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Neural Connections between the Nervus Intermedius and the Facial and Vestibulocochlear Nerves in the Cerebellopontine Angle: An Anatomic Study

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Abstract

Purpose: Unexpected clinical outcomes following transection of single nerves of the internal acoustic meatus have been reported. Therefore, this study aimed to investigate interneural connections between the nervus intermedius and the adjacent nerves in the cerebellopontine angle.

Methods: On 100 cadaveric sides, dissections were made of the facial/vestibulocochlear complex in the cerebellopontine angle with special attention to the nervus intermedius and potential connections between this nerve and the adjacent facial or vestibulocochlear nerves.

Results: A nervus intermedius was identified on all but 10 sides. Histologically confirmed neural connections were found between the nervus intermedius and either the facial or vestibulocochlear nerves on 34% of sides. The mean diameter of these small interconnecting nerves was 0.1 mm. The fiber orientation of these nerves was usually oblique (anteromedial or posterolateral) in nature, but 13 connections traveled anteroposteriorly. Connecting fibers were single on 81% of sides, doubled on 16% and tripled on 3%, Six sides had connections both with the facial nerve anteriorly and the vestibular nerves posteriorly. On 6.5% of sides, a connection was between the nervus intermedius and cochlear nerve. For vestibular nerve connections with the nervus intermedius, 76% were with the superior vestibular nerve and 24% with the inferior vestibular nerve.

Conclusions: Knowledge of the possible neural interconnections found between the nervus intermedius and surrounding nerves may prove useful to surgeons who operate in these regions so that inadvertent traction or transection is avoided. Additionally, unanticipated clinical presentations and exams following surgery may be due to such neural interconnections.

Introduction

The nervus intermedius carries the sensory and parasympathetic parts of the facial nerve. This small nerve has an average diameter of 0.62 mm and a mean length from the brainstem to the porus acousticus of 14 mm [1]. Historically known as the nerve of Wrisberg [7,29], the nervus intermedius can have an intimate relationship with adjacent nerves [2].

Rhoton et al. [20] described the nervus intermedius as having three parts: a proximal segment that is adherent to the vestibulocochlear nerve, an intermediate segment that is positioned between the acoustic nerve and the motor root of the facial nerve, and a distal segment that unites with the motor root to form the facial nerve proper. These authors also found that 22% of the nervus intermedius specimens examined in their study were adherent to the vestibulocochlear nerve in the cerebellopontine angle and separated from this nerve only after the roof of the internal acoustic meatus was opened.

Various unexpected postoperative symptoms have been reported following individual manipulation of the nerves of the internal acoustic meatus. For example, Sachs [22], after sectioning the nervus intermedius, reported pain following stimulation of the vestibular nerve. The pain resolved only after sectioning the vestibulocochlear nerve. Rowed [21] blamed rogue sensory interconnecting nerve fibers that are not transected during surgical treatment of geniculate neuralgia for persistent symptoms. Morgenlander and Wilkins [15] treated one patient with cluster headaches with nervus intermedius sectioning alone, and this patient experienced postoperative deafness. In fact, Rowed [21] reported that hearing impairment is the most common serious complication following sectioning of the nervus intermedius for geniculate neuralgia. Moreover, cases of taste dysfunction following vestibular nerve surgery have been reported [31],

In order to investigate an anatomical reason for such unanticipated clinical presentations and exams following surgery of the nervus intermedius in the cerebellopontine angle, the present anatomic study was performed.

Materials and Methods

We used 50 adult cadaveric specimens (100 sides) with an age at death between 46 and 99 years (mean 76.5 years) that had been formalin-fixed for the present study. Twenty-nine specimens were male and 21 female. We examined the nervus intermedius from the brainstem to the porus acousticus. No specimens were found to have gross intracranial pathology. All dissections were performed under a surgical microscope (Zeiss, Germany). After a large craniotomy was performed over the posterior fossa on left and right sides, the dura mater was incised and the cerebellopontine angle entered. The facial/vestibulocochlear nerve complex was visualized and severed with microsurgical scissors as close to the brainstem as possible. Once severed on both sides, the calvaria were removed with an oscillating bone saw (Stryker, Michigan) and the brains removed and observations/and dissections made of the facial/vestibulocochlear complex in the cerebellopontine angle with special attention given to the nervus intermedius and potential connections between this nerve and the facial or vestibulocochlear nerves. When identified, random samples of such communicating branches were submitted for histologic examination (Masson Trichrome) to confirm their neural nature. Connections were measured using a microcaliper (Mitutoyo, Japan). Statistical analysis was performed comparing sides and gender using Statistica for Windows and significance was set at $p<0.05$.

Results

A nervus intermedius was identified on all but 10 sides (6 right sides and 4 left sides). It was not separated from the vestibulocochlear nerve. On 59 sides (66%), no connections were identified (Fig. 1). Connections were found between the nervus intermedius and either the facial (11%) or vestibulocochlear nerves on 31 sides (34%). The diameter of these small interconnecting nerves had a mean of 0.1 mm (range 0.05-0.3 mm). The fiber orientation of these nerves was most often oblique (anteromedial or posteromedial) in nature (Figs. 2 and 3). However, on 4 sides (13%; 3 left and 1 right side) the connections traveled anteroposteriorly between the nervus intermedius and adjacent nerves (Fig. 4). Connections were usually single between the nervus intermedius and either facial nerve anteriorly or vestibular nerve posteriorly. Connecting fibers were single on 81% of sides, doubled on 16% of sides and tripled on 3% of sides. Six sides had connections both with the facial nerve anteriorly and the vestibular nerves posteriorly. On 2 sides (6.5%), the connection was between the nervus intermedius and the cochlear nerve. For vestibular nerve connections with the nervus intermedius, 74% were with the superior vestibular nerve and 26% were with the inferior vestibular nerve. Figure 5 shows schematically the various findings in our study. Histologically, all samples of these internervous connections were found to be neural in nature (Fig. 6). No statistical differences were identified between sides or gender. Figure 7 shows the salient findings of the various connections found.

Discussion

Peripheral nerves are known to sometimes communicate with one another [12]. Connections between neighboring lower cranial nerves have been reported [13,24,25,28]. However, few reports exist on the connections between the nerves of the internal auditory meatus. Oort [17] was the first to describe a connection within the internal auditory meatus between the vestibular and cochlear nerves, the so-called anastomosis of Oort. Regarding deep connections between the facial and vestibulocochlear nerves, Paturet [18] found connections between the genu of the facial nerve and Scarpa's ganglion. Cruveilhier [5] also described nerve connections between the facial and vestibulocochlear nerves and this was confirmed by later reports [8-10]. Hovelacque [11] cited Arnold two connections at the level of the porus acousticus, 1 lateral (from the facial nerve to the vestibular ganglion, with containing sympathetic fibers, 1 medial that might belong to the nervus. intermedius and connect to the vestibular nerve. This author also mentioned that Beck found each of these types as well but as single connections and that Bischoff identified two connections, the medial one from the nervus intermedius to the vestibulocochlear nerve and the lateral one from the this latter nerve to the facial nerve.

More recently and specifically, Tian et al. [27] reported vestibular to facial nerve and vestibular to cochlear nerve connections. Interestingly and historically, some investigators (e.g., von Haller, Sommering, Longet) have considered such connections to be nonexistent [23].

Within the internal acoustic meatus, Özdogmus et al. [17] reported a connection between the vestibular nerves and facial nerve, but no connections between the cochlear and facial nerves. Nageris et al. [16] noted a communication between the facial and vestibular nerves in the temporal bone in 82% of specimens. Clinically, this vestibular to facial nerve communication is a possible reason why some patients develop nystagmus following facial nerve block as a treatment of hemifacial spasm [30]. Furthermore, such connections have been implicated in the vestibular disturbance seen in patients with facial paralysis [8], Some have considered that persistence of vertigo in patients who have undergone cochlear nerve neurectomy might be due to connections between the cochlear and vestibular nerves [19]. Asram et al. [3] found that muscles around the mouth contracted with stimulation of the nervus intermedius, implying that this nerve might carry some motor fibers from the facial nerve. Chouard [4] recommended improving surgical outcomes in patients with Meniere's disease by transecting not only the vestibular nerve, but also any neural connecting fibers between the cochlear and facial nerves. Finally, Martin and Helsper [13] reported function of the muscles of facial expression even with complete transection of the facial nerve during removal of a parotid tumor. This reported case might lend credence to the notion that neural connections between the facial nerve and the nervus intermedius in the cerebellopontine angle might be functional connections that allow function even with injury to nerves downstream, i.e., motor fibers from the facial nerve that join the nervus intermedius in the cerebellopontine angle and travel through the geniculate ganglion and via its various branches (e.g., the greater petrosal-lacrimal branches to the upper eyelid), provide innervation to the facial muscles.

Rhoton et al. [20] did not identify a separated nervus intermedius in the cerebellopontine angle in 22% of sides in their study. The nerve was identified only after opening the internal acoustic meatus. We found the nervus intermedius in all but 10% of sides. Tarlov [26] suggested that the nervus intermedius is divisible into sensory and motor parts and that in some cases, the motor component is further separated into roots with vasodilatory and glandular secretory fibers.

Our study confirmed the presence of connections between the nervus intermedius and facial and vestibulocochlear nerves and demonstrated that these are neural in nature. Two types of fiber trajectory were noted, oblique (anteromedial and anterolateral) and anteroposterior.

These interconnections were not always found, but when present, they could be single, doubled, or tripled.

Conclusions

Misidentifying such neural connections as found in the present study between the nervus intermedius and facial and vestibulocochlear nerves may result in inappropriate traction on a neighboring nerve with the potential for iatrogenic injury. Such connections might also make dissection between the nerves of the internal acoustic meatus more difficult. Therefore, knowledge of such branching patterns is important to the surgeon who operates in the cerebellopontine angle and may help explain certain unusual neurological findings during physical examination [6]. The functional importance of such neural interconnections between the nervus intermedius and facial and vestibulocochlear nerves remains to be determined.

Conflicts of Interest

The authors declare no conflicts of interest. No funding was received for this study.

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Figure Legends:

Figure 1: Left-sided nerves showing no connections between the nervus intermedius (NI) and surrounding facial (VII) or vestibulocochlear nerves (VIII).

Figure 2: Left-sides nerves demonstrating a single oblique connection (arrow) between the nervus intermedius (NI) and anteriorly placed facial nerve (VII). Note the vestibulocochlear nerve (VIII).

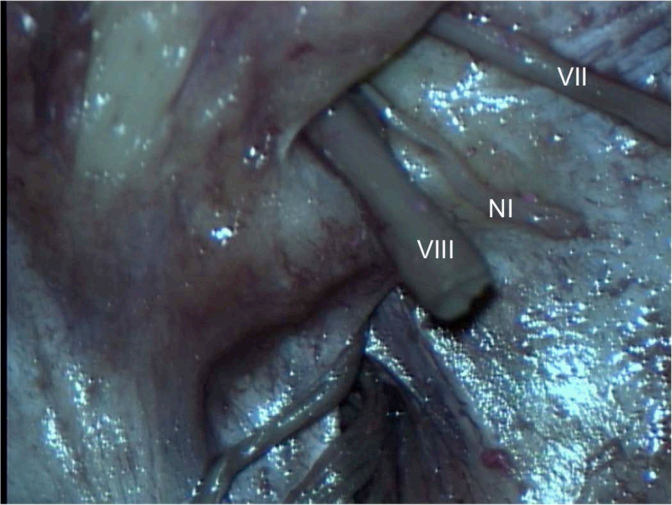
Figure 3: Left-sided skull base noting the abducens (VI), facial (VII), nervus intermedius (NI), and vestibulocochlear (VIII) nerves and adjacent glossopharyngeal/vagus nerve complex (IX/X). The arrow marks an anteroposterior connection between the nervus intermedius and vestibulocochlear nerves.

Figure 4: Right-sided skull base near the porus acousticus and jugular foramen. Note the trigeminal (V), facial (VII), and vestibulocochlear (VIII) nerves and nervus intermedius (NI). The arrows mark the multiple interneural connections between the nervus intermedius and facial and vestibulocochlear nerves.

Figure 5: Schematic drawing of the internal acoustic meatus with percentages of nerve connection findings from left and right sides combined.

Figure 6: Histological example (H&E ×440) of the neural nature of the interconnections (ramus communicans) identified between the nervus intermedius and facial and vestibulocochlear nerves. A normal population of myelinated nerve fibers is seen.

Figure 7: Connections between the nervus intermedius and surrounding nerves. Abbreviations: NI=nervus intermedius; VIII=vestibulocochlear nerve; VII=facial nerve; SVN=superior vestibular nerve; IVN=inferior vestibular nerve.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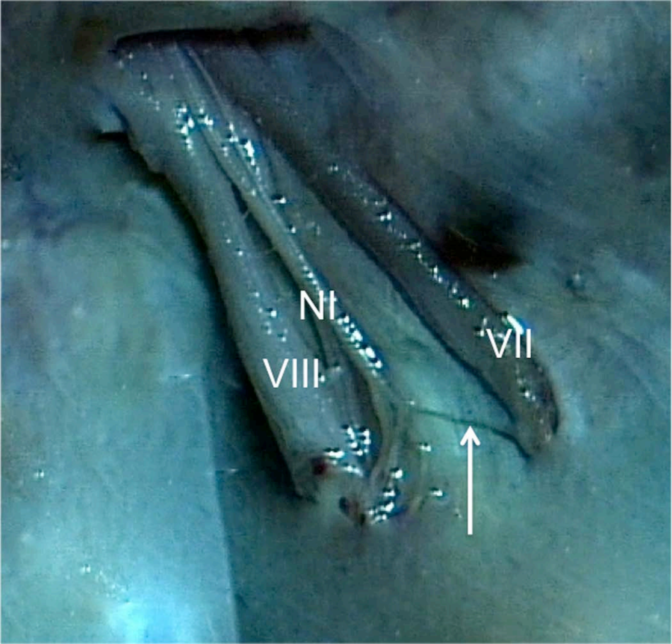
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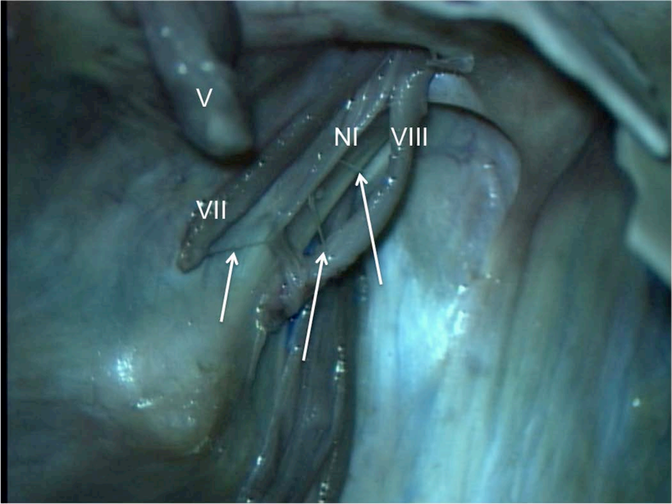
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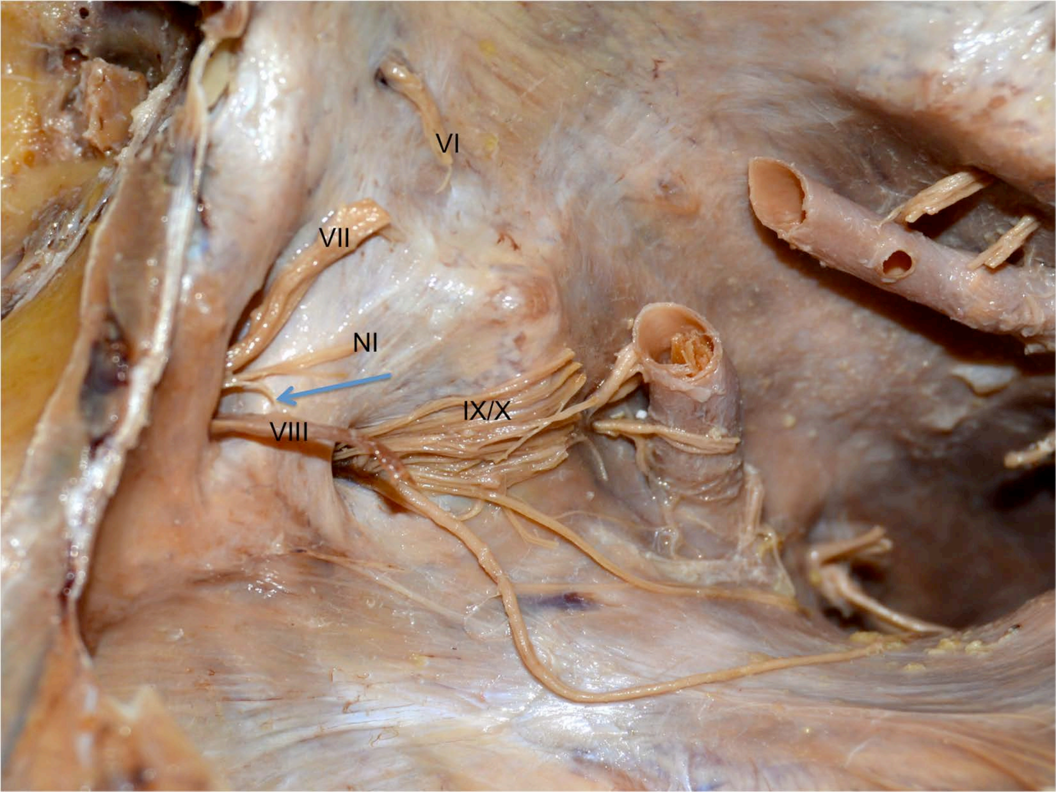
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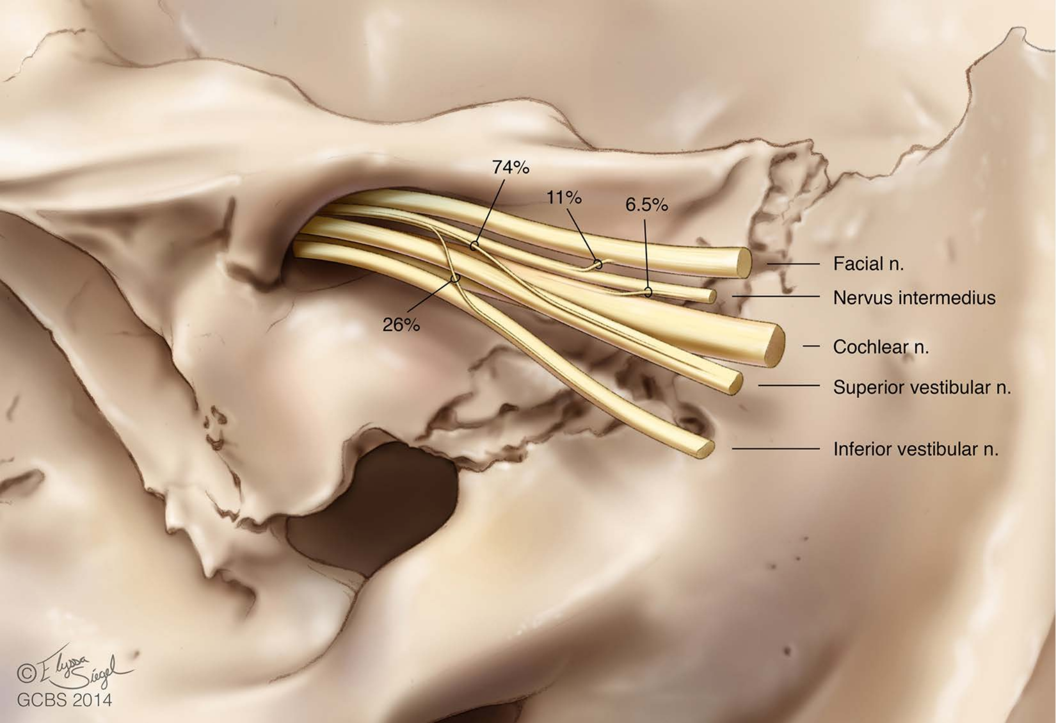
74%
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Cochlear n.
Superior vestibular n.
Inferior vestibular n.
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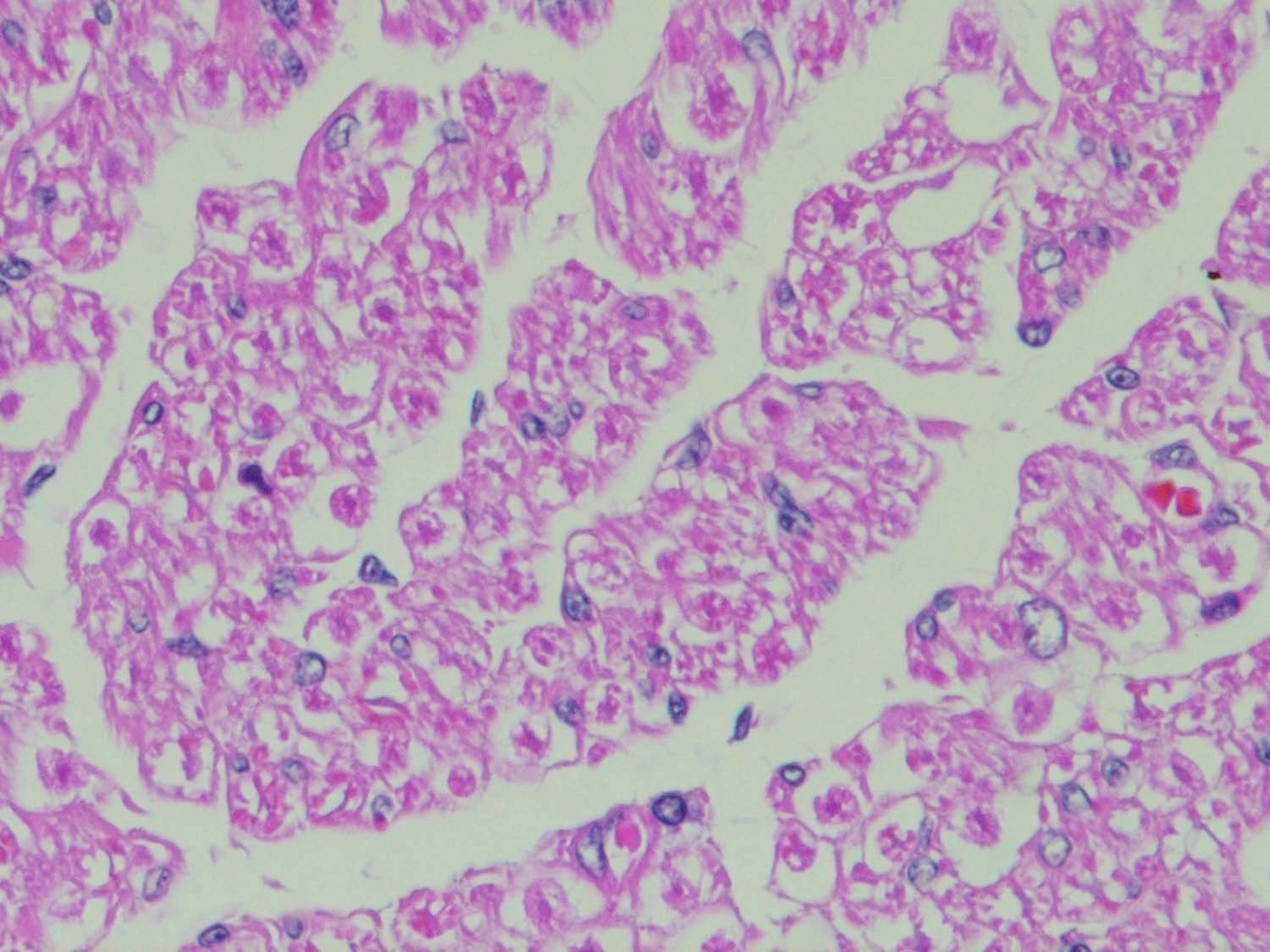

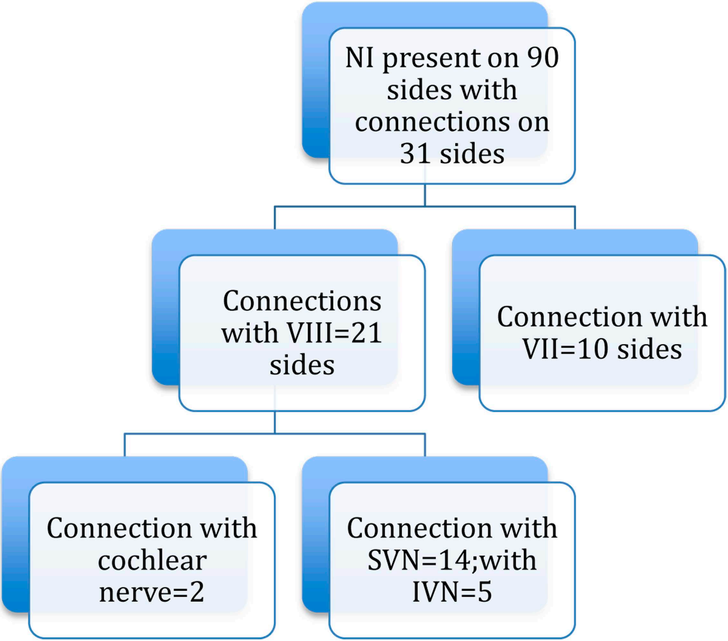
NI present on 90 sides with connections on 31 sides
Connections with VIII=21 sides
Connection with VII=10 sides
Connection with cochlear nerve=2
Connection with SVN=14;with IVN=5