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Cranial and spinal nerve anastomoses in man

Abstract

Nerve anastomoses normally exist in human body between cranial nerves, spinal nerves, and between cranial and spinal nerves. They are also frequently performed in surgeries for recovery of functions of denervated areas. These anastomoses are of utmost importance in the process of reinnervation and nerve repair following individual nerve injury. Examples of cranial nerve anastomoses are demonstrated between the branches of the facial nerve and other nerves, the nerves of the tongue, the laryngeal nerves of the vagus nerve, and the optic nerves. Examples of spinal nerve anastomoses are also displayed between the spinal nerve roots and between the individual nerves of the different somatic nerve plexuses: cervical, brachial, lumbar, and sacral.

Keywords: nerve anastomoses, cranial nerves, spinal nerves

Volume 7 Issue 4 - 2020

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Received: June 18, 2020 | **Published:** July 07, 2020

Introduction

Nerve anastomoses indicate interconnections between the branches of different nerves. They are also surgically done to reinnervate nerve-deprived regions. The incidence of these anastomoses may alter the clinical and electrophysiological manifestations of different muscular disorders, modify the required surgical procedures, or may be a source of iatrogenic nerve injury. The current article will review and some of the neural anastomoses naturally present or surgically performed, in different localities of the human body and will highlight their clinical significance.

Anastomoses of the cranial nerves

Facial nerve anastomoses

The seventh cranial (facial) nerve possesses anastomoses between its intraparotid branches, between its terminal branches of both sides of the face, and between its branches and those of other cranial nerves like the trigeminal (V) and accessory (XI) nerves. A good knowledge of this anastomosis is crucial to reduce the incidence of facial nerve paralysis during parotid surgery.

In a study on 48 cadavers and two patients, five types of intraparotid anastomoses of the facial nerve were described: 24% without anastomoses, 12% with anastomosis between the buccal and zygomatic branches, 14% with anastomoses between the buccal and other branches, 38% with multiple complex loop anastomoses, and 12% with two main trunks of the parent nerve. Bilateral similarity in distribution of the facial nerve was discovered in nearly half of the cadaveric specimens.[1] On dissection of human adult Egyptian cadavers, Haroun et al.[2] documented four configurational patterns of the intra parotid part of the facial nerve: plexiform pattern of either wide or narrow meshes (33.3%), tetrapod pattern (33.3%), comb-like pattern (16.7%), and spider-like pattern (16.7%); the facial nerves of both sides in the same cadaver were not essentially identical in configuration. Another cadaveric study on adults and fetuses revealed that anastomoses between facial and trigeminal nerves were similar in all specimens.[3] Recovery of traumatic facial nerve palsy, resulting during excision of an acoustic neuroma, was achieved through anastomosing the intact facial nerve to the paralyzed one.[4] Moreover, normal anastomoses between the terminal branches of the facial and trigeminal nerves provide an explanation for spontaneous recovery of paralyzed facial musculature.[5] In traumatic facial nerve injuries, the cervical branch of the intact facial nerve was anastomosed to the temporal branch of the paralyzed facial nerve using a 20cm- long sural nerve autograft or the ipsilateral descendens cervicalis (of ansa cervicalis) was anastomosed to the cervical branch of the paralyzed facial nerve.[6]

Anastomoses between the facial nerve and other nerves were detected in one-third of postmortem specimens.[7] In a radiological study on human temporal bones, vestibule facial and vestibule cochlear neural anastomoses were identified.[8] Surgical hypoglossofacial anastomoses were performed following excision of cerebello-pontine angle tumours, adopting a surgical technique that greatly reduced the risk of hemi-lingual atrophy and paralysis.[9] Surgical hypoglossofacial anastomosis was recommended as a reliable procedure for recovery of the paralyzed facial musculature when the facial nerve trunk was severed whereas its peripheral branches wereintact.[10] Masseteric-facial neurorrhaphy was also considered as an effective surgical intervention, with minimal morbidity, for correction of early unilateral facial nerve paralysis.[11] When muscle transfer was considered, the masseteric nerve and the anterior division of the obturator nerve (with the gracilis muscle)were highly effective for recovery of paralyzed facial muscles.[12]

The part of the facial nerve from its exit at the stylomastoid foramen till the parotid gland is commonly excised during radical parotidectomy for malignancy. The thoracodorsal nerve (nerve to latissimus dorsi muscle) was found to be morphologically identical with the facial nerve stump at its exit from the skull. Also branches of the thoracodorsal nerve were anastomosed to the severed distal branches of the facial nerve resulting in recovery of the facial musculature within 5-14 months.[13]

Neural anastomoses of the tongue

Anastomoses have been described between the 9th cranial nerve (glossopharyngeal) and the lingual nerve of the 5th cranial nerve (trigeminal}. Following middle ear surgeries, some patients with severed chorda tympani branch of the facial nerves till experienced taste sensation along the anterior 2/3 of the mucous membrane of the tongue. This was explained by the anterior overextension of the lingual branches of the glossopharyngeal nerve beyond the sulcus terminalis and circumvallate papillae thus, assuming a functional interrelation between the cranial nerves V and IX.[14] In addition to the extra lingual anastomosis between the lingual and hypoglossal nerves

on the hyoglossus muscle, microscopic dissection of the tongue demonstrated intralingual anastomoses between the branches of the lingual and hypoglossal nerves and between the terminal branches of the lingual nerve.[15] Sihler method of nerve coloration demonstrated constant intralingual anastomoses between the lingual and hypoglossal nerves and between the glossopharyngeal nerve and the hypoglossal and lingual nerves.[16]

Neural anastomoses of the larynx

Anastomoses between the laryngeal nerves have been well-determined in human cadavers. The branches of the recurrent laryngeal nerve revealed variable anastomotic configurations and innervation patterns of the laryngeal muscles; with reflection on the diagnosis and treatment of paralyzed vocal cords.[17] In most of thyroidectomized patients, motor anastomoses were observed between the recurrent laryngeal nerve and the external laryngeal branch of the superior laryngeal nerve of vagus, with the conclusion that the latter nerve had given motor supply to the intrinsic laryngeal muscles.[18] On microdissection of cadaveric larynges of both sexes, four anastomotic patterns were described between the internal and recurrent laryngeal nerves: Galen's anastomosis between dorsal branches of both nerves, arytenoid anastomosis between arytenoid branches of both nerves, cricoid anastomosis in front of the cricoid lamina , and thyroarytenoid anastomosis between a descending branch of the internal laryngeal nerve and an ascending branch of the recurrent laryngeal nerve. Variations in the laryngeal neural anastomoses between the internal and external laryngeal nerves on one hand and between the external and recurrent laryngeal nerves on the other hand reflected variations in the sensory and motor functions of the larynges.[19] These variations may explain the variable positions of the vocal cords following vocal cord paralysis.[20]

Visual pathway

Nerve fibers originating from the ganglion cells at the nasal side of the retina of one eye decussate, at the optic chiasm, to join the temporal fibers of the other eye then continue through the optic tract to the lateral geniculate body, then through the optic radiation to the visual cortex in the occipital lobe of the cerebral hemisphere.[21] Lesions of the different parts of the visual pathway lead to different extents of visual field defects.

Anastomoses of the spinal nerves

Intradural anastomoses were described on microscopic dissection of cervical nerve roots.[22] In a study on the spinal cords of Koreans, five types of anastomoses were demonstrated between the accessory (XI) nerve and the posterior roots of cervical nerves below C1 segment. In the most common type of these anastomoses, there were bridging fibers connecting the posterior roots of the cervical nerves to the rootlets of the spinal accessory nerve. These bridging fibers seemed to be proprioceptive to trapezius and sternocleidomastoid muscles.[23] Furthermore, textbooks of anatomy describe an anastomotic branch from the ventral primary ramus of C1 nerve to the hypoglossal (XII) nerve; this branch is distributed to the dura mater of the posterior cranial fossa, to the geniohyoid and sternohyoid muscles, and then continues as the superior root (descendens hypoglossi) of the ansa cervicalis (C1,2,3).

Awareness of the neural connections between the upper four cervical nerves (C1-C4) and the lower cranial nerves (V-XII) are helpful during surgeries on the skull base and upper part of the neck in order to avoid iatrogenic injury of any of these nerves.[24,25] Cervical cutaneous branches of the cervical plexus carry sensations from the skin of the anterolateral part of the neck. Nerve anastomoses are greatly variable in the lower part of the face between the cervical, trigeminal and facial nerves.[26] The transverse (anterior) cutaneous nerve of the neck(C2,3) and the great auricular nerve (C2,3) are branches of the cervical plexus, emerge at the posterior border of the sternocleidomastoid muscle, and the extent of their distribution to the lower face was found to be subject-dependent reaching the mandible in 97% of dissected specimens.[27] In dissected necks, anastomoses between the transverse (anterior) cutaneous nerve of the neck and the cervical branch of the facial nerve were located either along the inferior border of the submandibular salivary gland or posterior to the gland.[28] Ramsay Hunt syndrome is an acute herpes zoster affecting the geniculate ganglion of the facial nerve; it is manifested by vesicular eruptions on the ear and in the oral cavity, lower motor facial nerve paralysis and impairment of functions of other cranial nerves (V, IX, XI, and XII).Variability of these manifestations was attributed to the variable anastomoses between the cranial and cervical nerves.[29]

An aberrant accessory phrenic nerve of good size was described, in a cadaveric study, to originate from the supraclavicular nerves forming a neural loop that anastomosed with the phrenic nerve.[30] In the upper extremity, median and ulnar nerve anastomoses are commonly found in the brachial plexus, forearm, and hand. Based on their location, type of fibers (sensory, motor, or mixed), and direction (median to ulnar or ulnar to median), four main patterns of anastomoses have been reported as two anastomoses in the forearm and two in the hand. In the forearm: Martin-Gruber anastomosis included branching of the median nerve proximally to join the ulnar nerve distally, and Marinacci anastomosis as the rarest pattern and the reverse of Martin-Gruber with branching of the ulnar nerve proximally to meet the median nerve distally in the forearm. In the palm: Riche-Cannieu anastomosis was described between the recurrent branch of the median nerve and the deep palmar branch of the ulnar nerve whereas the most frequent Berrettini anastomosis was between the common palmar digital branches of the ulnar and median nerves. These anastomoses may alter the clinical and electrophysiological manifestations of different neuromuscular diseases of the forearm and hand, may modify the required surgical procedures, and may be a source of iatrogenic nerve injury.[31–34] Diseases of Riche-Cannieu anastomosis in the palm may be misdiagnosed as severe carpal tunnel syndrome of the median nerve with consequent unneeded performance of a surgery.[35]

Anastomoses were also determined between the musculocutaneous nerve and other major nerves in the arm and forearm.[36] A communicating branch was reported between the musculocutaneous and median nerves.[37]

In cadaveric specimens, the length, diameter, and total number of myelinated nerve fibers of each of the obturator and genitofemoral nerves were extensively studied to determine the validity of transfer of these nerves for the repair of sacral nerve roots (S1&S2) avulsion. The obturator nerve possessed about one-third of the number of fibers in S1 root whereas the genitofemoral nerve had about half the number of fibers in S2 root.[38]

In dissected adult cadavers, the dorsal nerve of penis was noticed to have 2-6 main branches with anastomoses between them in 22.7% of specimens. In 72.7% of specimens, branches from the inferior aspect of the dorsal nerve of penis perforated the tunica albuginea.

These anatomical observations must be considered during surgical reconstruction of the penile shaft.[39]

Conclusion

Anastomose are found between cranial nerves, between spinal nerves, and between spinal and cranial nerves. They are also surgically performed to resupply denervated areas. A thorough knowledge of the anatomical features of these nerve interconnections is crucial to clinical practice. Awareness of these anastomoses provides a tool for identification and preservation of the anastomotic nerves during surgeries to avoid iatrogenic nerve traction or transaction.

Acknowledgments

None.

Conflicts of interest

The authors declare there are no conflicts of interest.

Funding

None.

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