

History of the Italian Vestibology: The Masters

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The life and the works of the Italian scholars who, over the centuries, have made significant contributions to the knowledge of the vestibular system are presented: Valsalva, Cotugno, Scarpa, Lussana, Tullio, Arslan, Dufour, Guidetti

Keywords: vestibology, otoneurology, neurotology

Introduction

In this article, I present a series of Italian scholars who, over the centuries, have made significant contributions to advancing knowledge of the vestibular system, from anatomy and physiology to pathology and clinical practice.

Antonio Maria Valsalva (1666–1723)

Antonio Maria Valsalva (Fig. 1) was born in Imola on January 17, 1666 to parents of humble origin. Educated by the Jesuits, the young Valsalva - docile, disciplined, and of wide-ranging intelligence - soon revealed a strong inclination for anatomical studies: he dissected birds and other small animals with a zeal far beyond his age, carefully examining their internal organs. Recognizing his talents, he was sent to study at the Archiginnasio of Bologna, where he pursued medicine and, above all, anatomy under the guidance of Marcello Malpighi. He graduated *magna cum laude* in 1687 and in 1697 became chief physician of the Sant'Orsola Hospital. The following year he was elected Surgeon, a position he held with great distinction until his death. In 1697 he was appointed "public dissector of anatomy" by the city's High Council, which allowed him to display his prepared specimens in the Anatomical Theatre - an unprecedented

ed honour at the time. From 1705 he served as "public lecturer and demonstrator of anatomy", later becoming honorary lecturer of surgery and practical surgical anatomy. A favorite pupil of Malpighi, he shared with him a passion for scientific rigor and inquiry, and he later became the mentor of Giovanni Battista Morgagni. Valsalva died in Bologna on February 2, 1723.

Valsalva's studies of the anatomy of the ear, aorta, colon, and vagus nerve were fundamental. His masterpiece, *De aure humana tractatus*, was first published in Bologna in 1704 (Fig. 2), with a final revised edition prepared by Morgagni in 1740. Valsalva worked on this treatise for more than sixteen years, dissecting over one thousand heads. For the first time, the modern division of the ear into external, middle, and inner parts appeared in its pages. In his description of the auricle, he identified the extrinsic muscles and the ceruminous glands of the auditory canal. Most importantly, in his study of the inner ear he gave a detailed account of the cochlea and the semicircular canals, and for the first time described the presence of fluid - *ut aqua limpida* - within them, thereby laying the anatomical foundations for understanding the mechanisms underlying hearing and balance.



Figure 1. Portrait of Antonio Maria Valsalva

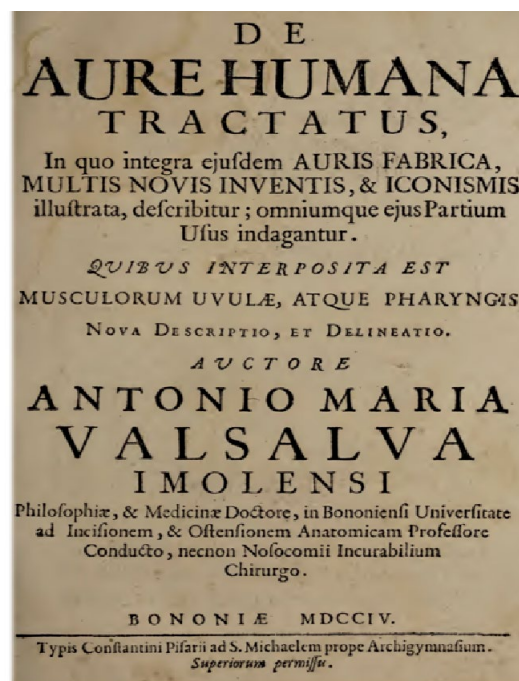


Figure 2. Valsalva's book: *De aure humana tractatus*, 1704 edition

Domenico Cotugno (1736–1822)

Domenico Cotugno (Fig. 3) was born in Ruvo di Puglia on January 29, 1736 into a modest family of farmers. After studying at the episcopal seminary of Molfetta, at the age of sixteen he moved to Naples, where from 1754 he served first as assistant and later as physician at the Ospedale degli Incurabili. This institution became his true laboratory of medico-scientific experimentation, offering him the opportunity to explore the close relationship between anatomy and surgery. He graduated in 1756 from the Salerno Medical School and began giving private medical lessons before competing for academic posts at the University of Naples. In 1758 he was appointed associate professor of *notomia* (descriptive and pathological anatomy), and in 1766, at just thirty years of age, he obtained the full professorship. In the following years he undertook two significant journeys: first within Italy, and later to Austria and Germany, during which he served as court physician to King Ferdinand IV of Naples. Back in Naples, Cotugno introduced prophylactic measures against tuberculosis, became dean of the Faculty of Medicine, rector of the University, and chief physician (*proto-medico generale*) of the Kingdom of the Two Sicilies. He died in Naples on October 6, 1822.

Among Cotugno's many writings, his *De aquaeductibus auris humanae anatomica dissertatio* (Naples, 1761) (Fig. 4) remains especially noteworthy. In this treatise he provided the first description of the vestibular and cochlear aqueducts and demonstrated the ubiquitous presence of fluid within the labyrinth, thereby refuting the prevailing belief - held even by distinguished anatomists such as Vieussens, Valsalva, and Morgagni - that air was also present in this structure. Cotugno described the bony labyrinth with remarkable detail, focusing particularly on its vestibular portion. He carefully depicted the bony semi-circular canals, the vestibular and cochlear windows, and the cochlea with its vestibular and tympanic scalae, emphasizing that the vestibular scala is much narrower than the tympanic scala at its basal origin. He also noted their incomplete separation by the osseous spiral lamina and precisely measured the width of the basilar membrane, broader at the apex than at the base of the cochlea. Cotugno did not, however, identify the membranous labyrinth or distinguish the labyrinthine fluid into endolymph and perilymph. Nevertheless, based on his morphological observations, he advanced a new theory of hearing, proposing that the labyrinthine fluid, being incompressible and confined within a closed

cavity, was forced by tympanic membrane vibrations induced by sound waves to flow into the aqueducts, which acted as a drainage system.

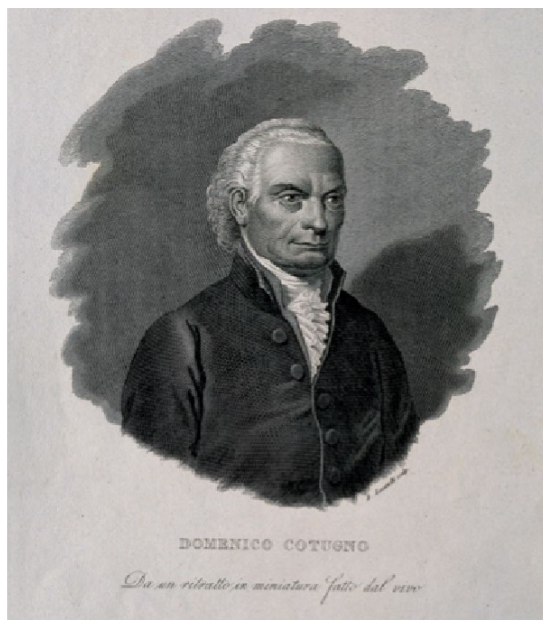


Figure 3. Portrait of Domenico Cotugno

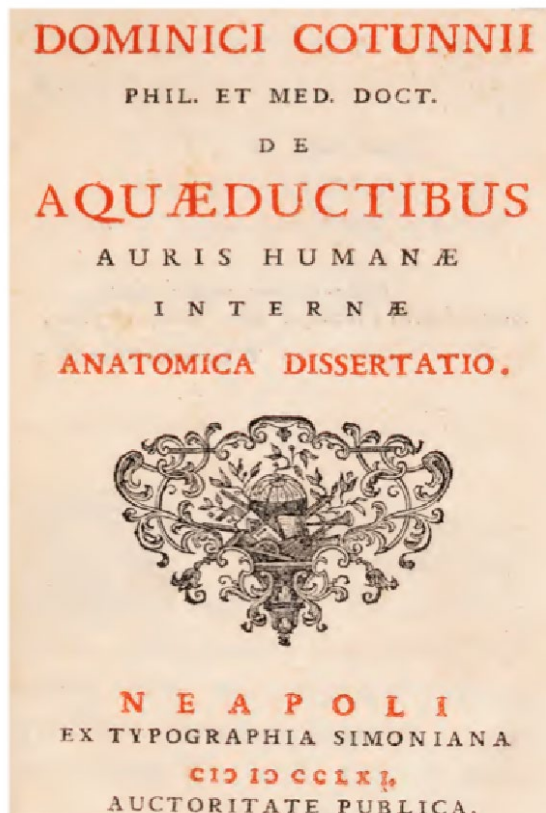


Figure 4. Cotugno's book: *De aquaeductibus auris humanae*, 1761

Antonio Scarpa (1752-1832)

Antonio Scarpa (Fig. 5-6) was born on May 19, 1752, in Lorenzago di Motta di Livenza, near Treviso, then a province of the Republic of Venice. Scarpa's family was of modest means. Scarpa showed intellectual promise in early childhood and was placed under the tutelage of his uncle Paolo, a learned priest, who taught him mathematics, philosophy, and Latin. Scarpa completed his basic education at the seminary of Portogruaro and, at age 15, he was admitted to the University of Padua. The 4-year curriculum included botany, zoology, comparative and human anatomy, and two clinical years which Scarpa spent, along with his summer vacations, in the hospitals of Bologna. After graduating with honors he became assistant to his most influential mentor, Morgagni and rapidly gained recognition and high praise for his knowledge, dedication, and intelligence. After Morgagni's death, he was recommended to direct the section of anatomy and clinical surgery at the University of Modena. He transferred there in 1772 at age 20, the same year that saw the publication of his first work, *De structura fenestrae rotundae auris et de tympano secundario*. In 1781, Scarpa traveled to Vienna, Paris, and London to further his studies with some of the leading scientists of the time. Shortly after his return to Modena, through the agency of Alessandro Brambilla, chief physician to Emperor Joseph II, he was offered the chair of anatomy at the University of Pavia. This institution ranked as one of the best in Europe because of the excellence of its faculty and its strong tradition of leadership in the sciences. Scarpa's appointment included a high salary, free living quarters, and traveling expenses. At the University of Pavia, Scarpa provided seminal inputs to the description of the nervous system, thus contributing significantly to the fields of neurosurgery and otoneurosurgery. Throughout his tenure at Pavia, he published many scientific works, among which the *Anatomicae disquisitiones de auditu et olfactu*, published by Pietro Galeatti, Pavia, in 1789 (Fig.7). Through his achievements in neuroanatomy, Scarpa became an honorary member of the Royal Society of London in 1791. In 1805, after Napoleon had been crowned King of Italy, he visited Pavia and inquired about the renowned anatomist Scarpa. Upon learn-

ing that Scarpa had been dismissed from the University because of his refusal to swear allegiance to the new king, Napoleon ordered to restore him in his position. Scarpa retired in 1813 to his country home in the hills of Pavia where he died, without friends or family, of the complications of a chronic urinary condition on October 31, 1832. Scarpa's intellectual prowess and scientific abilities appear to have been marred by his overpowering personality, which was focused on the pursuit of recognition and power. As an academician he continued to gain prominence and eventually a position of such power that allowed him to mold the university according to his own wishes and desires.



Fig. 5. Portrait of Antonio Scarpa

Scarpa's discoveries of the structure and various parts of the membranous labyrinth along with those of the fine cochlear and ampullary endings of the acoustic and vestibular nerves, and of the endolymph, are important landmarks in otology. It is probably safe to assume that most of today's otologists will relate Antonio Scarpa's name only to the discovery of the vestibular ganglion, a structure briefly described by him without insight on its functional significance. Scarpa's truly important observations on the inner ear, such as the first description of the membranous labyrinth and of the endolymph, and the precise out-

line of the distribution of the terminal branches of the cochleovestibular nerve, are rarely, if ever, related to his name.



Figure 6. The head of Antonio Scarpa (Museum of History, University of Pavia)

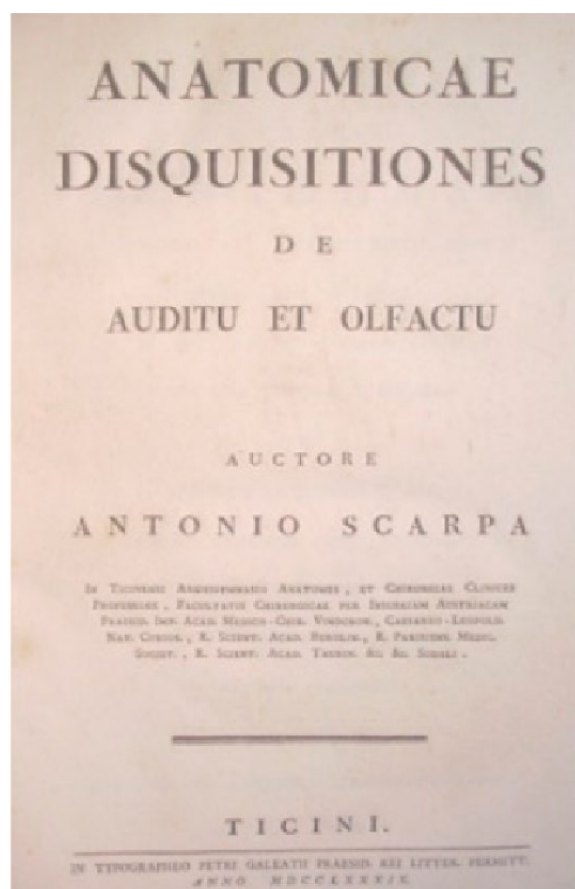


Figure 7. Scarpa's book: *Anatomicae disquisitiones de auditu et olfactu*, 1789

Filippo Lussana (1820-1897)

Filippo Lussana (Figure 8) was born on 17 September 1820 in Cenate San Leone (later renamed Cenate Sopra), close to Bergamo. He attended grammar school in Clusone and then Bergamo, where he developed a passion for the Humanities. In 1839 he enrolled at the Faculty of Medicine of Pavia University. His attendance at the Institute of Human Anatomy directed by Professor Bartolomeo Panizza (1785–1867) was instrumental in his future clinical and research activities. In April 1844, Lussana graduated and then began his medical and scientific career as a medical practitioner in the northern Italian valleys of Bergamo. His direct contact with his patients and daily medical practice became the cornerstones for the treatises he wrote during his university career. When he was awarded the chair of Physiology at Parma University in 1860, he had been practicing general medicine for almost 15 years. During this period, however, despite his many professional commitments, he had managed to pursue his studies, embodied in the publication of some 40 scientific works, the majority of which were neurological observations and post-mortem studies. In 1867, Filippo Lussana was appointed the chair of Physiology at Padua University. The focus of his various research studies was the central nervous system, including balance disorders, the role of the cerebellum and semicircular canals, taste innervation, pain and speech disorders and the phenomenon of synesthesia. He wrote treaties on physiology for university students and promoted its medical-scientific dissemination. He produced about 130 papers during his academic career. In 1889, Lussana was forced to abandon teaching due to ill health. The following year he was appointed professor emeritus and retired in 1891. Filippo Lussana died in Cenate Sotto on 25 December 1897. Lussana observations on the vestibular system were published in *Monografia delle vertigini e ricerche di fisiologia nevrológica*, in *Annali universali di medicina*, 1858 (Fig. 9-10), and *Sui canali semicircolari; ricerche fisio-patologiche*, 1872.



Figure 8. Portrait of Filippo Lussana

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Monografia delle vertigini e ricerche di fisiologia nevrológica; del dott. FILIPPO LUSSANA.

Capo 1.º — Preliminari sulla vertigine.

Articolo 1.º — Come si produca la vertigine.

Individualità complessa ed elementi sensitivi-motorj della vertigine. — La vertigine visiva a guardar dall'alto. — Vertigine da indistinte uniformità di sensazioni visive. — Da incertezza e confusione delle medesime sensazioni. — Vertigine visiva-tattile da nostra circonvoluzione. — Vertigine tattile nel mal di mare e simili. — Illusioni visive nel mal di mare e simili. — Vertigine da cessazione delle abituate confusioni sensorie. — Vertigine da moti insoliti e contemporanei degli oggetti e di noi. — Vertigine auditiva. — Ragione fisiologica sensoriale della vertigine visiva, tattile, auditiva. — Analoghe prove dalle definizioni degli Autori.

§. 1.º — Ognuno di noi, in qualche momento della propria vita, per questo o per quell'incidente, avrà provato il fenomeno della vertigine.

Se si ripensa a quanto sott'essa in noi accadeva, possiamo dire che, un pò più un pò meno, ma costantemente, gli oggetti sembravano muoversi intorno a noi stessi e sovente noi stessi con loro; e noi ci sentivamo mal fermi della nostra

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Figure 9. First page of the Lussana's *Monografia delle vertigini*

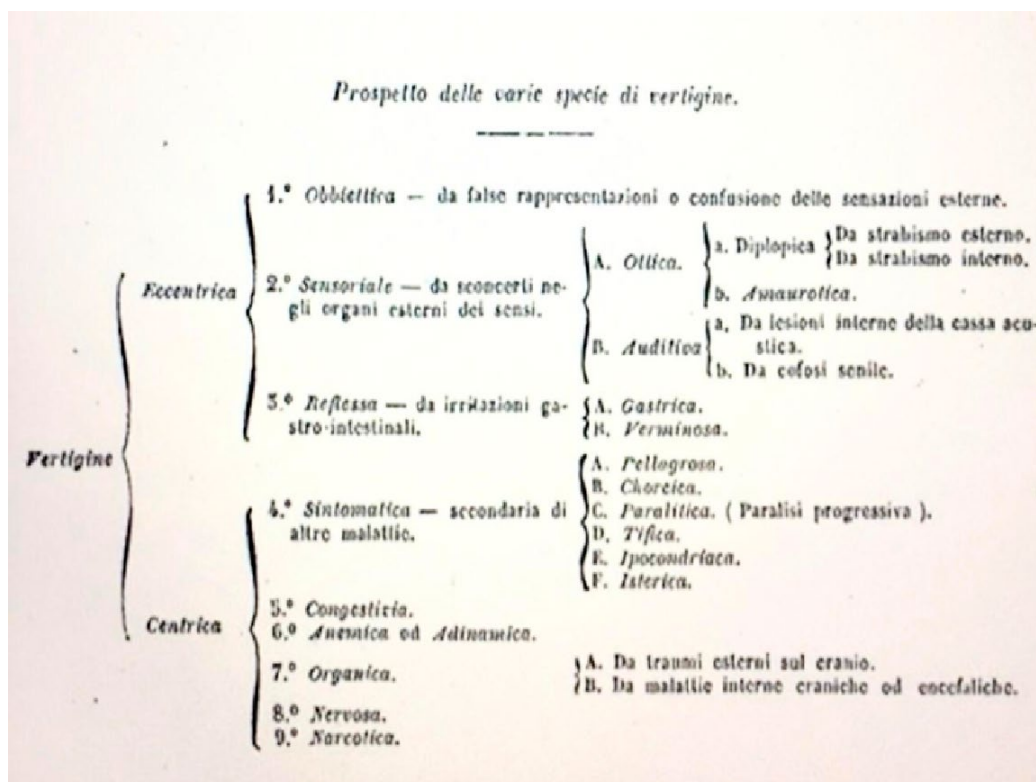


Fig. 10. Lussana's classification of vertigo

Pietro Tullio (1881–1941)

Born into a noble family in San Vito al Tagliamento in 1881, Pietro Tullio (Fig. 11) graduated in Medicine from the University of Bologna in 1905 with a thesis in physiology on pellagra and maize-based nutrition. He continued his scientific work at the Institute of Physiology of the same university, where he began his research on the inner ear, leading to his first publication on the function of the semi-circular canals in *Archivio di Fisiologia* (1917). That same year, he was appointed free lecturer and assistant at the Institute of Physiology. After serving as a medical captain in military hospitals on the Carso and Grappa fronts during the First World War, in 1919 he became director of the Physiology Laboratory at the University of Sassari and, in 1925, was appointed professor of Clinical Physiology for the School of Pharmacy at the University of Bologna. He later held positions as full professor and director of the Institutes of Physiology at the Universities of Cagliari (1928), Messina (1932), Bari (1937), Parma (1938), and Genoa (1940). He died in Genoa in 1941 of sepsis, a complication from a bicycle accident.

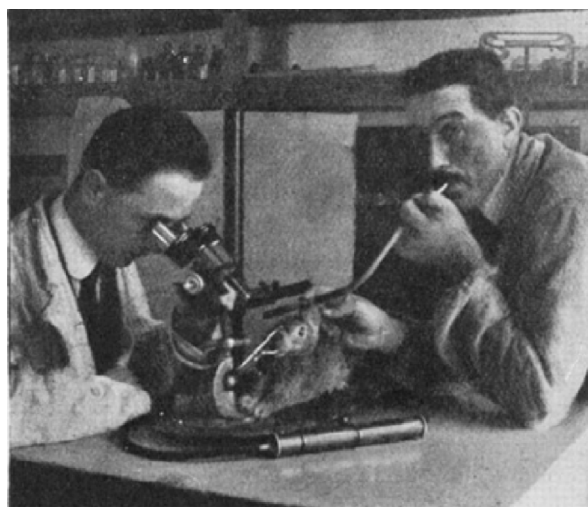


Fig. 11. Pietro Tullio and his binocular microscope

The majority of Tullio's research focused on the phenomenon that now bears his name: the occurrence of vestibular symptoms such as vertigo, nystagmus, and imbalance induced by intense acoustic stimulation (Fig. 12). Over the years, he studied this effect in pigeons, ducks, geese, turkeys, chickens, rabbits, dogs, fish, and humans. In his animal experiments, Tullio created a fistula near the ampulla of a semicircular canal, thereby experimentally

reproducing the clinical condition later recognized as semicircular canal dehiscence, or Minor's syndrome (1998). From his earliest investigations in 1918, Tullio employed the binocular microscope to study the inner ear of experimental animals. Simultaneously with the Swedish researcher Holmgren, he conceived of applying the binocular microscope to the observation and surgery of the human ear. In collaboration with the otologist Pietro Caliceti, Tullio introduced a series of modifications to the microscope then manufactured by Zeiss (Jena), adapting it for human use. These pioneering experiments were published in 1938.

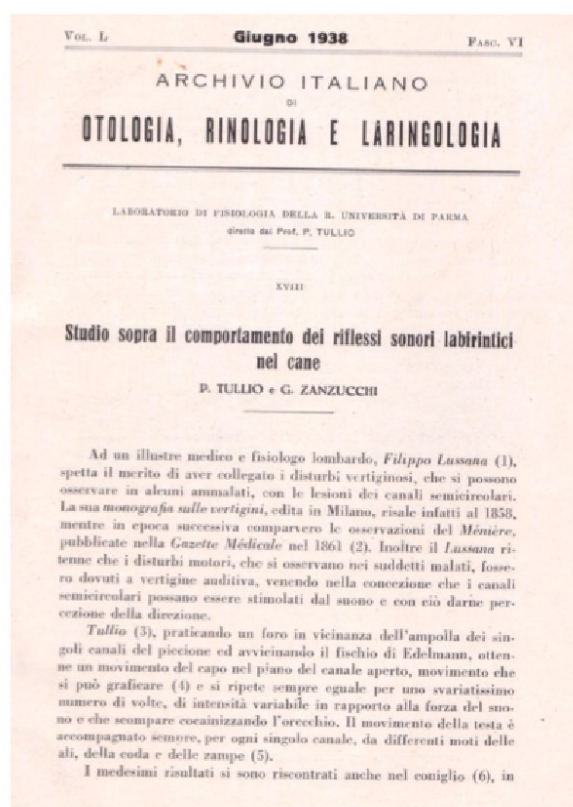


Fig. 12. The main article of Pietro Tullio (1938)

Michele Arslan (1904–1988)

Michele Arslan (Fig. 13) was born Khayel Andon Aram Mariam Arslanian on January 23, 1904, in Padua, to an Armenian father, Yerwant Arslanian, Professor and Director of the Otorhinolaryngology Clinic at the University of Padua, and an Italian mother, Antonietta de' Besi. In 1923, his father changed the family surname from Arslanian to Arslan. Mi-

chele Arslan graduated in Medicine from the University of Padua in 1927. He was initially a pupil of the physiologist Virgilio Ducceschi and the anatomist Tullio Terni, in whose institutes he conducted important studies on the histology and physiology of the vestibular system. Turning to clinical work, he trained under his father at the Otorhinolaryngology Clinic, first as a volunteer assistant and later as a permanent assistant. In 1935, succeeding his father, he was appointed professor in charge and director of the same Clinic. In 1957 he became full professor of Otorhinolaryngology at the University of Padua, position he held until his retirement in 1974. Arslan's scientific training was further enriched through advanced study at leading European universities, including Strasbourg, Frankfurt, and Berlin. He was a member of prestigious international scientific academies, such as the Barany Society, received *honoris causa* graduation from Uppsala (1963) and Strasbourg (1970) universities, organized major international meetings such as the Symposium on Menière's Disease (1962) and the World Congress of Otorhinolaryngology (Venice, 1973), and served as president of both the Italian Society of Audiology and the Italian Society of Otorhinolaryngology. He created a university school of Otorhinolaryngology that produced full professors not only at Padua but also at the Universities of Ferrara, Verona, and Trieste, as well as chief physicians in major hospitals throughout northeastern Italy. Michele Arslan passed away in Padua in 1988.

Arslan's scientific output comprises more than 280 publications, including the textbook *Otorinolaringoiatria* and the official report *Fisiopatologia e clinica delle vie vestibolari centrali* (Fig. 14) presented to the congress of the Italian Society of Otorhinolaryngology in 1956.

His main contributions concerned the physiology, pathology, and clinical aspects of the vestibular system, including the standardization of vestibular function testing methods, the pathophysiology of Menière's disease, and its treatment with ultrasound (Fig. 15).

Among Arslan's pupils who continued vestibular research were Oscar Sala, his successor in the chair at Padua, and David Megighian (Fig. 16-17), author of significant works and papers on electronystagmography.



Michele Arslan

Figure 13. Michele Arslan

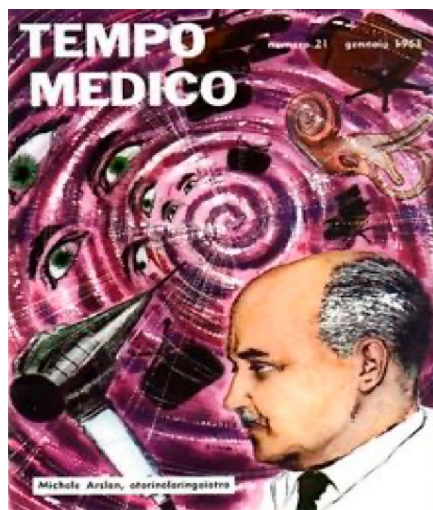


Figure 15. Arslan's ultrasound treatment for Menière's disease



Figure 16. David Megighian and the rotatory chair

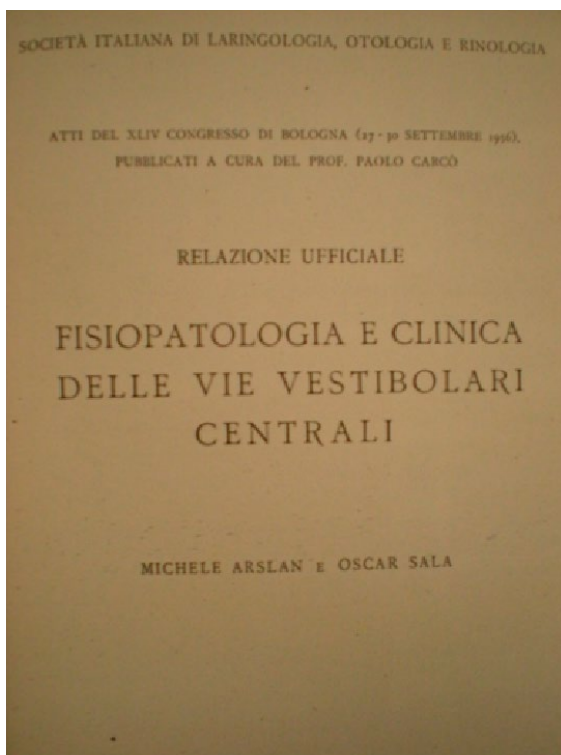


Figure 14. Arslan's official report at the Congress of the Italian Society of Otorhinolaryngology, 1956

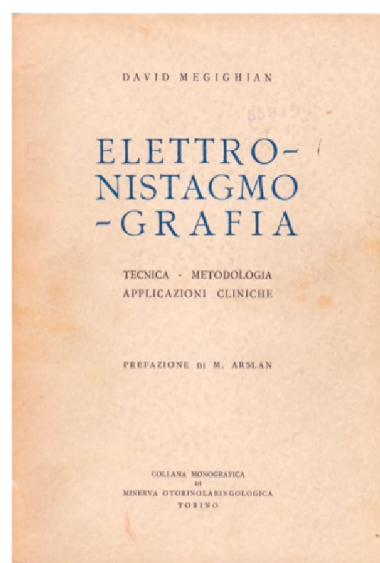


Figure 17. David Megighian textbook on Electronystagmography (1959)

Aldo Dufour (1931–2000)

Aldo Dufour (Fig. 18) was born in Milan into a middle-class family. He graduated in Medicine and Surgery and subsequently specialized in Otorhinolaryngology at the University of Milan. He pursued his hospital career as assistant and later first assistant at the Otorhinolaryngology Division of the Fatebenefratelli Hospital, directed by Professor Enrico de Amicis, whom he eventually succeeded as director. Dufour practiced all aspects of the specialty, with particular focus on otology. His interest in vestibology began when he was appointed head of the Vestibology Outpatient Service at the Besta Neurological Institute in Milan (Fig. 19), strongly supported by De Amicis. Daily interaction with neurologists enabled Dufour and his collaborators to deepen their understanding of the clinical aspects of central vestibular disorders, and the service soon became the national reference centre for these conditions.



Figure 18. Aldo Dufour



Figure 19. Vestibology Outpatient Service at the Besta Neurological Institute in Milan

Dufour authored numerous papers in national and international journals and delivered two official reports at national congresses of the Italian Society of Otorhinolaryngology: the first, in 1975, on *La funzione vestibolare nella patologia del sistema nervosa centrale*, and the second, in 1980, on *Nistagmografia clinica* (Fig. 20-21). The latter can be regarded as the swan song of electronystagmography, which, by the late 1970s, gave way to a clinical vestibology based on bedside vestibular examination. Dufour was among the first in Italy to recognize this transition, documented in the same year by the publication of the *Manuale pratico di vestibologia* (Fig. 22) authored by Dufour, Mira, and Pignataro and published by the Amplifon Research and Study Center. To the best of my knowledge, this was the first time the term *vestibologia* appeared in Italian, corresponding to *otoneurology* or *neurotology* in English. Dufour was also an indefatigable organizer of the Vestibology Courses at the Amplifon Research and Study Centre in Milan and of the Italian Nystagmography Meetings sponsored by Formenti group. His international collaborations were equally significant, particularly with the French *pélerins* group and with the French Society of Otoneurology. He trained countless disciples, the first and second generations of Italian vestibologists. Thanks to his efforts, vestibology, once a niche discipline restricted to a handful of superspecialists, became an integral part of the knowledge base of all otorhinolaryngologists, alongside otology, rhinology, and laryngology.

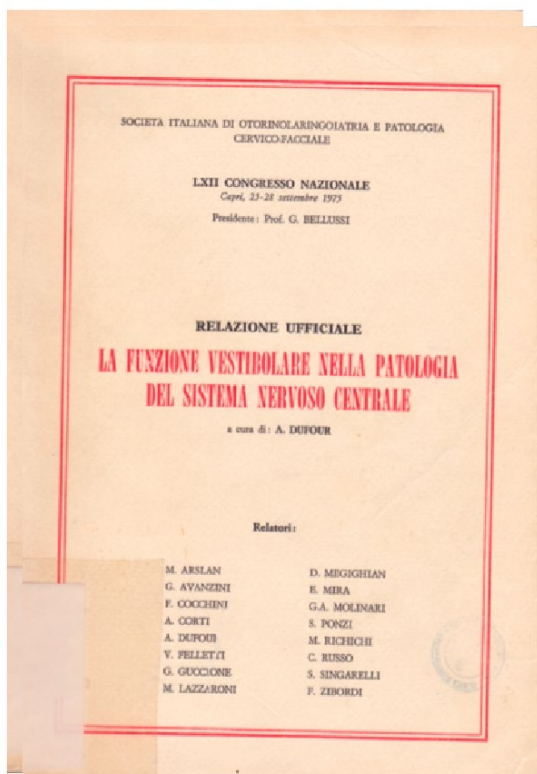


Figure 20. Dufour's official report at the Congress of the Italian Society of Otorhinolaryngology, 1975

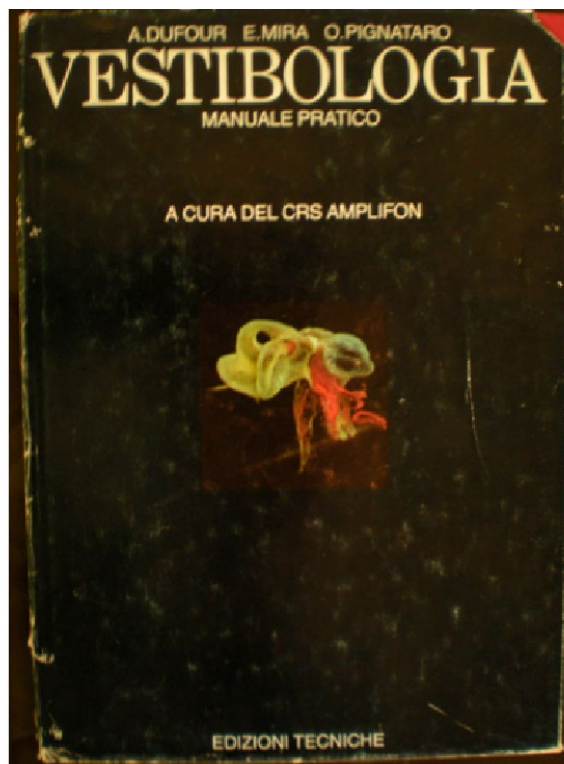


Figure 22. Aldo Dufour textbook on Vestibology (1980)

Giorgio Guidetti (1953-2021)

Giorgio Guidetti (Fig. 23) was born in Reggio Emilia on April 6, 1953. He graduated in

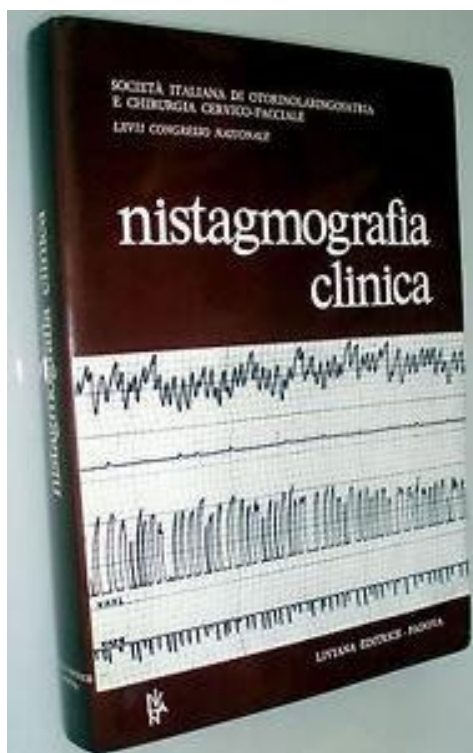


Figure 21. Dufour's official report at the Congress of the Italian Society of Otorhinolaryngology, 1980



Figure 23. Giorgio Guidetti

Medicine and Surgery in 1978 at the University of Modena, where he also specialized in Otorhinolaryngology and Cervico-facial Surgery in 1981; he later obtained a specialization in Audiology at the University of Milan. From 1980 to 2003 he served as first-level medical assistant at the Otorhinolaryngology Clinic of the Policlinico of Modena, and from 1996 to 2003 he directed the Vestibology and Vestibular Rehabilitation Unit of the same hospital. From 2004 to 2010 he headed the Vestibology Service of the Modena Local Health Authority (Azienda USL), and from 2010 to 2015 he was responsible for the Audiology-Vestibology Unit at the Ramazzini Hospital in Carpi (Modena). He later established the Vertigo Center in Modena. Giorgio Guidetti also devoted significant efforts to the field of sports medicine, serving as Scientific Director of the Modena Autodrome, where he contributed to the development of techniques for assessing spatio-temporal orientation skills in both clinical and sports contexts. These projects were carried out in collaboration with the Enzo Ferrari Department of Engineering at the University of Modena and the Technopole of Reggio Emilia. On January 25, 2013, together with Augusto Pietro Casani, Marco Manfrin, and Aldo Messina, he founded the Italian Society of Vestibology (Fig. 24). He passed away on March 14, 2021, at the Policlinico of Modena after a two-month hospitalization for COVID-19 infection.



Figure 24. The foundation of the Italian Society of Vestibology (2013)

Giorgio Guidetti scientific interests encompassed the diagnosis and treatment of balance disorders, vestibular semiotics, stabilometry, posturology, vestibular rehabilitation, benign paroxysmal positional vertigo, and the role of vestibular function in sports. He addressed these topics in several journals (*Otoneurologia* 2000) and books (*Stabilometria clinica*, *Diagnosi e terapia dei disturbi dell'equilibrio*, *Trattato italiano di Vestibologia clinica*) (Fig. 25-26) with national and international diffusion.

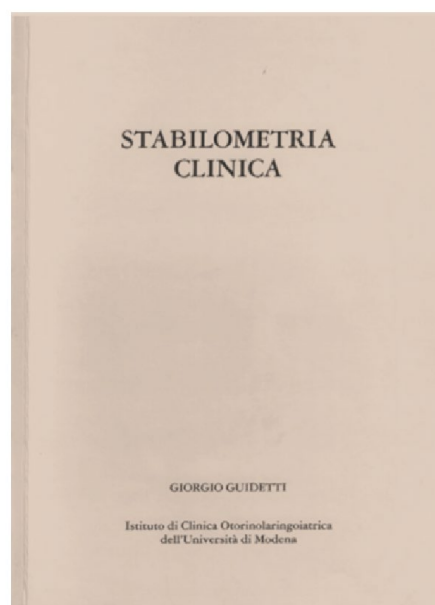


Figure 25. Giorgio Guidetti textbook on stabilometry (1980)



Figure 26. The last textbook of Giorgio Guidetti on clinical vestibology (2021)

Giorgio Guidetti was also deeply engaged in scientific divulgation and professional training, organizing national and international congresses and symposia on vestibology and posturology, including the annual national conference *Updates in Vestibology and Tinnitus Brainstorming*. Furthermore, he was actively involved in teaching, serving as director and lecturer in various national and international master programs, workshops, and advanced training courses in several universities and research centres in Italy and abroad.