SOME EXPERIMENTAL OBSERVATIONS ON THE INNERVATION OF THE LARYNX IN CATS

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The innervation and movements of the larynx have received the attention of many experimental investigators. It would be hard to find any series of results which has produced so many positively affirmed observations by many workers, with equally positive but exactly opposite results by many others. The experimental animals used have been varied and include rabbits, cats, dogs, goats, monkeys and finally man, and the only two generally accepted observations arising from the study of these species are that animal results cannot be applied with any certainty to man and that the larynx has as part of its raison d’être a valvular function.

That so little uniformity has been reached in the past 140 years since paralysis of the “cords” was observed by Legallois in sectioning both recurrent laryngeal nerves is sufficient to indicate the complexity of the problem. The copious literature on the subject bears further witness to that point and hence it is not without some trepidation that the following brief communication, relating to the experimental investigation of the larynx and its innervation, is contributed.

The animals used were adult cats on the whole and the sole reason for this selection was that other experimental procedures were being undertaken concurrently which, quite unrelated to this particular subject, afforded an opportunity to make the observations reported below. All that has been attempted was to observe the following effects:

1. Gradually increasing stimulation on the recurrent laryngeal nerve in the assumption that the various fibre sizes have different chronaxies.

2. Altering the physiological state of the nerve and again applying gradually increasing stimuli.

3. Stimulation experiments on the superior laryngeal nerve and its branches.

All these effects were watched by direct laryngoscopy and the movements evoked were recorded by ciné photography.

Results

Exposure of the recurrent laryngeal nerve alone was frequently quite sufficient to stop all respiratory movements of the glottis on the same side.

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The extent of exposure seemed to be of considerable importance because
a nerve widely exposed but lying free, frequently failed to conduct the
physiological stimuli from the respiratory centres, whereas a small
portion exposed, even though stretched tightly over a stimulating probe,
often continued to conduct the respiratory impulses for considerable
periods.

On stimulation, small voltages produced adduction movements of the
glottis, which were more readily observed if respiratory movements were
absent, for the abduction of inspiration overcame the weak adduction
produced by the stimulation. With increasing strength of stimulus, an
adductor “flick” could be observed followed by a strong abductor move-
ment. If the frequency of stimulation was now increased to the point of
putting the movements into tetany, the edge of the glottic opening became
sinuous with a tendency to adduct anteriorly but for the arytenoid to
abduct widely.

When the stimulation was applied to a nerve which had been lifted
free from its bed for some time and bathed in Ringer’s Solution, as
expected, the threshold of stimulation rose but nevertheless the first
movements observed in the glottis were those of adduction and were
followed by abduction as the strength of stimulation increased.

If an increasing pressure was applied to the nerve between the point
of stimulation and the larynx, conduction gradually failed as evidenced
first by weakening of laryngeal movements and finally paralysis. The
order of loss of movement was abduction first, followed by adduction and
finally complete paralysis. When the pressure was released the movements
returned in the reverse order i.e. adduction followed by abduction,
provided the nerve had not been irretrievably damaged.

Cocainization of the nerve did not demonstrate any proclivity to early
failure in conduction for abduction or adduction movements, but gradual
weakening of all movements until final paralysis. Concentrations of more
than 2 per cent. produced rapid blocking of conduction: complete block or
section of the nerve produced a lax, paralysed glottic edge.

Stimulation of the external branch of the superior laryngeal nerve
caused contraction of the ipsilateral crico-thyroideus resulting in back-
ward displacement of the arytenoid, tensing of the fold and also adduction.
Stimulation of the internal division of the superior laryngeal nerve caused
strong bilateral adduction with minimal stimuli. That this was due to
stimulation of sensory fibres only was readily demonstrated by sectioning
both recurrent and external laryngeal nerves. Subsequent stimulation
now elicited the coughing reflex but without laryngeal movements of
any kind, as demonstrated by performing a tracheostomy which prevented
the lax glottic folds behaving in a valvular fashion as the inspiratory
and expiratory movements caused the passage of air through the
larynx.
Observations on the Innervation of the Larynx in Cats

Discussion

Briefly, it is no great surprise that the highly specialized adaptation of laryngeal movements for use in phonation has resulted in the development of special qualities of the human larynx—particularly in relation to its nerve supply—and, obviously, applying results from animal experiments is of very limited value.

There seems to be no reason to dispute the original suggestion of Negus that the glottis subserved a primitive sphincteric function. It is of interest to note that in adult cats the adductors respond when smaller stimuli are applied to the recurrent laryngeal nerve, suggesting that the chronaxie of these fibres is less than that of the fibres subserving abduction. These findings are exactly opposite to the experiences reported by Lemere on dogs, in which he observed abduction on stimulation and stated that Dumont found in these animals that the chronaxie of the adductors was greater than that of the abductors. They are, however, in agreement with the findings reported by Williams (1951) on stimulating the recurrent laryngeal nerve in humans. With minimal stimuli he invariably observed adduction. Murtagh (1945) also obtained adduction invariably in similar experiments on goats. Williams (1951) reports that pressure on the recurrent laryngeal nerve with a swab during operation led to no change in cord movement. Experimentally, however, it can readily be observed that slight irritation of the nerve produces a series of adductor “flicks” and sustained pressure produces a definite failure of abduction first, continuing to failure of adduction with paralysis. Whether the explanation is that the adductor muscles are much the more powerful or that the fibres subserving the adductors are more resistant to the effects of interference with the blood-supply of the recurrent laryngeal nerve, by virtue of their numbers or intrinsic qualities, is difficult to decide. Paradoxically, the impression gained from observations made when movements were failing in a simple exposure of the recurrent laryngeal nerve, was that abduction remained to the last stages and that any “adduction” movements were purely passive “recoils”. However, touching the mucous membrane of the larynx or trachea, or stimulation of the internal laryngeal nerve immediately produced strong adduction of the glottic opening. There is thus clear indication that the pattern of behaviour is dependent on the integrity of afferent as well as efferent pathways at least to the level of the brainstem. This might be clarified further by temporal recordings timing the impulses from the intrinsic laryngeal muscles.

Another observation was made on an animal in whom the recurrent laryngeal nerve had been divided and allowed to regenerate. A thin but intact nerve was found, the glottis however, was paralysed on that side. Stimulation below the original point of division i.e. proximal to the brainstem, with somewhat higher orders of stimuli than in other experiments...
produced the usual results, namely, adduction with the weaker stimuli and abduction with the stronger. However, touching the mucous membrane of the larynx or stimulating the internal laryngeal nerve evoked strong adduction, indicating that the physiological stimulus from the respiratory centre under anaesthesia was inadequate to move that side of the glottis in respiration but the adduction of the sphincteric function could come into play when the reflex was involved.

To the controversial issue of innervation of the interarytenoids by the internal branch of the superior laryngeal nerve, these observations have little to contribute. Stimulation of the internal laryngeal nerve with nerve supply to the larynx intact results in strong adduction and coughing movements. Repeating the observations with both external and recurrent laryngeal nerves divided and a tracheostomy for reasons explained above, stimulation evoked no movement of the glottic opening, indicating that in so far as the cat is concerned, the interarytenoids, which are very poorly developed in this animal, do not receive a motor supply from the internal laryngeal nerve.

Summary
1. The adductors of the glottis in cats retain their function longer than the abductors when sustained pressure is applied to the recurrent laryngeal nerve.
2. The adductors are also responsive to lower orders of stimuli applied to the nerve than are the abductors.
3. Adductor reflex movements can be retained following regeneration of the recurrent laryngeal nerve or injury to the nerve, when, however, the glottic margin is "paralysed" to respiratory movements.
4. The internal laryngeal nerve seems to subserve a sensory function only.

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BIBLIOGRAPHY
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