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The laryngoscope and 19th century British understanding of laryngeal movements

Running Head: The laryngoscope and laryngeal paralysis

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Abstract

The source of the human voice is obscured from view. The development of the laryngoscope in the late 1850s provided the potential to see the action of the vocal folds during speaking for the first time. This new instrument materially contributed to the understanding of vocal fold neuroanatomy, neurophysiology, and neuropathology. The laryngoscope led to the elucidation of disorders that previously were determined by changes in sound. The objective of this paper is to detail the consequences of this novel visualization of the larynx, and to trace how it led to an appreciation of how the voice was produced by movements of the vocal folds. This is demonstrated through an examination of the activities and practices of a group of London clinicians in the second half of the 19th century.

Key Words: 19th century, Laryngoscope, Larynx, Voice, Phonation, Vocal Folds, Vocal Cords, Laryngeal Paralysis, Aphonia, Johann Czermak, Morell Mackenzie, Felix Semon, Medical technology

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Introduction

The question of how the human voice is produced has been considered since ancient times. Empirical investigation was undertaken through dissection and animal experimentation *in vivo*. As early as the 2nd century CE, Galen had described the function of the recurrent laryngeal nerve in vocal production. This understanding was derived from his exploration of the relations between the phrenic and intercostal nerves to the muscles of respiration in a pig (Gross, 1998). When he inadvertently severed the recurrent laryngeal nerve, the pig immediately stopped squealing. Galen described the anatomy of the twelve intrinsic muscles and three cartilages of the larynx (Duckworth, Lyons, & Towers, 2010). Subsequent contributions in the 16th and 17th century determined the finer anatomical details of the branches of the recurrent and superior laryngeal nerves through animal and human dissection (e.g., Garrison & Hast, 1993; Lanska, 2014).

Until the early 18th century, it was assumed that only the recurrent laryngeal nerves were involved in phonation, although there were some that proposed that the superior laryngeal nerves were also involved (Vogel, 1952). In addition to classical techniques of dissection, new approaches included stimulation with faradic currents to observe which muscles contracted, and the sectioning of the recurrent or superior laryngeal nerve to observe subsequent patterns of muscle atrophy in animals. However, as a consequence of conflicting results, the exact nature of the innervation of the larynx that controls the movements for voice production was unclear. Analogies were drawn from various musical instruments; the function of the vocal cords was likened to the vibration of strings, whistles, or reeds in the

production of tones. The Cambridge Professor Rev. Robert Willis (1800-1875), known as the first British mechanical engineer, proposed a physical model of the actions of the laryngeal muscles and identified the role of rotational movement of the cricoarytenoid joint in phonation (Willis, 1833).

In the 19th century, an urgent need existed for a means of viewing inside the throat due to the widespread and often life threatening infectious diseases affecting the larynx. There was a sense of frustration shared by doctors due to their inability to view past the tongue. As a consequence, clinicians were unable to determine whether the cause of laryngeal disease was from edema, ulceration, destruction of the cartilages, abscess, or tumor until dissection at autopsy revealed the source (e.g., Porter, 1837).

Clinicians could not distinguish neurologic from non-neurologic disorders of the larynx until the second half of the 19th century when clinicians could finally view this part of the throat using a newly invented device. This consisted of two mirrors and light source, and was called the laryngoscope. [Figure 1] This instrument provided the opportunity for investigating how the vocal folds (referred to here with the pre-20th century term 'vocal cords') related to voice production, and the pathological states which led to impairments in speaking. Its rapid adoption by medical practitioners and scientists led to the diagnosis and treatment of vocal cord disorders in large numbers of patients who previously received little relief. The drive to determine the range of diseases and impairments that led to aphonia led to new understanding of laryngeal disorders and the neurological basis of laryngeal movements.

The second half of the 19th century was generally a time of technological innovation, institution building, and increasing professionalization in the medical sphere. Although there has been a great deal of scholarship on the development of other medical instruments, such as the stethoscope and ophthalmoscope, the laryngoscope has received less consideration

(Weitz, 2006). However, it represents an important example of the development and adoption of endoscopic tools which rapidly came into widespread use at that time.

The "invention" of the laryngoscope is widely attributed to the foundational efforts of the Austrian neurologist Ludwig Türck (1810-1868) (Türck, 1860) and the Austrian-German physiologist Johann Czermak (1828-1873) (Czermak, 1859). Medical understanding of the larynx gained from employment of the instrument has been primarily represented as arising from the activities of a number of individuals in Continental Europe (e.g., Jahn & Blitzer, 1996; Pieters, Eindhoven, Acott, & van Zundert, 2015). There has been some investigation of the contributions of singular British individuals such as Sir Morell Mackenzie (1837-1892) (e.g., Haweis, 1893) and Sir Felix Semon (1849-1921) (e.g., Harrison, 2000). This paper focuses on the specific way in which the new laryngoscope was adopted by a large group of clinicians in London, and how it was employed to determine 'nervous disorders' of the vocal cords. The objective is to provide a richer picture of a large community of actors who have not received previous historiographic attention. It demonstrates their significant contributions to the understanding of the neurophysiology of the larynx and how this new technology influenced medical practice and theory.

19th century British context

The period of interest begins at a significant moment in British history. In 1858, the Medical Act of Parliament established legislation for medical qualifications and institutional oversight for the medical training of physicians and surgeons (Newman, 1957). The present investigation extends to the beginning of the 20th century when technological innovations led to the development of direct laryngoscopy (e.g., Killian, 1902) and initiated a new wave of medical activity regarding the nature of the larynx and its movements in voice production.

London was the primary site of British medical activity in the Victorian era. It had rapidly grown to become the most populous city in the Western world, with over 2.3 million inhabitants recorded in the 1851 census, and its exponential growth continued over the next four decades (Anonymous, 1851). As a consequence of numerous social factors arising from such high-density living, London's inhabitants suffered greatly from a range of infectious diseases (Hardy, 1993). Many of these specifically affected the throat, such as phthisis (i.e., tuberculosis), typhus, diphtheria, and syphilis. There was a significant increase in British medical-scientific activity in response to multiple social, cultural and economic factors (Peterson, 1978). The medicalization of the physiology and pathophysiology of the vocal cords arose in this London context.

In the first half of the 19th century, understanding of the production of the human voice remained limited. A summary of the state of knowledge in 1837 is presented in Frederick Ryland's (d. 1857) treatise, which was awarded the Jacksonian Prize by the Royal College of Surgeons:

> With regard to the second function of the larynx—the formation of the voice—there are few subjects on which physiologists have differed so much, if we may judge, at least by the numerous theories that have been offered, at various times, as explanatory of the production of the vocal phenomena. This may be accounted for in some measure, by the unsettled state of the science of acoustics, and by the difficulty of bringing observation to bear upon the workings of an organ like the larynx, so completely hidden from sight. (Ryland, 1837, p. 16)

Ryland presented a clear summary of what was known about physiological action of the larynx from pathological cases and experiments with dogs:

> [M]ost of the physiologists of the present day, consider this power as residing in the thyro-arytaenoid muscles. The reasons for this belief are, 1st, the situation of these muscles, their attachment to the vocal cords, and the influence they are capable of exercising over the vibrations of these cords; 2d, the effects of the division of the recurrent nerves which supply these muscles—if both are cut the voice will cease, if only one is cut the voice will only be half lost; 3d, the loss of voice that results from ulceration, purulent infiltration, or atrophy of these muscles. 'The extinction of the voice is carried to the highest degree, if the thyro-arytaenoid muscles have undergone any of the alterations that we have mentioned,' observes M. [Gabriel] Andral. These observations are sufficient to prove that the contractions of the muscles in question are necessary to the production of voice, and, together with the experiments of [François] Magendie—in which the glottis of an animal being laid bare at the moment that it cried, the vocal cords were seen vibrating—show beyond all doubt that the primary tone of the voice is due to the action of the thyro-arytaenoid muscles and ligaments, and probably to their vibrating backwards and forwards, and thus alternately allowing and intercepting the passage of the air which is forcibly expelled from the lungs through the rima glottidis. (Ryland, 1837, pp. 18-19)

This understanding of the workings of the laryngeal cartilages, ligaments and muscles persisted for the next two decades (Hunt, 1859). James Rush (1786-1869), an American physician trained in Edinburgh and London, had authored an account of the state of the art entitled *The Philosophy of the Human Voice* in 1827. In his 5th revised edition, Rush underscored the unsettled state of understanding of vocal physiology that still prevailed:

> The natural voice is said to be produced by the vibration of the glottis. This has been inferred, from supposed analogy between the action of the human organ, and that of the dog, in which the vibration has been observed…and by blowing through the

> human larynx, when removed from the body. The conclusion is therefore probable, but until there is sufficient approximation to this proof by other means, it cannot be admitted as a portion of exact physiological science. (Rush, 1859, p. 139)

While there was a growing consensus that the recurrent laryngeal nerve provided motor innervation to the larynx, and that the external branch of the superior laryngeal nerve supplied the crico-thyroid muscles, there were conflicting views on the role of the internal branch of the superior laryngeal nerve. Some believed it was exclusively sensory, while others proposed a motor function (Vogel, 1952).

In summary, up to the early 19th century, the anatomy and physiology of the larynx had been based on evidence from animal vivisection, human dissection, and mechanical models. As it was impossible before the invention of the laryngoscope to see the movement of the vocal cords *in vivo*, the mechanism by which the larynx produced the human voice was uncertain. The drive to employ this new endoscopic tool was motivated by a desire to gain improved understanding of the workings of the larynx during phonation and of the various pathologies that contributed to impairments in voice.

Development, dissemination and diffusion of laryngoscopy in London

The watershed period for the development of the laryngoscope came in 1857-8, when Ludwig Türck initiated an investigation of the clinical application of this tool and was further inspired by reading a paper by Manuel Garcia (1805-1906) (Garcia 1855). Türck shared his insights and tools with Johann Czermak who was also interested in solving the problem of viewing the larynx. There are many versions recounting the priority dispute that arose in the early 1860s, and commentators have continued to contest the subsequent legacy of these pioneers. However, it is clear that Czermak had a direct role in the expanding use of the laryngoscope in London. One of the earliest of his influences was on the young physician

Morell Mackenzie, who had visited Czermak in Budapest in 1859. This was during Mackenzie's extensive travels to medical centers in Europe after having gained membership in the Royal College of Surgeons the year before. Mackenzie returned to London, inspired by Czermak to use the laryngoscope to investigate diseases of the throat, and determined to develop a special service for such patients. In 1862, he founded the Metropolitan Dispensary for Diseases of the Throat and Loss of Voice located off Regent's Street.

While other British physicians and surgeons also visited Czermak to gain training as early as 1859, he made a greater impact on the British medical community through his repeated visits London in the early 1860s. Czermak gave numerous public and private demonstrations on the use of his instrument [Figure 2]. The *Lancet* repeatedly announced the schedule of these teaching tours and reported the details of his London lectures. Commentary about the new laryngoscope also highlighted the value of Czermak's demonstrations (e.g., Gibb, 1860). There was very rapid uptake of the use of the instrument by London clinicians and reports of its utility began to appear almost immediately (e.g., Anonymous, 1860).

The London surgeon John Bishop, FRS (1797-1873), who had been investigating the movements of the larynx since the 1830s (e.g., Bishop, 1836), described how seeing Czermak use the instrument motivated him to undertake new voice research (Bishop, 1862). A second well-established clinician of the older generation who readily adopted the new instrument was the London surgeon James Yearsley (1805-1869), founder of the Ear Infirmary and Orthophonic Institute in 1838. He published one of the earliest British introductions to the use of the laryngoscope (Yearsley, 1862). In his preface, Yearsley described how he provided the opportunity for his medical colleagues to test the value of this new method of investigating patients at his house in Savile Row with Czermak in attendance. He also noted that Czermak had confirmed his agreement with the material presented in the manuscript

before its publication. Both Yearsley and Bishop represent examples of longstanding practitioners who enthusiastically adopted this new method of investigating the larynx.

Many London clinicians were eager to report the clinical benefit of Czermak's instrument and teaching. One early promoter of the laryngoscope was the Canadian born George Johnson (1818-1896), physician at Kings College London. In the spring of 1864, he gave two lectures at the Royal College of Physicians that were reprinted in full in the *Lancet* (Johnson, 1864). He extensively documented the recent development of the instrument, provided guidance in its use, and included a number of case reports that demonstrated its utility in diagnosis. The prominent London throat physician George Duncan Gibb (1821-1876 was also an early adopter, who published extensively on the use of the laryngoscope for diagnosis and treatment (e.g., Gibb, 1860, 1864). Gibb served as the English translator for Czermak's 1859 groundbreaking paper published by the New Sydenham Society (1858-1907). This had a subscriber base of 3,000 individuals (Meynell, 1986), and proved a significant means for Czermak's work to reach a major English-speaking medical audience.

Yearsley, Bishop, Johnson, Gibb and other well-established London practitioners gained new impetus to investigate the larynx with the aid of the laryngoscope. Through their numerous publications and lectures, they encouraged its adoption by the wider London medical community in the early 1860s. Over the coming years, however, the impact of Mackenzie's activities in this regard was distinctive. While being from a much younger generation, he was also innovative, energetic and prolific.

The contribution of Mackenzie and his students

By the beginning of the 1860s, Morell Mackenzie had rapidly established his expertise in diseases of the throat in London. He was often called upon by colleagues to undertake laryngoscopic examinations to assess vocal cord movement. For example, a case

report from the London Hospital in 1862 describes a patient with aphonia, difficulty swallowing, and breathing (Anonymous, 1862). Mackenzie was invited to examine the patient and determined that tracheotomy would not be helpful, as the larynx appeared free of obstruction but was unmoving, which indicated difficulty below the glottis. The patient subsequently died, and the autopsy revealed a malignant growth which extended down the trachea, thus confirming Mackenzie's opinion. Use of the laryngoscope in this case was seen as significant as it saved the patient from a painful operation which would have had no benefit.

By the mid-1860s, the number of individuals with throat complaints seeking medical attention in London was vast. Mackenzie's dispensary had already outgrown its premises. The renamed and expanded Hospital for Disease of the Throat added in-patient beds at new premises in Golden Square. This hospital saw over 5,000 out-patients in the first two years alone; while by 1873, after 10 years in operation, it had treated almost 1,000 in-patients and over 37,000 out-patients (Haweis, 1893). In addition to his senior role there, and his post at the London Hospital (being promoted to assistant physician in 1866 and physician in 1873), Mackenzie also had an extensive private practice. This meant that he saw an unusually large number of patients with laryngeal disorders compared to other clinicians.

Mackenzie was also responsible for training a new generation in the use of the laryngoscope, who subsequently developed their own practices and research in laryngeal disorders. For example, one of Mackenzie's early assistants at The Throat Hospital in Golden Square was the surgeon Lennox Browne (1840-1902), appointed in 1867. Browne left there seven years later to open the Central London Throat and Ear Hospital, first based in Manchester Street, and later in Gray's Inn Road. By the 1870s, numerous separate specialist institutions for the treatment of diseases of the throat were staffed by Mackenzie's trainees

including (William) Gordon Holmes (1844-1927) and William McNeill Whistler (1836-1900).

Movements of the larynx and laryngeal paralysis

London specialists in throat diseases saw a large number of patients in the 1860s and 1870s in the various new hospitals and departments founded to treat these ailments. This growing body of observations afforded the opportunity to develop a new understanding of several neurological diseases of the throat that had previously been unrecognized. One notable example is what is now called laryngeal dystonia. Mackenzie accurately described this rare[1] movement disorder of the vocal cords in eight cases observed in his first eight years of practice (Lorch & Whurr, 2016). This achievement was only possible because of his large practice, and his rapidly established referral base. Mackenzie stated that "the spasmodic action of the tensors" was one of the only diseases of the throat for which the laryngoscope was not needed for diagnosis (Mackenzie, 1868). In contrast, vocal cord paralysis was a disorder that only became recognized and understood through the use of that instrument.

George Johnson was one of the early investigators who noted that unilateral damage to the vagus nerve may produce either bilateral paralysis of the vocal cords, or paralysis on one side and spasm on the other. He underscored the particular value of laryngoscopy to the understanding of neurological diseases affecting the larynx:

> The larynx being … is largely supplied by nerves and endowed with exquisite sensibility. Its muscular apparatus is therefore readily thrown into a state of spasm, not only by irritation of the larynx itself, but by disturbing influences transmitted from a distance through the nerves.... before the introduction of the laryngoscope it was often impossible to determine to what extent the symptoms were a result of structural changes

[1] The Epidemiological Study of Dystonia in Europe (2000) estimated its prevalence to be 6.7 per million.

> within the larynx, and how far they were due to spasm of the laryngeal muscle. (Johnson, 1864, p. 41)

The position of the vocal cords became widely recognized as an important contributor to diagnosis. Clinicians began to develop a more detailed picture of how difficulties of vocal cord movement contributed to various voice disorders. For example, in cases of "hysterical" or "nervous" aphonia, Johnson (1864) found that the larynx appears quite normal on laryngoscopic examination, and that the glottis does not close when such patients try to speak.

New understanding vocal cord paralysis was reflected by inclusion of "nervo-muscular affections of the larynx" in Mackenzie's 1868 update of his earlier book on the treatment of hoarseness (Mackenzie, 1863). He emphasized the particular utility of the laryngoscope for determining whether the cause of hoarseness or loss of voice was of neurological origin. Mackenzie provided detailed descriptions of unilateral and bilateral paralysis of the abductors, adductors, tensors and laxors--all terms he coined. He described 51 patients with neurological disorders affecting the voice; several of these were sent to him by John Hughlings Jackson (1835-1911) from the London Hospital and the newly founded specialist institution, the National Hospital for Paralysis and Epilepsy at Queen Square (founded 1859).

Mackenzie determined that one cause of voice difficulties arose from vocal cord paralysis due to pressure exerted by tumours or aneurysms on the recurrent laryngeal or other relevant nerves. Examination with the laryngoscope in several cases of aphonia revealed unilateral paralysis of the vocal cords without any other local disease. The autopsy of one established the cause as neurosyphilis (Mackenzie, 1868). Mackenzie further observed that hoarseness and aphonia, which were previously often attributed to the diseased state of the membranes of the throat and/or pulmonary system commonly found in chronic infectious diseases, may also be caused by impairment to the nerves that supplied the larynx. He

implemented the use of direct galvanic stimulation as a treatment for some motor disturbances of the larynx.

Alongside Mackenzie's contributions, there were many others made by the growing group of London specialists. By 1878, when Lennox Browne produced his textbook on *The Throat and its Diseases*, he included a 20-page chapter detailing various forms of "neurosis of the larynx". Browne underscored the necessity of laryngoscopic examination for diagnosis of such disorders. He illustrated his text with his own fine drawings of laryngoscopic views of laryngeal movement disorders (Browne, 1878). [Figure 3] These depict various cases of unilateral and bilateral paralysis of the vocal cords due to impairments of the recurrent or laryngeal nerves affecting the adductors, abductors and laxors.

As the actual position of the vocal cords and their movement during phonation became more widely recognized as a significant diagnostic sign, clinicians began to systematically detail the possible views that might be encountered in a laryngoscopic examination. Various simulation devices were also developed to train students to identify different laryngeal conditions. One model in widespread use in Britain was a mannequin of a throat in which colored slides could be inserted at the position of the vocal cords, replicating the view afforded by the laryngoscope. [Figure 4] The slides illustrated various abnormal conditions of the glottis and vocal cord postures. This device, called the "phantom larynx", was used for specialist training from the 1870s onwards. The instrument makers Krohne and Sesemann of London displayed their model at the British Medical Association meeting of 1879.

The contribution of Semon and his colleagues

Felix Semon, another of Mackenzie's early trainees, made significant contributions to the neurological understanding of movement disorders of the larynx. He had come to London

in 1874 to further his interest in laryngology, after receiving his medical degree in Berlin and training in Paris and Vienna. He obtained a position as assistant physician at the Throat Hospital at Golden Square under Mackenzie's mentorship. He energetically pursued a research question motivated by Mackenzie's (1868) observation that the vocal cords can be found in various positions in recurrent laryngeal nerve paresis. Numerous clinical reports with post-mortem examinations had appeared which detailed instances where the whole nerve trunk of the recurrent laryngeal nerve was affected. Yet, there was growing evidence that the laryngeal muscles were differentially rather than uniformly affected. The pathology in some patients was central, while in others it was peripheral, being due to local pressure on the nerves from aneurysms or tumors.

Semon discussed the problem at a meeting of the Clinical Society of London (Semon, 1878), and included some his ideas in footnotes to the German edition that he translated of Mackenzie's *Diseases of the Nose and Throat* (1880). Next, Semon collected 22 published cases in which the abductors were solely or more profoundly affected. He could find none describing a similar pattern selectively affecting the adductor muscles from organic disease, although he admitted that this might arise in cases of functional or local disorders (Semon, 1881). He drew an analogy to the similar proclivity of the extensor muscles of the limbs to be affected sooner or to a greater degree than the flexors in diseases of central origin, giving the example of lead paralysis. (Sir) David Ferrier FRS (1843-1928), the Queen Square neurologist known for his work on the motor cortex (Ferrier 1874), agreed with this analogy (Ferrier 1881).

Semon considered the finer details of the innervation of the larynx, stating that the individual muscular branches are only given off by the trunk of the inferior laryngeal nerve when they are close to the larynx. Although it had been acknowledged that the abductor and adductor muscles could become affected separately, Semon rejected the possibility that such

partial paralysis could be due to either central causes, or affections of the main nerve trunks. Based on his observations of a large series of such cases, Semon proposed a clinical prediction rule that explained the sequence of the internal laryngeal muscle paralysis as a consequence of the damage to laryngeal nerves. This became known as "Semon's law" (Vilensky & Sinish, 2004). It codifies Semon's observations that the abductor fibers of the recurrent laryngeal nerve are affected more than the adductor fibers in both central and peripheral damage to the roots or trunks of the vagus, spinal accessory, or recurrent nerves (Semon, 1881).

(Sir) Victor Horsley (1857-1916) and James Samuel Risien Russell (1863–1939) collaborated with Semon on experimental investigations concerning the innervation of the larynx. All three, who held appointments at Queen Square, undertook this research at the Brown Animal Sanatory Institution attached to University College London. Their hypotheses, derived from clinical and post-mortem observations in humans, were supported by investigations of the motor innervation of the larynx through lesion experiments in monkeys, dogs, rabbits, and cats. Semon and Horsley detailed the cortical representation of the larynx from such experiments where unilateral stimulation caused bilateral adduction and unilateral lesions had no effect. These findings led them to assert that unilateral paralysis of the vocal cords could not be caused by a lesion of one cerebral hemisphere, thus distinguishing aphonia from aphasia, and suggested that an "epileptic cry" was due to cortical excitation. They concluded that cortical representation of adduction of the laryngeal muscles corresponded to the purposive and volitional aspects of phonation, while the bulbar representation corresponded to the automatic process of abduction concerned with inspiration (Semon & Horsley, 1889). With regard to the neuroanatomy, Russell (1892) confirmed that the abductor and adductor nerve filaments exist as separate nerve bundles in the recurrent laryngeal nerve.

In 1892, Semon wrote a 30-year review of the developing understanding of paralysis of the vocal cords (Semon, 1892). He stated that the symptoms of laryngeal paralyses are usually voice defects or aphonia, and sometimes dyspnoea. As these could also indicate inflammation or a growth, it had not been possible to diagnose or treat such patients with any degree of confidence until the development of the laryngoscope. Through detailed clinical, experimental and post-mortem investigations, Semon had collected a large body of evidence to support his observation that the individual fibres of the recurrent laryngeal nerve are successively affected (abductors before adductors) in progressive organic lesions of the laryngeal motor nerves.

At a meeting of the Laryngology Section of the Royal Society of Medicine in 1913, there was extensive discussion regarding the unsettled nature of the interpretation of observations regarding vocal cord paralysis (de Havilland Hall et al, 1913). Ferrier restated the position he had asserted decades earlier that the findings for laryngeal paralysis reflected a general pattern whereby extensors were affected more or sooner than flexors in disease of central origin. Semon argued that the neurophysiology of the larynx was now known to be fundamentally more complex, reflecting its dual function in respiration and phonation (Semon, 1913).

The neurological understanding of the physiology of the larynx had evolved significantly since the 1860s. This was reflected in the increasingly extensive treatment of this subject in standard British textbooks. When Browne's book was revised and expanded for the 5th edition in 1899, he enlisted the assistance of a neurologist rather than author the chapter on nervous disease of the larynx himself as in previous editions. James Cagney (1859-1897), physician at the Hospital for Epilepsy and Paralysis in Regent's Park (at Maida Vale after 1900), wrote the new chapter that ran to over 50 pages (published posthumously). He detailed the difficulties of understanding the laryngeal paralyses, pointing to the small size

of the muscles, complex co-ordination of their movements, and the indeterminate manner for which nerve fibres are blended or contiguous. Although he acknowledged the contributions of animal experimentation to this understanding, Cagney credited the laryngoscope with removing the obstacle presented by their remote situation and inaccessibility to direct observation, and stated the absolute necessity of employing it for clinical diagnosis of neurological disorders of the larynx (Cagney, 1899).

Conclusions

The implementation of the laryngoscope by London clinicians from the 1860s onwards materially contributed to new understanding of the role of the vocal folds in phonation, and the neuropathological mechanisms responsible for voice disorders. A large number of patient observations and experimental findings were amassed, analyzed, debated, and synthesized by the wider British Victorian medical community through lectures and in publications. The development of this new tool directly facilitated the elucidation of 'nervous' diseases of the larynx, and motivated both clinical and experimental research into laryngeal innervation. The visualization afforded by the laryngoscope, in conjunction with the huge cohort of patients that existed in the metropolis, provided a new opportunity for these specialists to determine that one source of hoarseness and aphonia was the lack of movement of one or both vocal folds. This led to a deeper understanding of the neurophysiology and neuropathology of the larynx and contributed to new diagnostic categories and treatment options.

Although the present investigation focuses on the activities of a local network of actors, these individuals were strongly connected to an international group of investigators who were exploring the larynx. While this was an active topic in many Western medical

communities at this time, London represented a center of major developments. This was in part due to rapid urbanization and the expanding medico-scientific system in the largest city in the West. This analysis of a local network of actors' implementation of a new clinical tool provides a detailed demonstration of the impetus provided by technology to knowledge construction, professionalization, and specialization in the medical sphere. The evidence presented here documents the dissemination, adoption, and impact of the laryngoscope in London in the second half of the 19th century which led to the understanding of laryngeal paralysis.

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Illustrations

Figure 1. 'Czermak type laryngoscope, in case, Berlin, Germany, 1855-18' From the collection of the London physician Sir Thomas Brunton Lauder (1844-1916) who bequeathed a large collection of medical and surgical instruments to the Wellcome collection. Image credit: Wellcome Collection/The Science Museum, London. This image is released under a Creative Commons Attribution- CC-BY.

Figure 2. Illustration of laryngoscope in use. (Czermak 1863). Image credit: The Wellcome Collection, London. This image is released under a Creative Commons Attribution- CC-BY.

Figure 3. "Neuroses of the larynx." *The Throat and its Diseases*, Lennox Browne, 1878. "Designed and executed by the author." Plate X, facing p. 334.

In the text, Browne describes the individual cases from which the drawings of laryngoscopic views derived: Fig. 93 "Bilateral paralysis of Adductors-- crico-arytenoidei laterales and arytenoideus"; Fig. 94 "Unilateral paralysis of adductors"; Fig. 95 "Bilateral paralysis of abductors-- crico-arytaenoidei postici"; Fig 96 & 97 "Unilateral paralysis of abductors"-- left and right; Fig. 98 "Paralysis of Laxors"; Fig. 99 "Paralysis of laxors—arytenoideus"; Fig. 100 "Paralysis of theLaxors-- ayrtenoideus proprius".

Figure 4. Phantom larynx, with cards showing various laryngoscopic views, cased. European, circa 1870-1916. The case is marked with the owner's name "Sir Thomas Brunton Lauder" (1844-1916). Image credit: Thomas S.G. Farnetti/Wellcome Collection**.** Use by permission from the Wellcome Collection.