Audiology & Neuro-Otology

Audiol Neurootol 2004;9:66–71
DOI: 10.1159/000075997

Sketches of Otohistory

Part 1: Otoprehistory: How It All Began

Joseph E. Hawkins

Kresge Hearing Research Institute, University of Michigan, Ann Arbor, Mich., USA

Medical knowledge of the ears and insight into their diseases came late in history, and clinical progress was painfully slow. From the earliest times there were folk remedies for earache and related ailments, but profound deafness was long regarded as a sign of feeble intelligence, and the deaf were thought to be both unteachable and untreatable. In later years there were 'aurists', both ethical and otherwise, who attempted – or pretended – to treat ear diseases, including deafness. It was not until after the middle years of the 19th century that otology became an essential and respected medical specialty.

The inner ear's small size and surgical inaccessibility must have been primarily responsible for medical ignorance and long neglect, as well as for the lack of fruitful philosophical interest in hearing and deafness. Even so, the few Egyptian medical papyri that have survived the ages suggest that there may have been some physicians of that era who dealt only with the ears, just as others had limited their practice to the eyes. The earliest known scientific document, the Edwin Smith Surgical Papyrus of 3,000–2,500 BC, includes descriptions of battle injuries to temporal bones, and how they affected the hearing and speech of the wounded. In the sacred Egyptian pharmacopoeia from about 1,500 BC that is known as the Ebers Papyrus, there is a chapter on 'Medicines for the Ear with Weak Hearing'.

Among the Greeks, the first to write of acoustics was the mathematician Pythagoras, of Croton in southern Italy's Magna Graecia, who discovered the inverse relationship between the length of a monochord string and the pitch of the note it produced. The physician Alcmaeon, of that same Greek colony, who was the earliest neuroanatomist, carried out dissections that revealed the cranial nerves. Some have suggested that he may have discovered the Eustachian tube, but Politzer in his *Geschichte der Ohrenheilkunde* assures us that he must have been dissecting the external ear canal and not the tube when he got the notion that goats breathe through their ears. Alcmaeon believed that hearing occurs when movements of the air strike the void within the ear, and that deafness is the result of concussion that shifts the brain and prevents auditory signals from reaching it.

The cochlea was probably discovered by the Sicilian philosopher Empedocles, patron of the four elements. At least he must have been impressed by its form, for he named it after the sea snail, κόχλοζ, the prized source of the Tyrian purple dye. (He would have known from his native Greek that the omicrons in that word were pronounced as short o. This knowledge seems lost on the editors of certain modern dictionaries that countenance the sorely frequent US pronunciation with a long o.) Later Greek philosophers, including Diogenes, Plato and Aristotle, may have thought more deeply, but they had no knowledge of ear anatomy. They believed that a resonant space in the ear or head was filled with highly purified air. When it vibrated in response to sound, it gave rise to hearing, which they regarded as the 'air sense'. Aristotle's illusion of that special air, implanted in the fetus or at birth, persisted unchallenged until the 18th century, when Cotugno demonstrated to the world that the inner ear was entirely filled with a watery fluid.

KARGER

Fax + 41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

1420–3030/04/0092–0066$21.00/0

Accessible online at:
www.karger.com/aud

Joseph E. Hawkins
Kresge Hearing Research Institute
1301 E. Ann Street
Ann Arbor, MI 48109-0506 (USA)
Tel. +1 734 764 0215, Fax +1 734 764 0014, E-Mail josehawk@umich.edu

In sickness the Romans depended upon their Greek physicians. The acute observations of Hippocrates of the Aegean island of Cos (450–377 BC) about the symptoms, diagnosis, course and treatment of diseases, including those of the ear, had been faithfully recorded by his disciples and reverently handed down. His methods of treatment were almost entirely empirical, and he had scant knowledge of anatomy of the ear. He was mainly concerned with its infections and with their relations to other organs, including the tonsils and the brain.

It was only in the first century AD that a Roman medical writer, Celsus, described treatments for tinnitus, otitis, deafness and foreign bodies in the ear, as well as surgery for atresia of the external meatus and injuries to the pinna. The Empire's most famous physician-anatomist and most prolific medical author was Galen, a native of Pergamon, who spent some of his years in Rome caring for the health of the philosopher-emperor, Marcus Aurelius. In the course of his many dissections of dogs and monkeys, Galen seems to have taken a cursory look at the inner ear. He named it for the Cretan *labyrinth,* thus admitting his wonder and ignorance of its intricate structure. In fact, his notions of otoanatomy seem to have been little better than those of Hippocrates. Nevertheless, the arbitrary rules he laid down for the treatment of signs and symptoms of diseases, including those of the ear, such as otitis, tinnitus and hearing loss, were followed religiously for the next 14 centuries.

Little if anything of value or significance was added to medical knowledge after the fall of Rome. In that sterile period, Byzantine physicians upheld, but did not expand, traditional Greek medical knowledge, and much the same can be said for the Arabs and the Jews. It was only in the 16th century, after the Renaissance in painting and sculpture, that human anatomy came into its own, with such dominant figures as Leonardo, Michelangelo, Eustachi, Vesalius, Fallopio and Fabrizi. The ear was by no means neglected. Its malleus and incus were discovered by several anatomists independently, but Berengario da Carpi was apparently the first to note those ossicles. Credit for discovery of the stapes was claimed by several famous anatomists, included Eustachi, Vesalius and Fallopio, but it seems rightfully to belong to his contemporary, the Sicilian Ingrassia. According to Politzer, Eustachi gave the first accurate description of the tensor tympani and recognized the chorda tympani as a nerve and not a blood vessel. Of his numerous anatomical discoveries, the only one that bears his name is the tube. Fallopio, as surgeon and anatomist, was hailed as the 'Aesculapius of his century' and brought renown to the Paduan school of medicine. He discovered and explored the facial canal or Fallopian aqueduct, and, likening the middle ear cavity to a drum, he named it the *tympanum*. In his *De morbo gallico* he wrote of the unbearably loud tinnitus that can occur in the late stage of lues (fig. 1).

Of the followers of Fallopius, the best known is Girolamo Fabrizi (Fabricius ab Aquapendente), who gained fame and wealth as a surgeon. He published a theory of hearing that involved the mixing of animal spirits from the auditory nerve with Aristotle's implanted air. He insisted that ear surgery required adequate lighting, with either focused sunlight or candlelight. Fabrizi's chosen successor, Casseri, an early comparative anatomist, recoded the forms of the auditory ossicles in various animal species. He was also concerned with the human voice, and with tracheotomy as a surgical procedure. Among the 16th-century Italians there was also Varoli, a neuroanatomist of Bologna, whose name is linked with the pons. In his brief career he accurately described the stapedius muscle and likened its action and that of the tensor tympani to the role of the iris in protecting the retina against overstimulation.

Anatomical studies of the ear continued in the 17th century, but in the light of new knowledge of its inner structure there was a growing tendency, especially among the French, to speculate about its physiology. Laurant denied the importance of the implanted air and emphasized the role of the 'fifth' (i.e. the eighth) cranial nerve in hearing. The architect and physicist Perrault, in his essay on noise *(Du bruit)*, regarded the 'spiral membrane' of the cochlea as the true organ of audition. It could be shattered by the strong vibrations of loud noise, and in old age it could become too dried out to respond to sound. Mery rediscovered Eustachi's membranous spiral lamina that divided the spiral canal into two scalae and pointed out 'un petit trou' (a little hole) the cochlear apex, to which Breschet later gave the name *helicotrema.*

The most celebrated anatomist during the reign of Louis XIV was Duverney, who was appointed to instruct the royal family and courtiers in his fashionable science. In his elegant small volume, *Traité de l'organe de l'ouïe*, he not only presented impressive drawings of his dissections of the inner ear, but affirmed that sound is transmitted, not by air to the round window, but by the ossicular chain to the oval window. In proposing a resonance theory of sound analysis by the cochlea, he anticipated Helmholtz. From the gradual narrowing of the osseous spiral lamina from base to apex, he inferred that the base responds to the lower frequencies and the apex to the higher. He could not measure the tapered width of the

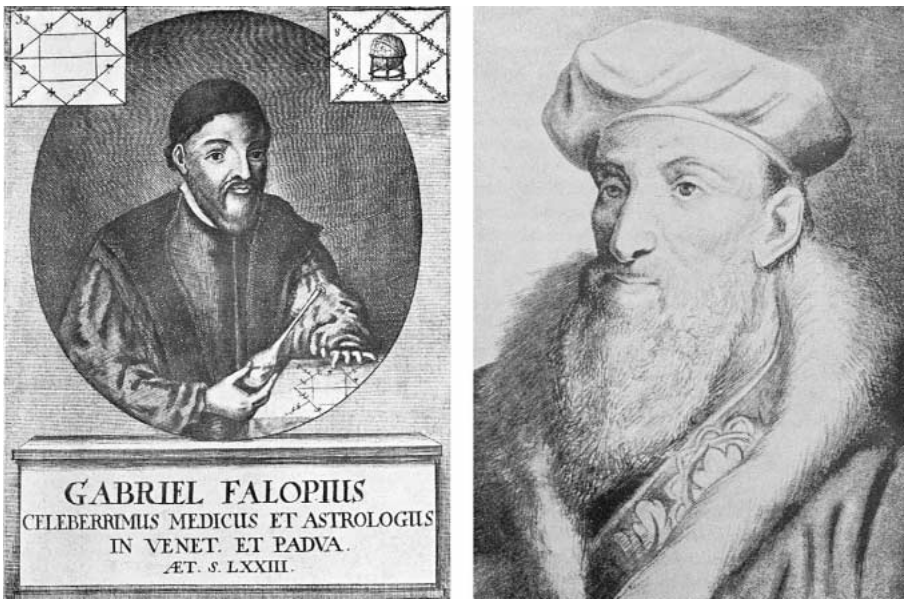

Fig. 1. Sixteenth-century Italian anatomists. Left: Gabriel Fallopius (1523–1562). Right: Bartholomeo Eustachi (1510–1574). From Politzer A: Geschichte der Ohrenheilkunde. Stuttgart, Enke, 1907, vol 1, plates III and IV.

Fig. 2. British scientists, Elizabethan and Jacobean. Left: Francis Bacon (1561–1626). From 'Portrait of Sir Francis Bacon', Holl F: Works of Francis Bacon. London, Spedding, Ellis, Heath, 1857, vol 1. Right: Thomas Willis (1621–1675). Portrait by George Vertue; in Birch T: Heads of Illustrious Persons of Great Britain. London, Knapton, 1742.

basilar membrane, which shows the exact opposite to be true.

In Elizabethan and Stuart England there were two noteworthy contributors to auditory studies, the court philosopher and alleged author of Shakespeare, Francis Bacon, and the Oxford physician and founder of neurology, Thomas Willis (fig. 2). Bacon wrote about hearing and speech, and numerous other acoustic phenomena, including the injurious effect of intense sound. He mentioned a Spanish auditory instrument, perhaps the first hearing

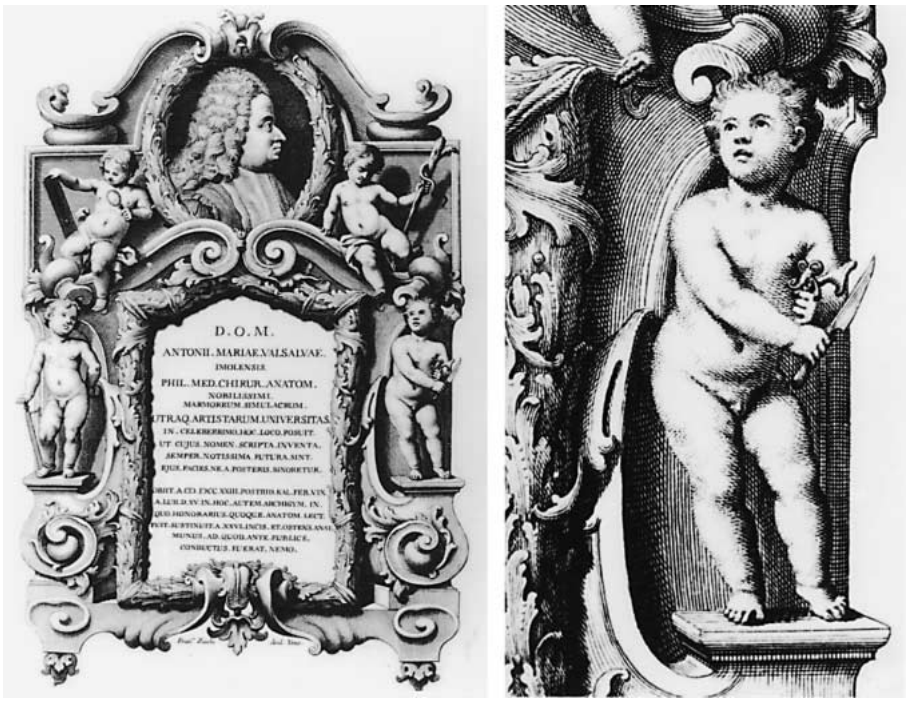

Fig. 3. A tribute to Valsalva. Left: Engraving from his posthumously published *Tractatus de aure humana*, Bologna, 1740. Right: Putto with knife and well-dissected ear.

aid, 'that helpeth somewhat those that are thick of hearing'. Unfortunately, he never got around to writing the volume on audition and acoustics that he promised to his readers. Willis was the first to recognize that the cochlea was the true organ of hearing. He pointed out that diplacusis was possible, and also wrote of the phenomenon of 'paracusis', whereby some hard-of-hearing patients hear better in noise than in quiet. Furthermore, he suggested a theoretical distribution of high and low frequencies in the cochlea, even before Duverney.

Otological studies in the 18th century were dominated by the Italians, primarily from Bologna. The first of them was Valsalva (fig. 3), a pupil of the histologist Malpighi. Valsalva's *Tractatus de aure humana,* published after his death by his follower and former prosector, the pathologist Morgagni, was based on 16 years of work, in dissecting more than a thousand human heads. One section of its text was anatomical, the other physiological. In one case of deafness he demonstrated disarticulation of the incudo-stapedial joint, and in another, ankylosis of the stapes. Unlike his predecessors, he located the terminations of the auditory nerve in the membranous portion of the labyrinth rather than in the osseous spiral lamina and referred to them as sound receptors, comparable with harps having strings of different lengths. Thus, Valsalva may also be said to have anticipated Helmholtz.

Of Morgagni's 20 *Epistolae anatomicae,* 7 were concerned with the ear. One described the minor effect on hearing of experimental perforation of the tympanic membrane in a dog. In his monumental work of pathology, *De causis et sedibus morborum,* he considered the relation between otitis media and brain abscess, concluding, in opposition to so many of his contemporaries, that the otitis was primary, the brain abscess its secondary effect.

Credit for the discovery of the liquids filling the inner ear also belongs to the Italians, to Cotugno of Naples (fig. 4) for the perilymph and to Scarpa of Modena and Pavia (fig. 5) for the endolymph. At the age of 24, while still a student, Cotugno published his epoch-making *De acquaeductibus auris humanae...* His impressive later contributions were made in other fields of medicine. Scarpa's *Disquisitiones anatomicae de auditu et olfactu* tells of his discovery of the membranous labyrinth with its 'spiral passage' (the cochlear duct), containing a watery fluid, the endolymph. He also traced the course of the branches of the auditory nerve to their various sites of ending in the labyrinth, of course never suspecting that almost half of them were concerned with a sense quite different from hearing.

By the early years of the 19th century, knowledge of the gross anatomy of the inner ear was well established, and physiology was beginning to be based on experiment rath-

Fig. 4. Italian finders of the inner ear fluids. Left: Domenico Cotugno (1736–1822). Right: Antonio Scarpa (1752–1832). From Politzer A: Geschichte der Ohrenheilkunde. Stuttgart, Enke, 1907, vol 1, plates XV and XVI.

Fig. 5. Parisian otoanatomist and Viennese otologist. Left: Gilbert Breschet (1784–1845). Lithograph by Grégoir et Deneux after A. Maurir, edited by Rosselin, Paris. Right: Adam Politzer (1835–1920). Undated photo by Angerer. From Majer EH, Skopec M: Zur Geschichte der Oto-Rhino-Laryngologie in Österreich. Vienna, Brandstätter, 1985. Reproduced with permission by Institut für Geschichte der Medizin, Wien.

er than imagination. Breschet of Paris (fig. 5), with his *Recherches anatomiques et physiologiques sur l'organe de l'ouïe,* brought order into otoanatomical nomenclature, in imitation of Carl von Linné's monumental service to biological taxonomy. Breschet insisted upon precision in the definitions of older terms and coined welcome new names, such as *helicotrema, endolymph, perilymph, otolith* and *otoconia.*

In Germany the pioneer of experimental physiology was Johannes Müller of Berlin, who attracted many pupils, including Helmholtz. Müller was interested in all aspects of sensation, including hearing, and he was the first to make an experimental study of the passage of sound waves from air to water. Among contemporary anatomists was Rosenthal of Greifswald, whose dissections revealed the modiolar canal that contains the spiral ganglion and still bears his name. Huschke of Jena discovered the zona dentata of the limbus when he examined the inner ears of birds. He thought that he had found the true endings of the auditory nerve fibers. That triumph was

left for Corti, whose teacher, Hyrtl of Vienna, used the corrosion technique to study the blood vessels of the ear.

Despite this upsurge of research activity, the practice of aural medicine and surgery languished for years, dominated and misdirected by the edicts of a German autodidact named Kramer, who insisted upon the rightness of his not infrequently wrongheaded clinical convictions and the futility of further anatomical and pathological investigation. Many aurists, both in Britain and on the Continent, were far worse: either unskilled incompetents with virtually no training or outright quacks and charlatans. In a letter to Covington in 1859, Charles Darwin expresses regrets over his friend's deafness, but advises him that aurists are humbugs. A few conscientious practitioners, fully aware of the almost total absence of professional or public respect for their chosen medical field, were determined to rehabilitate it by the reforms that it so desperately needed. Their devoted labors were soon to begin in the British Isles.

Acknowledgment

The most thorough and reliable account of the origins of otology, from its very beginnings until the early years of the 20th century, was offered by Politzer in figure 6 in the first volume of his *Geschichte der Ohrenheilkunde* (1907; an English translation was published in 1981). His *Geschichte* was the major source used by this writer for the chapter, 'Auditory Physiological History: A Surface View', that appeared in Jahn and Santos Sacchi's *Physiology of the Ear* (1988, 2001). The information presented here is based on those sources.