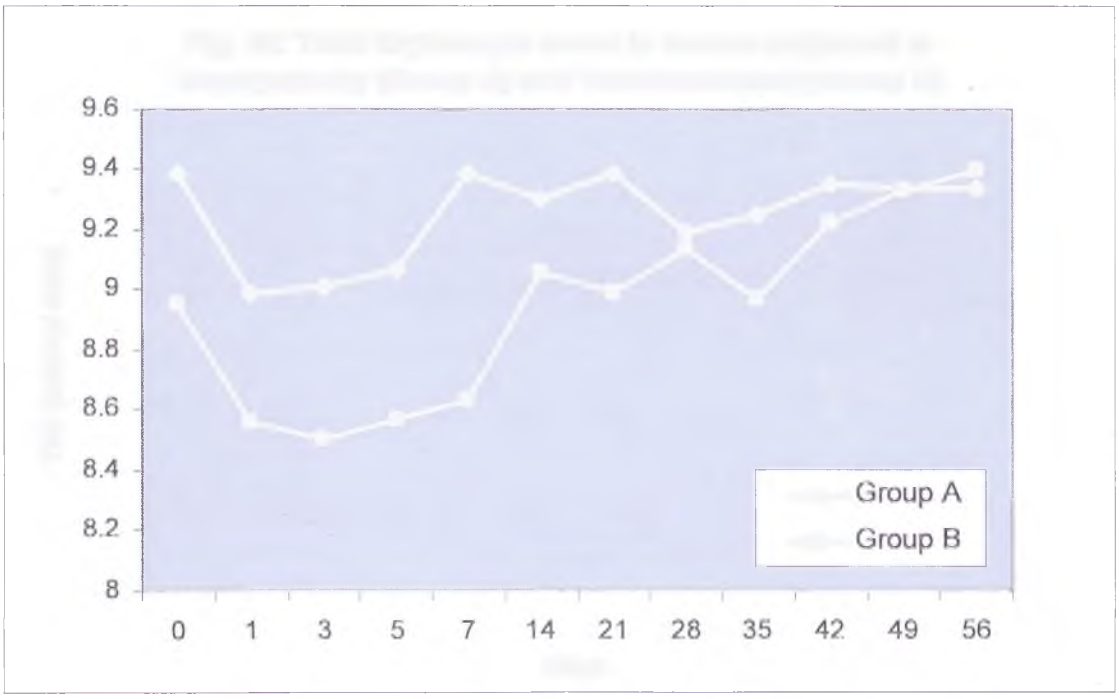
In Group B, the packed cell volume prior to surgical procedure was 44.78 ± 1.61. The post operative packed cell volume ranged from 42.67 ± 1.60 to 48.00 ± 2.12. No statistically significant variation was found within or between the groups. The values were within the normal range.

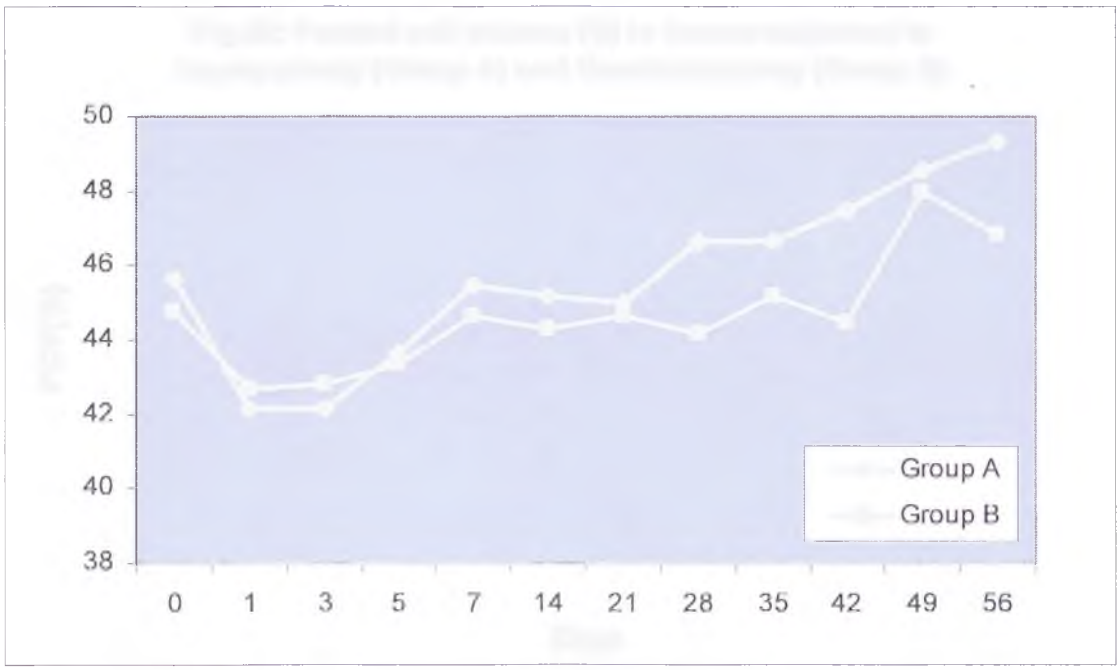
The mean values of total erythrocyte count determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 3 and graphically depicted in Fig 66.

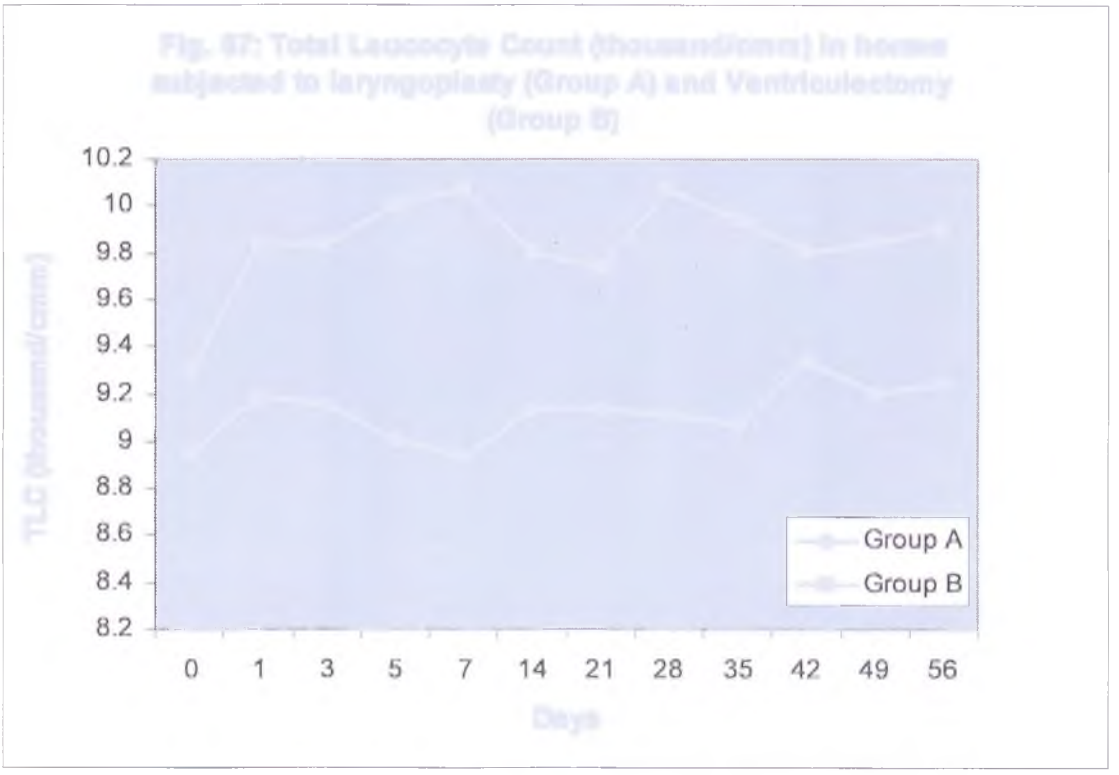
4.10.4 Total leucocyte count (thousands/cmm)

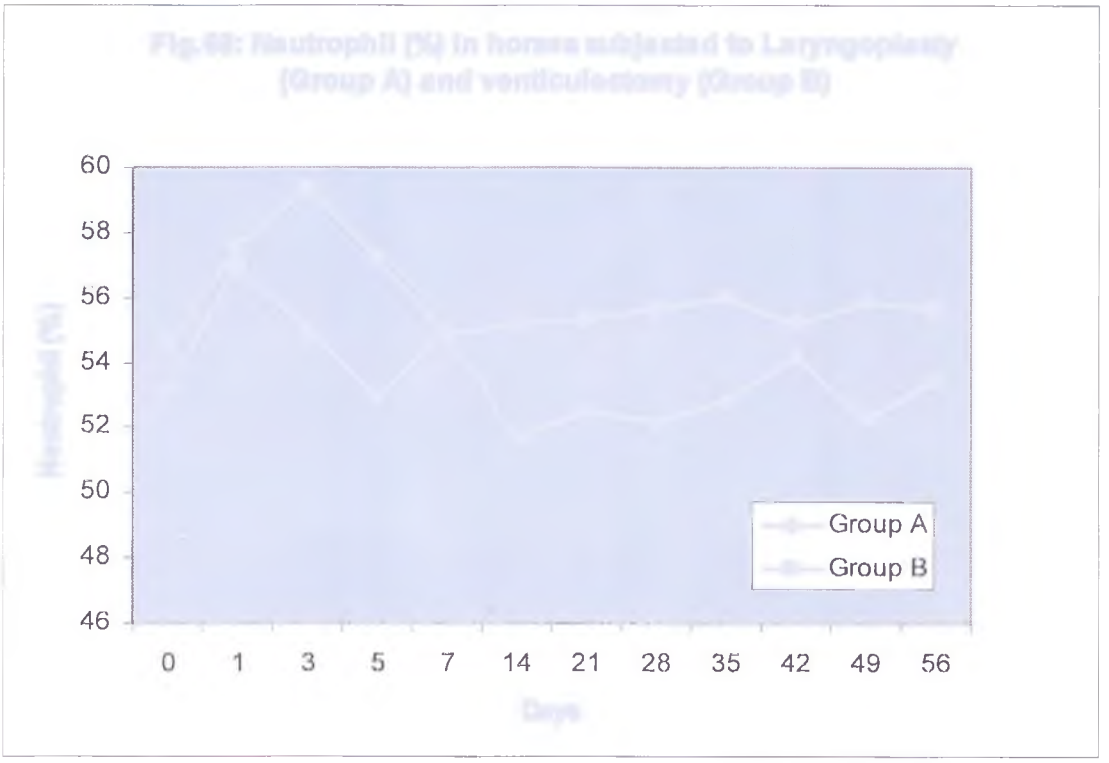
In Group A, the total leucocyte count (TLC) prior to surgical procedure was 8.950 ± 0.43. The post-operative TLC ranged from 8.933 ± 0.36 to 9.333 ± 0.34. No statistically significant variation was found within or between the groups in post-operative days.

In Group B, the TLC prior to surgical procedure was 9.300 ± 0.80 the post-operative TLC ranged from 9.833 ± 0.80 to 10.07 ± 0.70.


9.6
9.4
9.2
9
8.8
8.6
8.4
8.2
8
0
1
3
5
7
14
21
28
35
42
49
56
Group A
Group B


50
48
46
44
42
40
38
0
1
3
5
7
14
21
28
35
42
49
56
Group A
Group B


10.2
10
9.8
9.6
9.4
9.2
9
8.8
8.6
8.4
8.2
0
1
3
5
7
14
21
28
35
42
49
56
Group A
Group B


60
58
56
54
52
50
48
46
0
1
3
5
7
14
21
28
35
42
49
56
Group A
Group B

No statistically significant variation was found within or between the groups.

The mean values of total leucocyte count determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 3 and graphically depicted in Fig 67.

4.10.5 Differential leucocyte count

4.10.5.1 Neutrophil (%)

In Group A, the pre-operative neutrophil count was 53.17 ± 1.57. Post-operatively neutrophils were found to increased on 1st post-operative day (57.00 ± 1.23) which later came down to 51.67 ± 0.66 by 2nd post-operative week. No statistically significant variation was found within or between the groups in post-operative neutrophil count.

In Group B, the mean neutrophil count prior to surgical procedure was 54.50 ± 3.13. The post-operative neutrophil count was found to increased on 3rd post-operative day, (59.33 ± 2.36) which later came down to 55.17 ± 1.90 by 2nd post-operative week. No statistically significant variation was found within or between the groups.

Even though the changes were found to be statistically significant within groups ($P \leq 0.05$), it was not significant between groups.

The mean values of neutrophils determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 4 and graphically depicted in Fig 68.

4.10.5.2 Lymphocyte (%)

In Group A, the mean lymphocyte count prior to surgical procedure was 44.67 ± 3.57. The post-operative lymphocyte count

Table 4. Differential Leucocytes count (Mean±SE) in horses subjected to laryngoplasty (Group A) and ventriculectomy (Group B)

Intervals	Neutrophil		Lymphocyte		Monocyte		Eosinophil		Basophil	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
0 day	53.17 ± 1.57	54.50 ± 3.13	44.67 ± 3.57	47.17 ± 3.63	3.500 ± 1.19	1.500 ± 0.50	3.000 ± 0.83	3.500 ± 1.19	1.500 ± 0.50	1.500 ± 0.50
1 day	57.00 ± 1.23	57.50 ± 2.63	39.50 ± 1.08	37.00 ± 2.11	1.833 ± 0.30	1.500 ± 0.22	1.000 ± 0.36	1.833 ± 0.74	0.6667 ± 0.33	0.1667 ± 0.16
3 days	55.00 ± 0.85	59.33 ± 2.36	41.33 ± 1.30	37.00 ± 1.91	2.500 ± 0.42	2.000 ± 0.25	1.167 ± 0.40	1.000 ± 0.51	0.1667 ± 0.16	0.6667 ± 0.33
5 days	53.00 ± 0.85	57.17 ± 2.34	42.67 ± 0.42	40.50 ± 1.45	1.833 ± 0.54	1.000 ± 0.25	1.667 ± 0.42	2.333 ± 0.42	0.6667 ± 0.42	0.6667 ± 0.33
7 days	55.00 ± 0.85	54.83 ± 2.16	41.33 ± 0.66	37.67 ± 2.49	2.167 ± 0.16	2.667 ± 0.33	2.167 ± 0.54	2.333 ± 0.49	1.000 ± 0.44	1.500 ± 0.22
14 days	51.67 ± 0.66	55.17 ± 1.90	41.33 ± 1.82	40.17 ± 1.32	3.167 ± 0.40	1.833 ± 0.30	2.500 ± 0.34	1.333 ± 0.49	0.3333 ± 0.21	1.167 ± 0.40
21 days	52.50 ± 0.88	55.33 ± 1.90	42.00 ± 0.73	39.17 ± 1.68	2.667 ± 0.49	1.833 ± 0.40	2.333 ± 0.33	2.000 ± 0.51	0.5000 ± 0.34	1.333 ± 0.33
28 days	52.17 ± 0.94	55.67 ± 2.31	41.33 ± 0.49	40.33 ± 2.66	3.333 ± 0.55	1.167 ± 0.30	2.000 ± 0.57	1.500 ± 0.56	0.8333 ± 0.30	0.6667 ± 0.33
35 days	52.83 ± 1.04	56.00 ± 2.40	42.50 ± 1.02	38.00 ± 2.25	2.500 ± 0.42	2.000 ± 0.57	1.500 ± 0.56	1.833 ± 0.40	0.6667 ± 0.21	1.000 ± 0.36
42 days	54.17 ± 0.83	55.17 ± 1.86	41.17 ± 0.65	38.67 ± 2.34	1.167 ± 0.40	2.500 ± 0.61	1.500 ± 0.50	2.167 ± 0.40	1.000 ± 0.25	0.8333 ± 0.40
49 days	52.33 ± 1.05	55.83 ± 1.27	43.00 ± 0.89	38.33 ± 1.38	1.500 ± 0.34	2.000 ± 0.51	2.167 ± 0.16	1.167 ± 0.47	1.000 ± 0.36	0.6667 ± 0.33
56 days	53.50 ± 1.20	55.67 ± 2.49	41.83 ± 0.65	41.00 ± 1.93	1.667 ± 0.66	1.167 ± 0.40	1.833 ± 0.40	0.6667 ± 0.42	0.8333 ± 0.40	0.6667 ± 0.42

ranged from 39.50 ± 1.08 to 43.00 ± 0.89. No statistically significant variation was found within or between the groups in lymphocyte count in post-operative period. The values were within the normal range.

In Group B, the mean lymphocyte count prior to surgical procedure was 42.17 ± 3.6. The post-operative lymphocyte count ranged from 37.00 ± 1.91 to 40.50 ± 1.45. No statistically significant variation was found within or between the groups in lymphocyte count in post-operative period. The values were within the normal range.

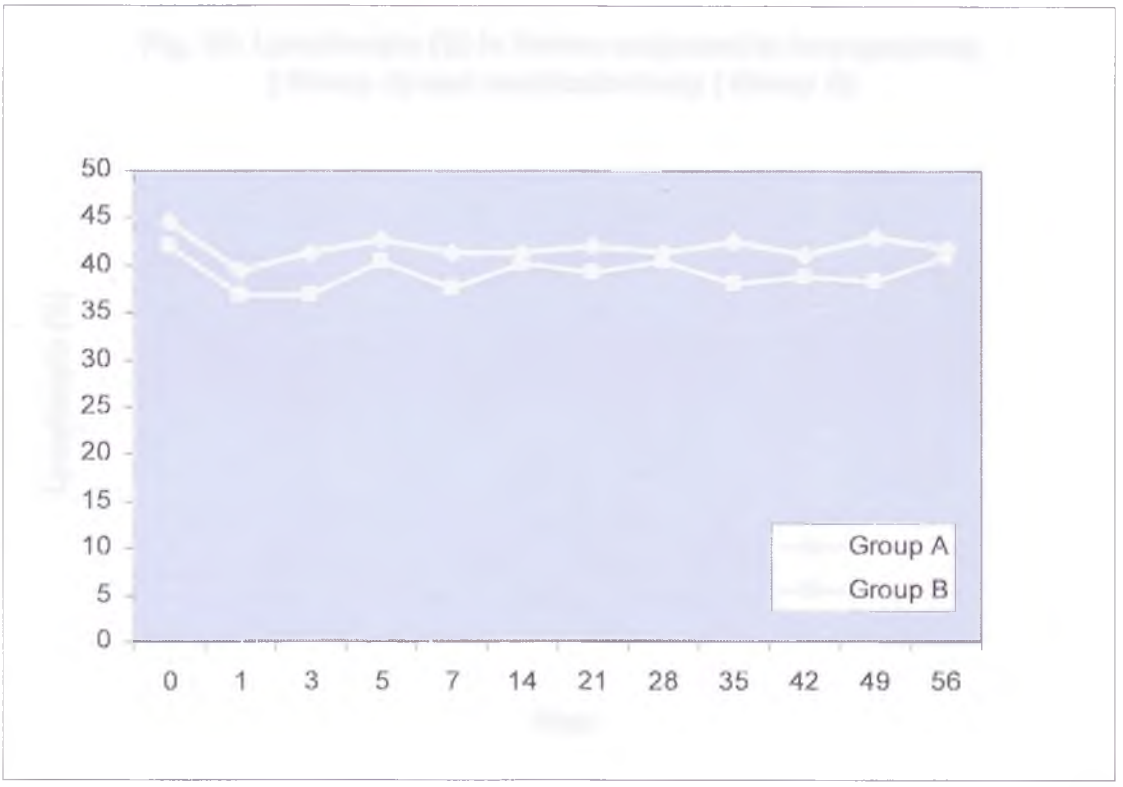
The mean percentage of lymphocyte count determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 4 and graphically depicted in Fig 69.

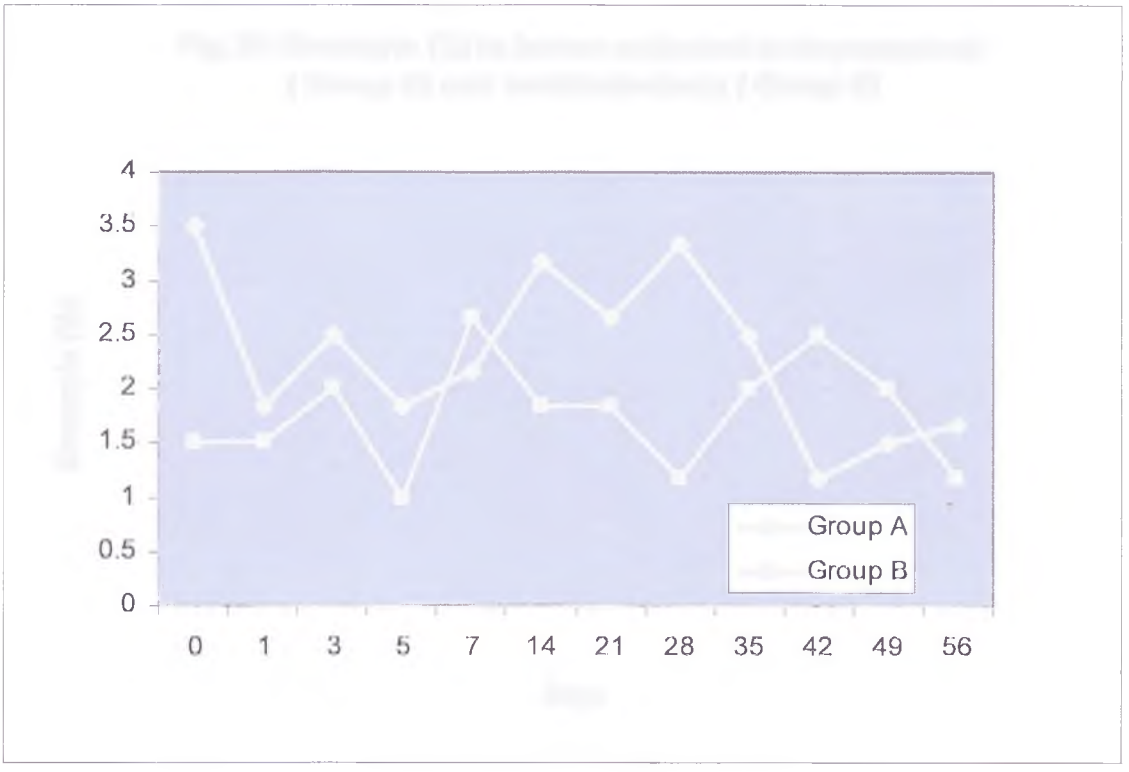
4.10.5.3 Monocyte (%)

In Group A, the monocyte count prior to surgical procedure was 3.500 ± 1.19. The post-operative monocyte count ranged from 1.500 ± 0.34. to 3.333 ± 0.55. No statistically significant variation was found within or between the groups. The values were within the normal range.

In Group B, the monocyte count prior to surgical procedure was 1.500 ± 0.50. The post-operative monocyte count ranged from 1.167 ± 0.40 to 2.667 ± 0.33. No statistically significant variation was found within or between the groups. The values were within the normal range.

Mean values of monocyte count determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 4 and graphically depicted in Fig 70.


50
45
40
35
30
25
20
15
10
5
0
0
1
3
5
7
14
21
28
35
42
49
56
Group A
Group B


4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
3
5
7
14
21
28
35
42
49
56
Group A
Group B

4.10.5.4 Eosinophil (%)

In Group A, the eosinophil count prior to surgical procedure was 3.000 ± 0.83. The post-operative eosinophil count ranged from 1.000 ± 0.36 to 2.500 ± 0.34. No statistically significant variation was found within or between the groups. The values were within the normal range.

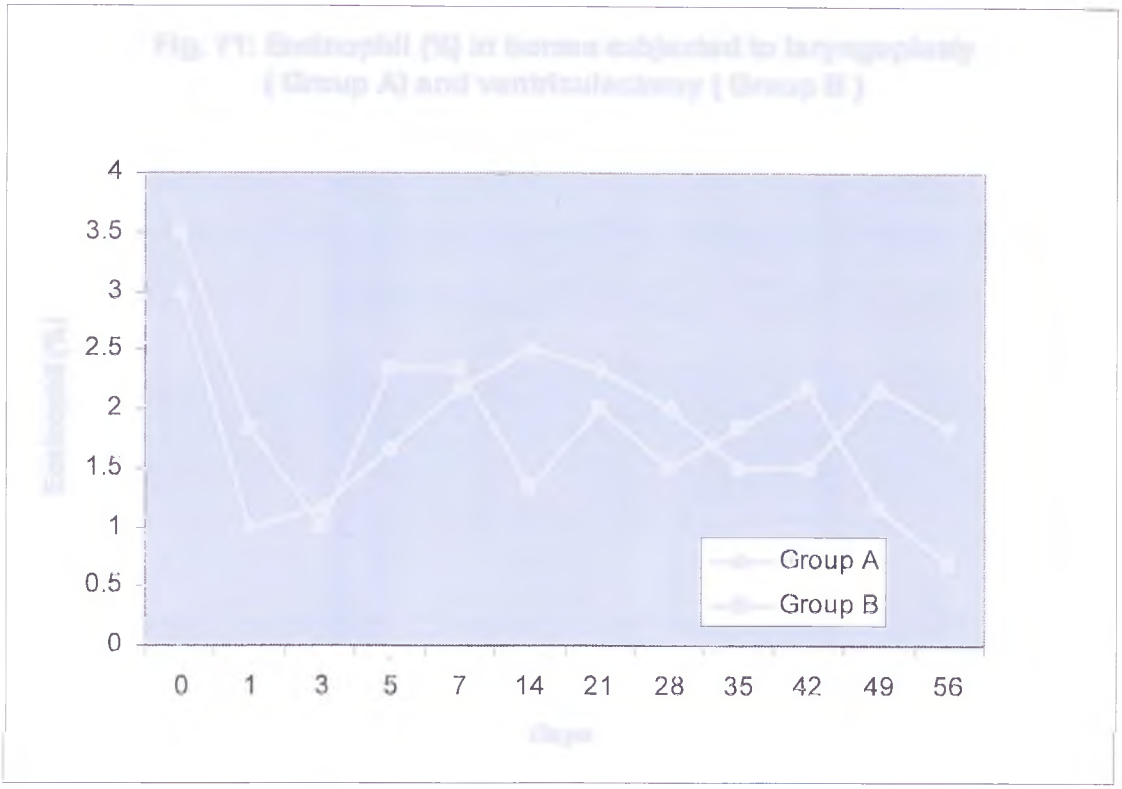
In Group B, the eosinophil count prior to surgical procedure was 3.500 ± 1.19. The post-operative eosinophils count ranged from 0.6667 ± 0.42 to 2.333 ± 0.42. No statistically significant variation was found within or between the groups. The values were within the normal range.

The mean values of eosinophils determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 4 and graphically depicted in Fig 71.

4.10.5.5 Basophil (%)

In Group A, the basophils count prior to surgical procedure was 1.500 ± 0.50. The post-operative basophils count ranged from 0.1667 ± 0.16 to 1.000 ± 0.36. No statistically significant variation was found within or between the groups. The values were within the normal range

In Group B, the basophils count prior to surgical procedure was 1.500 ± 0.50. The post-operative basophils count ranged from 0.1667 ± 0.16 to 1.333 ± 0.33. No statistically significant variation was found within or between the groups. The values were within the normal range.


4
3.5
3
2.5
2
1.5
1
0.5
0
0 1 3 5 7 14 21 28 35 42 49 56
Group A
Group B

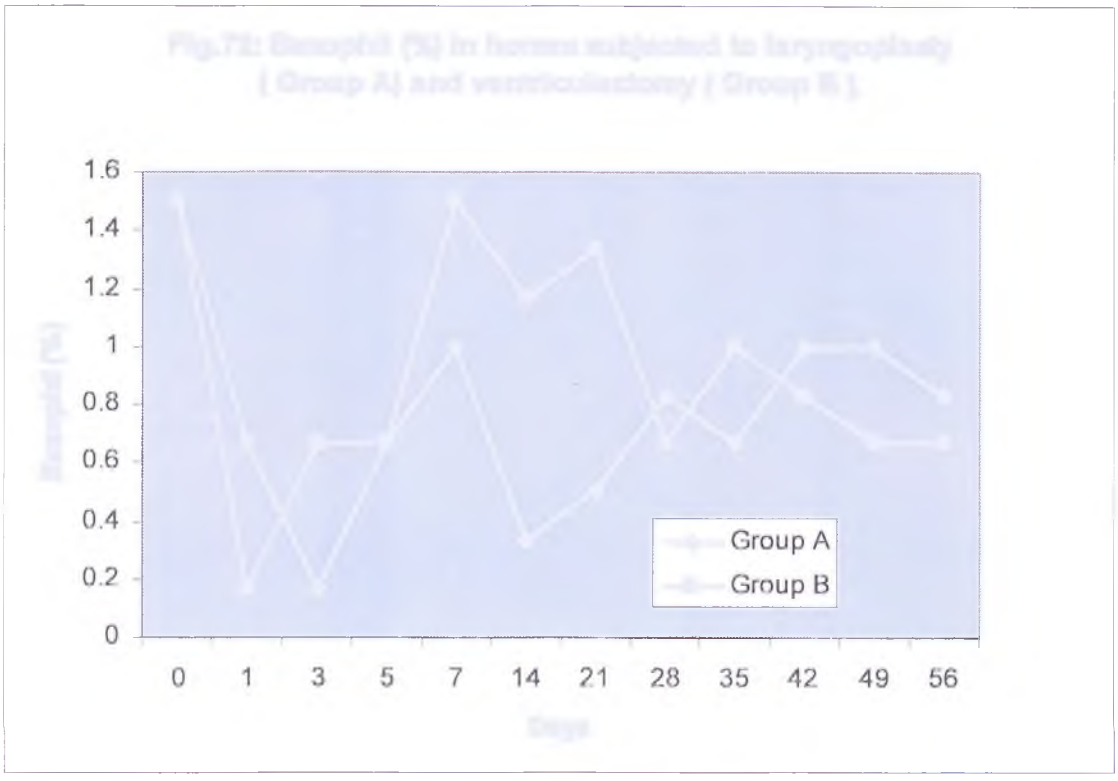

1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 1 3 5 7 14 21 28 35 42 49 56
Group A
Group B

Table 5. Biochemical parameters (Mean±SE) in horses subjected to laryngoplasty (Group A) and ventriculectomy (Group B)

Intervals	ALT(IU/L)		AST(IU/L)		Creatinine (mg /dl)		ALP (IU/L)	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
0 day	12.95 ± 1.12	14.23 ± 1.71	324.7 ± 24.03	352.2 ± 39.24	1.217 ± 0.11	1.300 ± 0.09	106.7 ± 11.73	152.3 ± 20.37
1 day	15.20 ± 0.88	15.75 ± 1.69	321.3 ± 19.67	360.0 ± 31.96	1.433 ± 0.08	1.417 ± 0.07	132.2 ± 12.91	156.7 ± 20.99
3 days	15.32 ± 0.74	16.12 ± 1.54	321.0 ± 19.87	359.7 ± 31.36	1.417 ± 0.07	1.467 ± 0.08	142.3 ± 12.67	155.8 ± 20.39
5 days	13.95 ± 0.66	16.28 ± 1.61	321.2 ± 22.82	357.0 ± 29.61	1.233 ± 0.04	1.317 ± 0.06	138.8 ± 10.79	161.5 ± 20.49
7 days	13.72 ± 0.66	15.73 ± 1.53	318.0 ± 20.78	356.7 ± 32.70	1.167 ± 0.05	1.283 ± 0.05	135.5 ± 9.61	159.3 ± 18.35
14 days	13.57 ± 0.50	15.23 ± 1.61	320.5 ± 20.12	347.3 ± 34.78	1.117 ± 0.05	1.083 ± 0.03	124.8 ± 7.67	161.8 ± 16.26
21 days	12.90 ± 0.53	15.00 ± 1.46	325.0 ± 21.29	342.3 ± 32.32	1.050 ± 0.05	1.017 ± 0.04	118.0 ± 5.99	160.8 ± 14.46
28 days	12.50 ± 0.54	15.15 ± 1.51	320.3 ± 19.73	338.0 ± 32.98	1.083 ± 0.04	0.9833 ± 0.03	112.5 ± 5.98	159.0 ± 14.63
35 days	12.02 ± 0.57	15.20 ± 1.39	324.7 ± 20.88	334.0 ± 29.22	1.133 ± 0.02	0.9667 ± 0.04	102.8 ± 6.13	161.3 ± 15.88
42 days	12.58 ± 0.67	15.22 ± 1.49	323.7 ± 20.64	328.3 ± 26.14	1.117 ± 0.04	1.083 ± 0.04	102.7 ± 6.64	153.5 ± 12.82
49 days	11.97 ± 0.49	15.22 ± 1.40	325.7 ± 20.37	336.3 ± 29.21	1.000 ± 0.05	0.9333 ± 0.03	101.8 ± 4.23	150.7 ± 12.61
56 days	11.48 ± 0.53	15.28 ± 1.41	324.7 ± 20.48	339.3 ± 28.48	1.100 ± 0.02	1.083 ± 0.03	102.5 ± 7.23	152.5 ± 13.43

The mean values of basophils determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 4 and graphically depicted in Fig 72.

4.10.6 Biochemical studies

4.10.6.1 Alanine Amino Transferance (ALT) (IU/L).

In Group A, the Mean ± SE values of ALT prior to surgical procedure was 12.95 ± 1.12. The post-operative value ranged from 11.48 ± 0.53 to 15.20 ± 0.88. No statistically significant variation was found within or between the groups. The values were within the normal range.

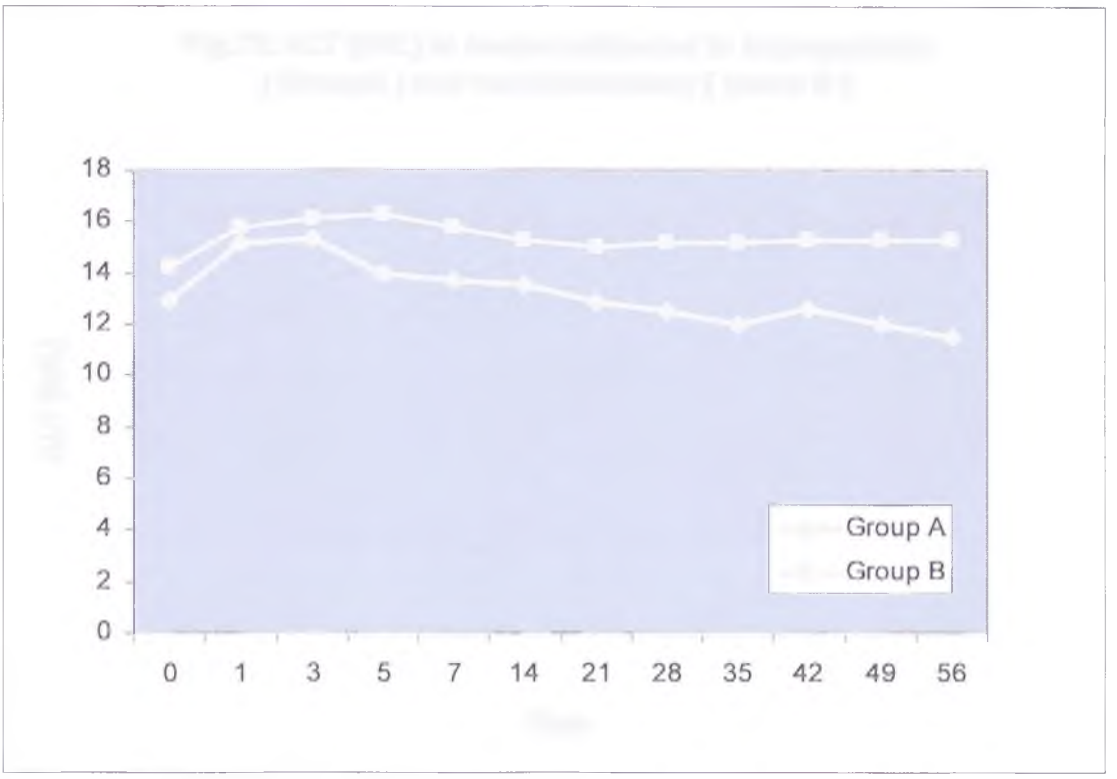
In Group B, the Mean ± SE value of ALT prior to surgical procedure was 14.23 ± 1.71. The post operative values ranged from 15.00 ± 1.46 to 16.28 ± 1.61. No significant difference was noticed in post-operative days. There was no significant difference between the Group A and B.

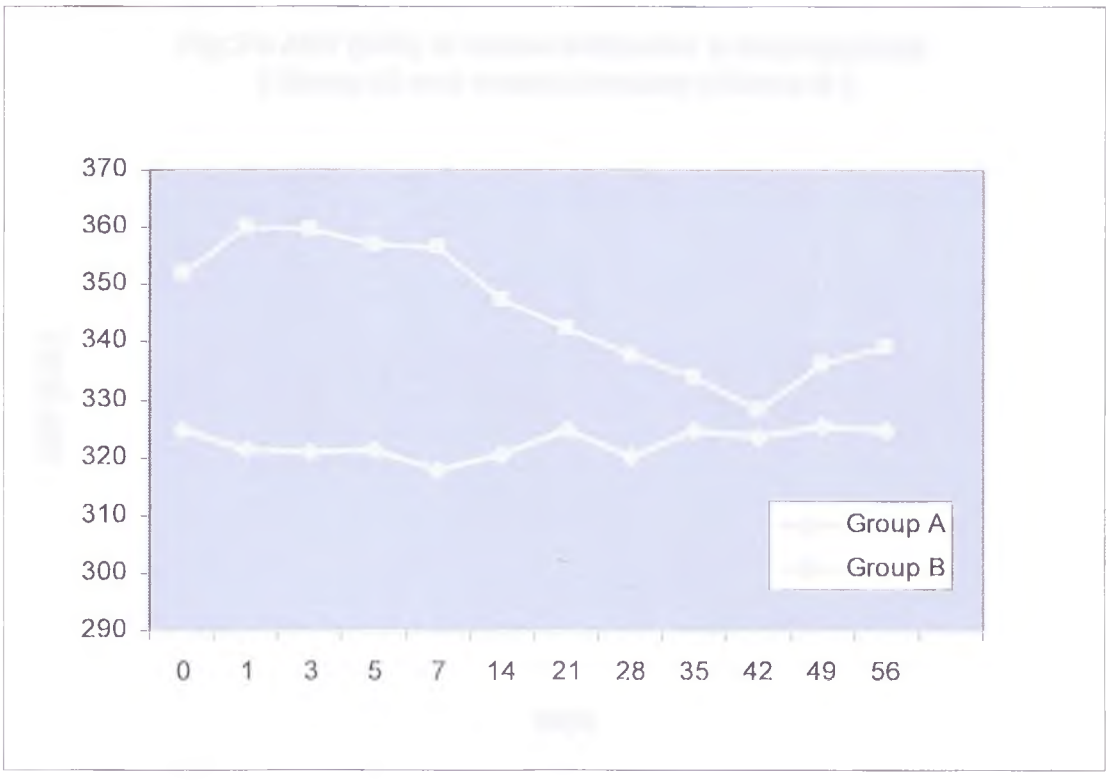
The mean values of ALT determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 5. and graphically depicted in Fig 73.

4.10.6.2 Aspartate amino Transferance (AST) (IU/L).

In Group A, the Mean ± SE value of AST prior to surgical procedure was 324.7 ± 24.03. The post-operative values ranged from 318.0 ± 20.78 to 325.7 ± 20.37. No statistically significant variation was found within or between the groups. The values were within the normal range.

In Group B, the Mean ± SE values AST prior to surgical procedure was 352.2 ± 39.24. The post-operative values ranged from


18
16
14
12
10
8
6
4
2
0
0 1 3 5 7 14 21 28 35 42 49 56
Group A
Group B


370
360
350
340
330
320
310
300
290
0 1 3 5 7 14 21 28 35 42 49 56
Group A
Group B

328.3 ± 26.14 to 360.0 ± 31.96. No significant difference was noticed in post-operative days. There was no significant difference between the Group A and B.

The mean values of AST determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 5 and graphically depicted in Fig 74.

4.10.6.3 Creatinine (mg/dl).

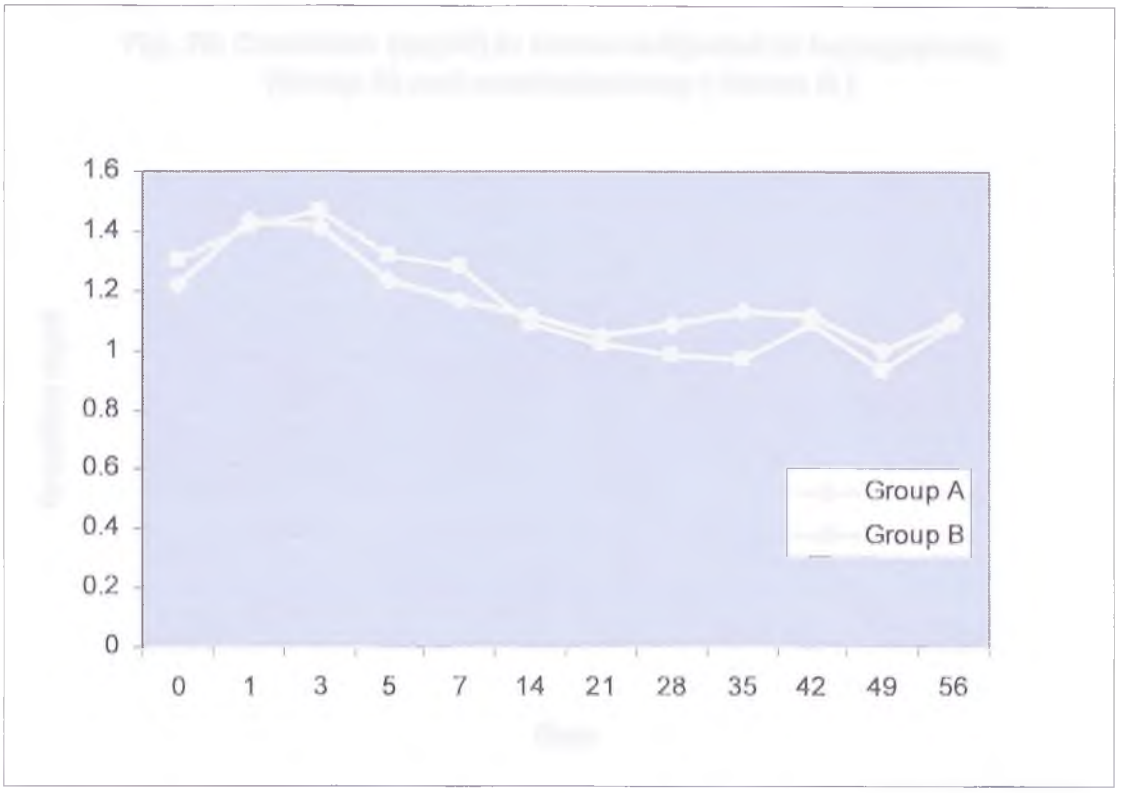
In Group A, the Mean ± SE values of creatinine prior to surgical procedure was 1.217 ± 0.11. The post-operative values ranged from 1.000 ± 0.05 to 1.433 ± 0.08. No statistically significant variation was found within or between the groups. The values were within the normal range.

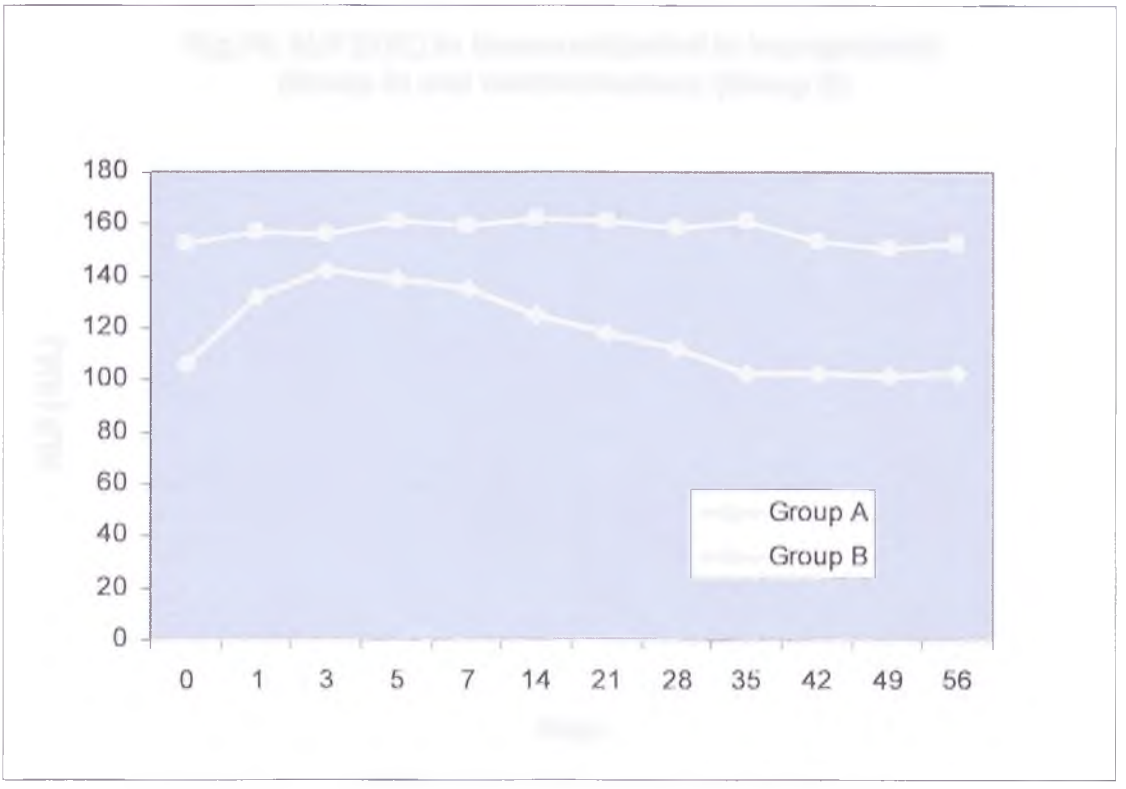
In Group B, the Mean ± SE values of creatinine prior to surgical procedure was 1.300 ± 0.09. The post-operative values ranged from 0.9667 ± 0.04 to 1.467 ± 0.08. No significant difference was noticed in post-operative days. There was no significant difference between the Group A and B.

The mean values of creatinine determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 5 and graphically depicted in Fig 75.

4.10.6.4 Alkaline Phosphatase (ALP) (IU/L).

In Group A, the Mean ± SE values of ALP prior to surgical procedure was 106.7 ± 11.73. The post-operative values ranged from 101.8 ± 4.23 to 142.3 ± 12.67. No statistically significant variation was found within or between the groups. The values were within the normal range


1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 1 3 5 7 14 21 28 35 42 49 56
Group A
Group B


180
160
140
120
100
80
60
40
20
0
0 1 3 5 7 14 21 28 35 42 49 56
Group A
Group B

In Group B, the Mean ± SE values of ALP prior to surgical procedure was 152.3 ± 20.37. The post-operative values ranged from 150.7 ± 12.61 to 161.8 ± 16.26. No significant difference was noticed in post-operative days. There was no significant difference in between the Group A and B.

The mean values of ALP determined at 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49 and 56th day in Group A and B animals are given in Table 5 and graphically depicted in Fig. 76.

Discussion

5.0 DISCUSSION

In the present study, the two techniques *viz.,* laryngoplasty and ventriculectomy were compared in 12 horses with Grade III or Grade IV laryngeal hemiplegia, and the findings are discussed below.

5.1 OCCURENCE OF LARYNGEAL HEMIPLEGIA

In the present study, overall occurrence of laryngeal hemiplegia was found to be 12.63 per cent. The occurrence of three to eight per cent was reported by Cook (1974), Raphel (1982) and Hillidge (1986). It was found that left laryngeal hemiplegia was more common than right laryngeal hemiplegia. This may be because the left recurrent laryngeal nerve is longer than the right recurrent laryngeal nerve, which could have affected the axonic transmission as discussed by Auer and Stick (1992) and Griffiths (1996).

The incidence was found more in three year old horses (40.65%). Goulden *et al.* (1983) also noticed highest incidence in younger horses. Laryngeal hemiplegia has been recognized as a common problem and it said to occur mainly in horses between five to nine years old (Hall *et al.*, 1990, King *et al.*, 1994, Christley *et al.*, 1997, Strand *et al.* 2000).

In the present study, horses aged three to eight years were only studied, because in India horses between two to eight years are only allowed to race by Turf Authority of India. Even though comparison of the prevalence of lesions in male and female horses revealed no predisposition of the condition in either sex, in the present study 57.52 per cent of the animals with laryngeal hemiplegia were males.

In the present study, occurrence of Grade I was more (69.05 %) followed by Grade II (20.97%), Grade III (8.30%) and Grade IV (1.69%). However, Hawkins *et al.* (1997) reported a 1 per cent incidence of Grade

II, 47 per cent were of Grade III and 52 percent of Grade IV. Benson *et al* (2000) reported an incidence of 40.2 percent of grade II, 43.90 percent were of grade III and 4.80 percent of grade IV.

Occurrence was more in geldings (47.35%) followed by female (42.48%) and intact males (10.17%). This may be due to the fact that horses used for racing were geldings. In a study conducted in England by Kidd and Slone (2000) it was found that males (53.00%) had the highest incidence of laryngeal hemiplegia followed by geldings (31.00%) and females (18.00%). The variation of these findings from the present study may be because more intact males are used for racing in England.

5.2 SELECTION OF ANIMALS

Selection of animals of Grade III and IV only in the present study ensured that most of the animal had good arytenoid abduction post operatively. This was because these animals had complete paralysis of recurrent laryngeal nerve and there will be no contractibility of cricoarytenoideus dorsalis muscle (CAD). Residual contractibility of cricoarytenoideus dorsalis muscle would result in failure of laryngoplasty as noted by Adam and Fessler (2000). Grade I and Grade II animals would have retained contractibility of cricoarytenoideus dorsalis muscle (CAD) leading to assured failure of laryngoplasty. Hence these animals were avoided in the present study.

5.3 PRE-OPERATIVE PREPARATION

Admission of the animals on the day prior to surgery assured that the animals were fasted and prepared properly for surgery. Careful grooming and bathing helped to control the viable particle count in the operation theater.

5.4 RESTRAINT AND ANESTHESIA

Combination of xylazine (1.1 mg/kg) and ketamine (2.2 mg/kg) provided satisfactory general anesthesia in all cases as was also observed by Rangraj (1998).

The use of tetanus toxoid prevented tetanus in all cases. The use of tetanus toxiod pre operatively in horses is highly recommended because horses are highly susceptible to tetanus due presence of large number of clostridium tetani in their large intestine which are eliminated in dung.

In the present study, benzyl-penicillin and phenylbutazone were administered given to reduce the post-operative edema and infection. Similarly phenylbutazone and procaine penicillin were administered IV during the post-operative period by Tullners *et al* (1988), Russel and Slone, (1994) and Tetens *et al* (1996). Baxter *et al* (1992) used phenyl-butazone orally and potassium-G penicillin IM for five days after surgery and observed satisfactory wound healing.

Phenylbutazone and dexamethasone administered during pre and post-operative period were found to be satisfactory in controlling inflammation following surgery for laryngeal hemiplegia as also observed by Hawkins *et al.* (1997) and Davenport *et al.* (2001).

Tetens *et al.* (2002) administered pre and post-operatively potassium penicillin-G (22,000 IU/kg), gentamicin sulfate (6.6 mg/kg) and phenylbutazone (2.2 mg/kg) in horses treated surgically for laryngeal hemiplegia.

5.5 SURGICAL INSTRUMENTATION

The use of laryngeal burr, half circle trocar point needle, saucrbrach and weitlaner retractors and surgical staples recommended

by Auer and Stick (1992), Adam and Fessler (2000) and Mcllwraith and Turners (1998) was essential in performing surgery.

5.6 SURGICAL PROCEDURE

In the present study, two techniques were used for treatment of laryngeal hemiplegia in racehorses, namely laryngoplasty and ventriculectomy.

Laryngoplasty was first reported as a treatment for laryngeal hemiplegia by Marks *et al.* (1970a). Subsequently Baxter *et al.* (1983) reported success rate of 48 to 95 per cent. Similar results have been observed and laryngoplasty was recommended as a treatment for laryngeal hemiplegia by several authors Spiers *et al.* (1983), Derksen *et al.* (1986), Bohanon *et al.* (1990), Dean *et al.* (1990), William *et al.* (1990), Russel and Slone (1994) and Stick and Holcombe (1998).

Ventriculectomy was used for treatment of laryngeal hemiplegia by Shappell *et al.* (1988). Similarly Bohanon *et al.* (1990), Hawkins *et al.* (1997), Davenport *et al.* (2001), Kraus *et al.* (2002) and Dixon *et al.* (2003a) also found this technique to be useful for the treatment of laryngeal hemiplegia.

5.6.1 Group A – Laryngoplasty

Positioning of the animals on lateral recumbency with extended head and neck as recommended by Adam and Fessler (2000) helped easy access of the surgical site. The procedure was performed according to the standard technique suggested by Auer and Stick (1992), Mcllwraith and Turners (1998) and Adam and Fessler (2000).

5.6.2 Group B – Ventriculectomy

Positioning of the animals on dorsal recumbency with extended head and neck as recommended by Adam and Fessler (2000) helped easy access of the ventricles. The procedure could be performed without difficulty according to the standard technique suggested by Auer and Stick (1992), Mcllwraith and Turners (1998) and Adam and Fessler (2000).

5.7 POST-OPERATIVE MANAGEMENT

The use of benzyl-penicillin at dose of 22,000 IU/kg and phenyl-butazone at a dose of 4.4 mg/kg for seven days was found to help uncomplicated wound healing in all cases as also reported by Tullners *et al.* (1988), Baxter *et al.* (1992), Russell and Slone (1994) and Tetens *et al.* (1996).

Cleaning of the surgical wound with dilute povidone iodine solution as reported by Tetens *et al.* (1996) was found to be effective in preventing infection of the surgical wound.

Providing stall rest for four weeks and feeding dry grass during the first post operative week prevented adynamic ileus. This type of postoperative management was also recommended by Russel and Slone (1994), Hawkins *et al* (1997), Kidd and Slone (2002) and Kraus *et al* (2003).

5.8 Post-operative complications

The horses of both groups were subjected to training after four weeks of stall rest and observed for production of respiratory noise. One horse of Group A had persistent respiratory noise, which was due to failed laryngoplasty (poor abduction). Dixon *et al* (2003a) also reported a

similar condition due to dorsal displacement of soft palate that was later diagnosed during post-operative endoscopic examination.

Similar post-operative complications were noticed by Dean *et al.* (1990) and Russel and Slone, (1994). Rest of the horses in both groups had no such complications as was observed by Dixon *et al* (2003b).

5.9 CLINICAL STUDIES

5.9.1 Gross examination of surgical wound

In Group A, one horse developed seroma with serous discharge from surgical wound with subsequent subcutaneous infection and secondary incision wound dehiscence. This could be due to early introduction of animal to full feed and training regimen. Similar wound complications were observed by Tetens *et al.* (1996), Hawkins *et al.* (1997), Dean *et al.* (1998), Tullners *et al.* (1998), Shappell *et al.* (1998), Davenport *et al.* (2001).

In Group B, no wound complications were noticed. This could be due to effective drainage by leaving the laryngotomy wound without suturing.

5.9.2 Endoscopic evaluation

One horse of Group A had poor arytenoid abduction observed from first post-operative week, which continued to be so during the period of study. This could have been due to loosening of suture prosthesis leading to poor cartilage retention and failure of laryngoplasty technique as reported by Dean *et al.* (1990) and White *et al.* (1992).

In Group B, wound healing was assessed endoscopically and no complication was observed. In all cases the ventricles could be removed completely with the help of laryngeal burr.

Although, no complications were seen in horses of Group B, horses subjected to exercise or training showed poor exercise tolerance compared to horses of Group A. This may have been be due to improvement in the upper airway flow mechanics in exercising horses as noted by Derksen *et al.* (1986) and Shappel *et al.* (1988).

5.9.3 Rectal temperature, heart rate and respiratory rate

No changes were observed in rectal temperature, heart rate and respiratory rate within or between the groups. All the values were within the normal range. This may have been due to the fact that all horses were healthy and that laryngeal hemiplegia did not alter these parameters as observed by Derksen *et al.*(1986).

5.9.4 Haematological studies

There was no significant change in haemoglobin (Hb), total erythrocyte count (TEC) and packed cell volume (PCV) value and remained without much change both within and between the groups.

Since the procedure did not result is much blood loss, no changes in haemoglobin level and TEC were anticipated. In the present study, all the animals were in normal range of Hb and TEC throughout the experimental period as reported by Goulden *et al.* (1981).

There was slight increase in total leucocytes count above normal value on first post-operative day. The change could be due to slight post-operative inflammatory changes as noted by Kelly (1974). The values remained within the normal range throughout the study period.

The differential leukocyte count revealed little variation in neutrophil value. Slight increase in neutrophil values noticed on first post-operative day, may have been due to inflammatory changes as opined by Kelly (1974).

No changes in monocyte, lymphocyte, eosinophil and basophil counts were observed within and between the groups throughout the study period.

5.9.5 Biochemical studies

In the present study, ALT, AST, creatitine and ALP values were within the normal range during the study period and no significant changes were observed both within and between the groups. Benjamin (1998) noted that no variation in these biochemical parameters was expected in horses suffering from laryngeal hemiplegia or in which similar surgeries were performed.

Summary

6.0 SUMMARY

The present study was undertaken to compare laryngoplasty and ventriculectomy as treatment for laryngeal hemiplegia in race horses.

Twelve clinical cases of laryngeal hemiplegia of grade III or IV were selected for study, and randomly divided into two groups of six animals each. Clinical, hematological and biochemical, and gross examination at the surgical site were conducted in all animals pre and post-operatively. The results of the present study are summarized as follows.

1. Occurrence of laryngeal hemiplegia in race-horses was found to be 12.63 per cent (229 out of 1813 animals examined).

2. Age wise, laryngeal hemiplegia in race-horses was found to be more in three year old horses (40.65%) followed by four year old (33.08%), five year old (17.77%), six year old (6.06%), seven year old (1.29%) and eight year old horses (0.43%)

3. Gender wise, 57.53% of the affected animals were male (geldings, 47.35%) and intact males (10.17%) and the rest were females (42.45%).

4. Occurrence of laryngeal hemiplegia of Grade I was found to be more (69.05%) followed by Grade II (20.97%), Grade III (8.30%) and Grade IV (1.69%) respectively.

5. Xylazine hydrochloride (1.1 mg/kg b.wt) and ketamine hydrochloride (2.2 mg/kg b.wt) combination provided satisfactory general anaesthesia in all cases.

6. Pre and postoperative injection of benzylpenicillin (22,000 IU/kg) and phenylbutazone (4.4mg/kg) ensured good wound healing.

7. Povidone-iodine as a topical antiseptic was found to be very effective.

8. Phased feeding and controlled exercise helped in prevention of postoperative complication.

9. It was observed that laryngoplasty reduced respiratory noise increased the performance of horse as evidenced by the racing performance of the operated horses.

10. Both the surgical techniques did not influence any change in physiological, haematological and biochemical parameters.

11. Haematological parameters like haemoglobin, packed cell volume, total leucocytes count, differential count did not show any significant variation either within or between the groups.

12. Biochemical parameters like ALT, AST, creatinine and ALP values were within normal range and did not show any significant variation either within or between the groups.

In conclusion, based on reduction of respiratory noise, enhanced exercise tolerance and gross examination of surgical site, along with simplicity of instrumentation and technique, it could be opined that laryngoplasty is a better technique as compared to ventriculectomy in management of horses with laryngeal hemiplegia.

References

6.0. REFERENCES

Archer, R.M., Lindsay, W.A. and Duncan, I.D., 1991, A comparison of techniques to enhance the evaluation of equine laryngeal function. *Equine Vet. J.*, **23**: 104-107.

Brahmasa. A and Kalpravidh, C. 2003, Prosthetic laryngoplasty with unilateral ventriculectomy for treatment of idiopathic laryngeal hemiplegia in racehorses. *J. Thai. Vet. Practitioners,* **15**: 21-30.

Attenburrow, D.P., 1978a, The development of a radio stethoscope for use in the horse at rest and during exercise. *Equine Vet. J.,* **10**: 14-17.

Attenburrow, D.P., 1978b, Respiratory sounds recorded by radio-stethoscope from normal horses at exercise. *Equine Vet. J.,* **10**: 176-179.

Auer.J.A. and Stick. J.A. (1992) Equine Surgery. 2nd Edn., W.B Saunders Co., Philadelphia. Pp. 349-368.

Barnes, A.J., Slone, D.E. and Lynch, T.M., 2004, Performance after partial arytenoidectomy without mucosal closure in 27 thoroughbred racehorses. *Vet. Surg.,* **33**: 398-403.

Baxter, G.J., 1983, Laryngeal hemiplegia in the horse. *Compend. Contin. Educ. Pract. Vet.,* **5**: 561-565.

Baxter, G.M., Allen, D. and Farrell, R.L., 1992, Paralaryngeal accessory bronchial cyst as a cause of laryngeal hemiplegia in a horse. *Equine Vet. J.,* **24**: 67-69.

Bayly, W.M., Grant, B.D. and Modransky, P.D., 1989, Arterial blood gas tensions during exercise in a horse with laryngeal hemiplegia before and after corrective surgery. *Res. Vet. Sci.,* **36**: 256-258.

Belknap, J.K., Derksen, F.J. and Nickels, F.A., 1990, Failure of subtotal arytenoidectomy to improve upper airway flow mechanics in exercising standardbreds with induced laryngeal hemiplegia. *Am. J. Vet. Res.*, **51**: 1481-1487.

Bohanon, T.C., Beard, W.L. and Robertson, J.T., 1990, Laryngeal hemiplegia in draft horses- A review of 27 cases. *Equine Vet. J.*, **20**: 370-374.

Brown, J.A., Derksen, F.J., Stick, J.A., Hartmann, W.M. and Robinson, N.E., 2003, Ventriculocordectomy reduces respiratory noise in horses with laryngeal hemiplegia. *Equine Vet. J.*, **35**: 570-573.

Brown, J.A., Derksen, F.J., Stick, J.A., Hartmann, W.M. and Robinson, N.E., 2004, Effect of laryngoplasty on respiratory noise reduction in horses with laryngeal hemiplegia. *Equine Vet. J.*, **36**: 420-425.

Brown, J.A., Derksen, F.J., Stick, J.A., Hartmann, W.M. and Robinson, N.C., 2005a, Laser vocal cordectomy fails to effectively reduce respiratory noise in horses with laryngeal hemiplegia. *Vet. Surg.*, **34**: 247-252.

Brown, J.A., Hinchiliff, K.W., Jackson, M.A., Deedge, A.F., O'Callazhen, P.A., McCaffrey, J.P., Slocombe, R.F. and Clarke, A.F., 2005b, Prevalence of pharyngeal and laryngeal abnormalities in thoroughbreds racing in Australia and their association with performance. *Equine Vet. J.*, **37**: 397-401.

Christley, R.M., Hodgron, D.R., Evans, D.L. and Rose, R.J., 1997, Cardiorespiratory responses to exercise in horses with different grades of idiopathic laryngeal hemiplegia. *Equine Vet. J.*, **29**: 6-10.

Cole, C.R., 1946, Changes in the equine larynx associated with laryngeal hemiplegia. *Am. J. Vet. Res.*, **7**: 69-77.

Cook, M.R. 1965, The diagnosis of respiratory unsoundness in the horse. *Vet. Surg.*, **77**: 516-528.

Cook, W.R., 1974, Some observations on diseases of the ear, nose and throat in the horse and endoscopy using a flexible fibreoptic endoscope. *Vet. Rec.*, **54**: 535-541.

Davenport, C.L.M., Tullners, E.P. and Parkente, C.J., 2001, The effect of recurrent laryngeal neurectomy in conjunction with laryngoplasty and unilateral ventriculocordectomy in thoroughbred racehorses. *Vet. Surg.*, **30**: 417-421.

Dean, W.P., Nelson, K.J. and Schumacher, J., 1990, Effects of age and prostheses material on *in vitro* cartilage retention of laryngoplasty prosthesis in horses. *Am. J. Vet. Res.*, **151**: 114-117.

Derksen, F.J., Stick, J.A., Scott, Robinson, N.E. and Slocombe, R.F., 1986, Effect of laryngeal hemiplegia and laryngoplasty on airway flow mechanics in exercising horses. *Am. J. Vet. Res.*, **47**: 16-20.

Dixon, P.M., McGorum, B.C., Railton, D.I., Hawe, C., Tremaine, W.H., Pickles, K. and McCann, J., 2001, Laryngeal paralysis: a study of 375 cases in a mixed-bred population of horses. *Equine Vet. J.*, **33**: 452-457.

Dixon, P.M., McGorum, B.C., Railton, D.I., Hawe, C., Tremaine, W.H., Daere, K. and McCann, J., 2003a, Long term surgery of laryngoplasty and ventriculocordectomy in an older, mixed bred population of 200 horses. Part 1: Maintenance of surgical arytenoid abduction and complications of surgery. *Equine Vet. J.*, **35**: 389-396.

Dixon, P.M., McGorum, B.C., Railton, D.I., Hawe, C., Tremaine, W.H., Daere, K. and McCann, J., 2003b, Long-term survey of laryngoplasty and ventriculocordectomy in an older, mixed-bred population of 200 horses. Part 2: Owners assessment of the value of surgery. *Equine Vet. J.*, **35**: 397-401.

Derksen, F.J., Holcombe, S.J., Hartmann, W., Robinson, N.E. and Stick, J.A., 2001, Spectrum analysis of respiratory sounds in exercising horses with experimentally induced laryngeal hemiplegia or dorsal displacement of the soft palate. *Am. J. Vet. Res.*, **62**: 359-664.

Duncan, I.D. and Griffiths, I.R., 1973, Pathological changes in equine laryngeal muscles and nerves. *Proc. Am. Ass. Equine Pract.*, **19**: 97-113.

Duncan, I.D., Baker, G.J., Heffron, C.J. and Griffiths, I.R., 1977, A correlation of the endoscopic and pathological changes in sub clinical pathology of the horses larynx. *Equine Vet. J.*, **9**: 220-225.

Duncan, I.O. and Brook, D., 1985, *Bilateral laryngeal paralysis in the* horse. *Equine Vet. J.*, **77**: 228-223

Duncan, I.D., Amundson, J., Cuddon, P.A., Sufit, R., Jackson, K.F. and Lindrag, W.A., 1991, preferential denervation of the adductor muscles of the equine larynx-1: Muscle pathology. *Equine Vet. J.*, **23**: 96-99.

Ehrlich, P.J., Seeherman, H.J., Morris, E.A., Kolias, C. and Cook, W.R., 1995, The effect of reversible left recurrent laryngeal neuropathy of the metabolic cost of locomotion and peak aerobic power in thoroughbred racehorses. *Vet. Surg.*, **24**: 36-48.

Franklin, S.H., Usmar, S.G., Lane, J.G., Shuttleworth, J. and Burn, J.F., 2003, Spectral analysis of respiratory noise in horses with upper airway disorders. *Equine Vet. J.*, **35**: 264-268.

Franklin, S.H., Price, C. and Burn, J.F., 2004, The displaced equine soft palate as a source of abnormal respiratory noise during expiration. *Equine Vet. J.*, **36**: 590-594.

Fulton, I.C., Derksen, F.J., Stick, J.A., Robinson, N.E. and Walshaw, R., 1991, Treatment of left laryngeal hemiplegia in standard breds using a horse muscle pedicle graft. *Equine Vet. J.*, **52**: 1461-1467.

Gilbert, G.H., 1972, Laryngeal hemiplegia following jugular injury. *J. Am. Vet. Med. Assoc.*, **161**: 1686-1687.

Goulden, B.E. and Anderson, L.J., 1981, Equine laryngeal hemiplegia. Part II: Some clinical observations. *NZ. Vet. J.*, **29**: 194-198.

Goulden, B.E., Anderson, L.J. and Cahill, J.L., 1985, Roaring in Clydesdales. *NZ. Vet. J.*, **33**: 73-76.

Greet, T.R.C., Baker, G.J. and Lee, R., 1979, The effect of laryngoplasty on pharyngeal function in the horse. *Equine Vet. J.*, **11**: 153-158.

Greet, T.R.C., Jeffcott, L.B., Whitwell, K.E. and Cook, W.R., 1980, The slap test for laryngeal adductory function in horses with suspected cervical spinal cord damage. *Equine Vet. J.*, **23**: 127-131.

Gunn, H.M., 1972, Histochemical observations on laryngeal skeletal muscles fibre in normal horses. *Equine Vet. J.*, **4**: 144-148.

Hackett, R.P., Ducharme, N.G., Fubin, S.L. and Erb, H.N., 1991, The reliability of endoscopic examination in assessment of arytenoid cartilage movement in horses. Part 1: Subjective and objective laryngeal evaluation. *Vet. Surg.*, **20**: 174-179.

Hall, L.W., Young, S.S., Franklin, R.J.M., Jefferies, A.K. and Corke, M., 1990, Use of the forced oscillating airflow technique to measure the resistance of the equine upper airway: effects of laryngo-ventriculectomy and laryngoplasty. *Res. Vet. Sci.*, **49**: 229-235.

Hammer E.J., Tullners, E.P., Parents, E.J. and Martin, B.B., 1998, Video-endoscopic assessment of dynamic laryngeal function during exercise in horses with grade-III left laryngeal hemi paresis at rest: 26 cases (1992-1995). *J. Am. Vet. Med. Assoc.*, **3**: 399-403.

Hawe, C., Dixon, P.M. and Mayhew, I.G., 2001, A study of an electrodiagnostic technique for the evaluation of equine recurrent laryngeal neuropathy. *Equine Vet. J.*, **33**: 459-465.

Hawkins, J.F., Tullners, E.P., Ross, M.W., Evans, L.H. and Rakes, W.C., 1997, Laryngoplasty with or without ventriculectomy for treatment of left laryngeal hemiplegia in 230 race horses. *Vet. Surg.*, **26**: 484-491.

Hay, W.P., Tullners, E.P. and Ducharme, N.G., 1993, Partial arytenoidectomy in the horse using an extra laryngeal approach. *Vet. Surg.*, **22**: 50-56.

Haynes, P.F., Snider.T.G. Mc Clure, J.R. and Mc Clure, J.J, 1980, Chronic chondritis of equine arytenoids cartilage. *J. Am. Vet. Med. Assoc.*, **177**: 1135-1142.

Haynes, P.F., 1984, Surgery of the equine respiratory tract. In: *The Practice of Large Animal Surgery.* Vol. 1, Ed: P.G. Jennings, W.B. Saunders Co., Philadelphia, pp. 338-487.

Heffron, C.J. and Baker, G.J., 1979, Observations on the mechanism of functional obstruction of the nasopharyngeal airway in the horse. *Equine Vet. J.*, **11**: 142-147.

Hillidge, C.J., 1986, Interpretation of laryngeal function tests in the horse. *Vet. Res.*, **118**: 535-536.

Jansson, N., Ducharme, N.G., Hackett, R.P. and Mohammed, H.O., 2000, An *in vitro* comparison of cordopexy, cordopexy and laryngoplasty and laryngoplasty for treatment of equine laryngeal hemiplegia. *Vet. Surg.*, **29**: 326-334.

Kidd, J.A. and Slone, D.E., 2002, Treatment of laryngeal hemiplegia in horses by prosthetic laryngoplasty, ventriculectomy and vocal cordectomy. *Vet. Rec.*, **82**: 481-484.

King, C.M., Evans, D.L. and Rose, R.J., 1994, Cardiorespiratory and metabolic response to exercise in horses with various abnormalities of the upper respiratory tract. *Equine Vet. J.*, **26**: 220-225.

Kraus, B.M., Parente, E.J. and Tullners, E.P., 2002, Laryngoplasty and ventriculectomy or ventriculocordectomy for the treatment of laryngeal hemiplegia in 104 draft horses. *Proc. Am. Assoc. Equine Pract.*, **48**: 231-232.

Kraus, B.M., Parente, E.J. and Tullners, E.P., 2003, Laryngoplasty with ventriculectomy or ventriculocordectomy in 104 draft horses (1992-2000). *Vet. Surg.*, **32**: 530-538.

Lane, J.G., Bladon, B., Little, D.R.M., Naylor, J.R.J. and Franklin, S.H., 2006a, Dynamic obstructions of the equine upper respiratory tract. Part 1: Observations during high speed treadmill endoscopy of 600 thoroughbred race horses. *Equine Vet. J.*, **38**: 393-399.

Lane, J.G., Bladon, B., Little, D.R.M., Naylor, J.R.J. and Franklin, S.H., 2006b, Dynamic obstructions of the equine upper respiratory tract. Part 2: Comparison of endoscopic findings at rest and during high speed treadmill endoscopy of 600 thoroughbred race horses. *Equine Vet. J.*, **38**: 401-407.

Lumsden, J.M., Derksen, F.J., Stick, J.A., Robinson, N.E. and Nickels, F.A., 1994, Evaluation of partial arytenoidectomy as a treatment for equine laryngeal hemiplegia. *Equine Vet. J.*, **26**: 125-129.

Marks, D., Mackay Smith, M.P., and Cushing, L.S., 1970a, Use of a prosthetic device for surgical correction of laryngeal hemiplegia in horses. *J. Am. Vet. Med. Assoc.*, **157**: 157-163.

Marks, D., Mackay Smith, M.P. and Cushing L.S., 1970b, Etiology and diagnosis of laryngeal hemiplegia in horses. *J. Am. Vet. Med. Assoc.*, **157**: 429-436.

Morris, E.A. and Seeherman. H.J. 1990, Evaluation of upper respiratory tract during strenuous exercise in racehorses *J. Am. Vet. Med. Assoc.*, **196**: 430-436.

Morris, E.A.1991, Dynamic evaluation of the equine upper respiratory tract In; veterinary clinics of North America. Equine practice. Advanced Diagnostic method, Ed: R.R. Saunders, Philadelphia. pp, 403-416.

Pascoe, J.R., Ferraro, G.L. and Cannon, J.H., 1981, Exercise induced pulmonary haemorrhage in racing thoroughbreds: A preliminary survey. *Am. J. Vet. Res.*, **42**: 703-707.

Quinlan, T., Goulden, B.E. and Davies, A.S., 1975. Bilateral asymmetry of equine laryngeal muscles. *NZ. Vet. J.*, **23**: 145-147.

Radicliffe, C.H., Woodie, J.B., Hackett, R.P., Ainsworth, D.M., Erb, H.N., Mitchell, L.M., Soderholm, L.V. and Duchams, N.G., 2006, A comparison of laryngoplasty and modified partial arytenoidectomy as treatment for laryngeal hemiplegia in exercising horses. *Vet. Surg.*, **35**: 643-652.

Rakestraw, P.C., Hackett, R.P., Ducharme, N.G., Nielan, G.J. and Erb, N.B., 1991, Arytenoid cartilage movement in resting and exercising horses. *Vet. Surg.*, **20**: 122-127.

Raphel, C.F., 1982, Endoscopic findings in the upper respiratory tract of 479 horses. *J. Am. Vet. Med. Assoc.*, **181**: 470-473.

Riggs, D.L. Ramey, D.W. and Reinertson, E.L., 1985, Tracheal compression secondary to obscuration of cranial medial final lymph nodes in a horse. *J. Am. Vet. Med. Assoc.*, **186**: 283-284.

Russell, A.P. and Slone, D.E., 1994, Performance analysis after prosthetic laryngoplasty and bilateral ventriculectomy for laryngeal hemiplegia in horses: 70 cases (1986-1991). *J. Am. Vet. Med. Assoc.*, **8**: 1235-1241.

Schumacher, J., Wilson, A.M., Pardoe, C. and Easter, S.L., 2000, *In vitro* evaluation of a novel prosthesis for laryngoplasty of horses with recurrent laryngeal neuropathy. *Equine Vet. J.*, **32**: 43-46.

Shappell, K.K., Derksen, F.J., Stick, J.A. and Robinson, N.E., 1988, Effects of ventriculectomy, prosthetic laryngoplasty and exercise on upper airway function in horses with induced left laryngeal hemiplegia. *Am. J. Vet. Res.*, **49**: 1760-1765.

Speirs, V.C., Bourke, J.M. and Anderson, G.A., 1983, Assessment of the efficacy of an abductor muscle prosthesis for treatment of laryngeal hemiplegia in horses. *Aust. Vet. J.*, **60**: 294-299.

Stick, J.A. and Derksen, F.J., 1989, Use of video-endoscopy during exercise for determination of appropriate surgical treatment of laryngeal hemiplegia in a colt. *J. Am. Vet. Med. Assoc.*, **195**: 619-622.

Stick, J.A. and Derksen, F.J., Nickels, F.A., Brown, C.M. and Fulton, I.C. 1990, Upper airway videoendoscopy during exercise in poorly performing horses. *Proc. Am. Assoc. Equine Pract.*, **36**: 431-438.

Stick, J.A. and Holcombe, S.J., 1998, What to expect following surgery of obstructive lesions of the upper respiratory tract. *Proc. Am. Assoc. Equine Pract.*, **44**: 39-45.

Strand, E. and Staempfli, H.R., 1993, Dynamic collapse of the roof of the nasopharynx as a cause of poor performance in a standard bred colt. *Equine Vet. J.*, **25**: 252-254.

Strand, E., Martin, G.S., Haynes, P.F., McClure, J.R. and Donald Vice, J., 2000, Career racing performance in thoroughbreds treated with prosthetic laryngoplasty for laryngeal neuropathy: 52 cases (1981-1989). *J. Am. Vet. Med. Assoc.*, **11**: 1689-1696.

Tetens, J., Derksen, F.J., Stick, J.A., Lloyd, J.W. and Robinson, E., 1996, Efficacy of prosthetic laryngoplasty with and without bilateral ventriculocordectomy as treatment for laryngeal hemiplegia in horses. *Am. J. Vet. Res.*, **57**: 1668-1673.

Tetens, J., Hubert, J.D., Eddy, A.L. and Moore, R.M., 2000, Dynamic tracheal collapse as a cause of exercise intolerance in a thoroughbred. *J. Am. Vet. Med. Assoc.*, **5**: 722-724.

Tullners, E.P., Harrison, I.W. and Rakes, W.C., 1988, Management of arytenoid chondropathy and failed laryngoplasty in horses – Report of 75 cases (1979-1985). *J. Am. Vet. Med. Assoc.*, **172**: 670-679.

White, N.A., 1992, Surgical treatment of laryngeal abnormalities. Current recommendations. *Proc. Am. College Vet. Surgeons*, pp. 86-89.

Williams, J.W., Pascoe, J.R., Meaghes, D.M. and Hornof, W.J., 1990a, Effects of left recurrent neurectomy, prosthetic laryngoplasty and subtotal arytenoidectomy on upper airway pressure during maximal exertion. *Vet. Surg.*, **19**: 136-141.

Williams, J.W., Meaghes, D.M., Pascoe, J.R. and Hornof, W.J., 1990b, Upper airway function during maximal exercise in horses with chronic upper airway lesions effect of surgical treatment. *Vet. Surg.*, **19**: 142-144.