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Atlas of Endoscopic Neurosurgery of the Third Ventricle

Basic Principles for Ventricular Approaches and Essential Intraoperative Anatomy

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To the two fathers of Neurosurgery, giants to whom all current neurosurgical practice is beholden: Professor Harvey Williams Cushing and Professor Mahmut Gazi Yaşargil.

Foreword

A much-needed Atlas of Neuroendoscopy is here! That was my first thought when I received a copy of the manuscript of the present atlas. It is hard to believe the speed with which the practice of neuroendoscopy for the brain and skull base has advanced in the past two decades. Endoscopic approaches to the third ventricle remain as the most basic and essential approaches for the beginning endoscopic neurosurgeon. An excellent understanding of the third ventricular anatomy is a basic requirement prior to the performance of the most basic neuroendoscopic procedures, such as endoscopic third ventriculostomy (ETV).

This well-designed atlas comprises seven rich chapters. The first chapter focuses on the historical, morphological, and physiological aspects of the ventricular system, while the second chapter details the general principles of endoscopic neurosurgery, including historical evolution, basic endoscopic techniques, and procedural indications. The third chapter gives the reader a detailed description of the techniques for entry into the third and lateral ventricles, while the fourth chapter provides a thorough endoscopic anatomy of the anterior, middle, and posterior segments of the third ventricle. The last three chapters enrich the reader's appetite with a more complex neuroendoscopic assessment of the interpeduncular and prepontine cisterns, as well as outlining clinical applications in cases of suprasellar arachnoid cyst and hydranencephaly.

I congratulate Dr. Roberto Dezena, an outstanding Brazilian neurosurgeon, on this excellent effort to advance the education of neurosurgeons and neurosurgical students worldwide in the field of ventricular neuroendoscopy. This meticulous effort of collecting a large number of intraoperative endoscopic images from a personal clinical series required significant hard work and dedication to the field of neuroendoscopy. The main recent advances in the field of hydrocephalus and intraventricular pathologies relate to modern radiological investigations and modern management via minimally invasive endoscopic approaches, since shunts are no longer the exclusive treatment for a patient with hydrocephalus. The evolution of neuroendoscopic techniques to treat hydrocephalus and intraventricular tumors, cysts, and infections has led to significant improvements in the quality of life of millions of patients worldwide, as well as reducing the significant morbidity and mortality rates associated with shunting alone. This evolution in the field requires excellent anatomical and procedural endoscopic resources for the practicing neurosurgeon, such as those provided by the contribution of this remarkable neuroendoscopic atlas. This remarkable multimedia book reflects the technological advances in endoscopic equipment and instrumentation achieved in the past two decades. This atlas is a must-have resource for neurosurgeons who are early or advanced in their endoscopic experience, pediatric neurosurgeons, and all physicians involved in the care of patients with intracranial and intraventricular disease.

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Preface

A medical book is not created by chance. It is created, most often, as the result of living and experiences. On the other hand, it may result from the need for a simple, practical and easily accessible work. According to this reasoning, this book was not designed specifically for the luminaries of world neuroendoscopy, whose enormous expertise goes far beyond the contents of this work. It was, rather, intended for those who wish to take the first steps in endoscopic neurosurgery, such as general neurosurgeons, young neurosurgeons, neurosurgical residents, medical students, and professionals in related fields, such as neurologists, neuroscientists, and health professionals in general who are curious about the subject. Despite the title of the book, it looks at more than just the third ventricle. Rather, it deals with the principal ventricular locations and their surroundings, which the neuroendoscopist must know thoroughly. Of all these sites, the third ventricle should undoubtedly be the center of attention, given its strategic position in the center of the ventricular system. For a comprehensive but concise description of the structures, the book was divided into two parts. Part I presents basic general concepts of the ventricular system and the neuroendoscopic ventricular technique in two chapters. Part II, comprising five chapters, is the atlas itself. In Part I, Chap. 1 deals specifically with the cerebral ventricles, the ventricular neuroendoscopy battlefield, emphasizing the historical aspects of their description, their classic anatomy, and the complex mechanism of the cerebrospinal fluid circulation, which is not yet fully elucidated. In Chap. 2, also in Part I, the neuroendoscopic technique is presented, from its historical evolutionary aspects to concepts, techniques, and current indications for ventricular approaches. Part II presents ventricular endoscopic anatomy through properly labeled intraoperative images. In a different way of viewing the usual ventricular anatomy, the anatomical descriptions follow a logical sequence, from the entry of the neuroendoscope into the skull, through the lateral ventricle and its portions, to the third ventricle and its recesses, until the neuroendoscope reaches the opening in the floor of the third ventricle and the membrane of Liliequist, with the view of the main structures within the interpeduncular and prepontine cisterns. Part II also presents endoscopic anatomical aspects inside the suprasellar arachnoid cyst, as well as the endoscopic anatomical aspects of a disease in which there is no brain itself, much less ventricles, called hydranencephaly. All intraoperative endoscopic images, as well as all additional imaging examinations for the illustrative cases presented, are from our series of patients, all operated at the Clinics Hospital of the Federal University of Triângulo Mineiro in Uberaba, Minas Gerais, Brazil, which is the main site of our neuroendoscopic practice and general neurosurgery.

A special thanks to all the members of my team, especially the surgical instrumentalists responsible not only for the preparation of the operating field and the important intraoperative assistance, but also for recording the surgeries on media. Without such recordings, this work would not have been possible. Far from being the final word on the subject, since new concepts and theories arise in the literature every day, our humble contribution to this fascinating and challenging field of neurosurgery comes to a close.

Uberaba, Minas Gerais, Brazil Roberto Alexandre Dezena

Contents

Part I

Basic Principles for Ventricular Approaches

1 The Ventricular System

1.1 Historical Aspects

The first description of the human ventricular system was made in the third century BC by the Greek anatomists Erasistratus (ca. 304 BC–ca. 250 BC) and Herophilus (ca. 335 BC–ca. 280 BC), considered the first anatomists in history (Fig. 1.1). They were founders of the famous School of Medicine of Alexandria and both were allowed to perform dissections and vivisection on humans [1]. Erasistratus considered atoms as the essential elements of the human body, and considered that the atoms were vitalized by external air (*pneuma*), which circulated through the nerves. He described the heart valves and the sigmoid colon, and also suspected that the heart was not the center of the emotions, but that it worked like a pump. He was one of the first to distinguish veins from arteries, and he also believed that the arteries contained air and carried the vital spirit (*pneumazooticon)* from the heart. This idea went against the prevailing belief at the time, that of body humors, suggested by Hippocrates. Additionally, Erasistratus is considered to be the first heart arrhythmologist, studying the rhythm of the heart. It is said that he was appointed royal physician after curing Antiochus I Soter, a Seleucid king, son of Seleucus I Nicator. By measuring the heart palpitations of Antiochus, Erasistratus observed the reactions of the ailing man. He noted that when Antiochus' young and beautiful stepmother, Stratonice, visited him, he had palpitations. Erasistratus concluded that it was the love of Antiochus for her that afflicted him, and so they were allowed to marry [2] (Fig. 1.2).

Herophilus studied the brain in detail, recognizing this organ as the center of the nervous system and intelligence. He described seven pairs of cranial nerves. He also distinguished blood vessels and nerves, including distinguishing the motor nerves from the sensory nerves. Other objects of his study were the eyes, liver, pancreas, salivary glands, digestive system, and genitals. He was one of Hippocrates' scholars and wrote a treatise on the Hippocratic method. Erasistratus and Herophilus both had a particular interest in brain anatomy and, from the first human dissections known in history, described in the brain four "small stomachs" or "cells", and their communications with each other. At that time, it was believed that the function of these cavities was to convert the vital spirit (*pneumazooticon*), contained in the blood and coming from the heart, into animal spirit (*pneumapsychikon*), giving rise to thoughts and emotions [3]. It was Herophilus who described and defined the rearmost brain cavity (the fourth ventricle). This region was regarded as the command center of thoughts and emotions, and he compared its posterior wall to the reed pens that were used in Alexandria at the time, and thus emerged the name *calamus scriptorius* or *calamus Herophili* [4].

Claudius Galenus (ca. 129 – ca. 217), or simply Galen (Fig. 1.3), was one of the most important doctors of ancient times. Born in Pergamon, an ancient Greek city (now in Turkey), he traveled extensively throughout the Roman Empire, studying medicine. In 157, Galen returned to

Fig. 1.1 Woodcut depicting ancient herbalists and scholars of medicinal lore, including the Alexandrian physicians Herophilus and Erisistratus. *Spiegel der Arzney*, woodcut, Lorenz Phryesen (1532)

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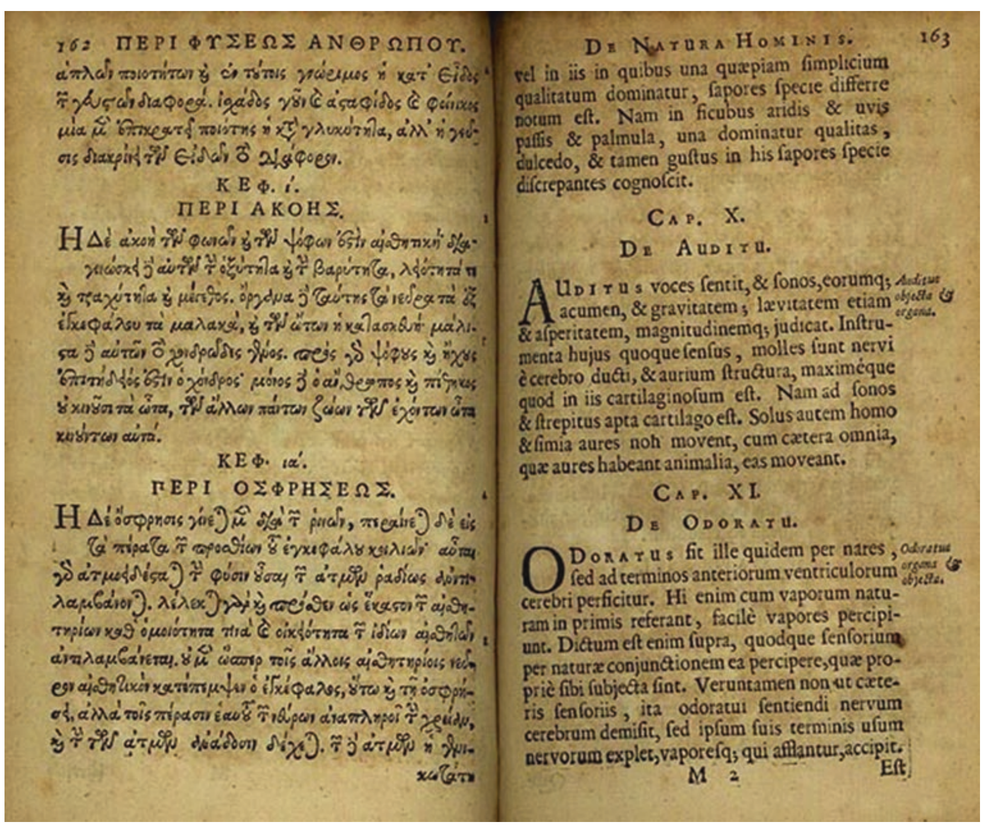
Fig. 1.2 Erasistratus, *in red*, shown discovering the cause of Antiochus' disease. Antiochus and Stratonice, oil on canvas, Jacques-Louis David (1774), École Nationale des Beaux-Arts, Paris, France

Fig. 1.3 Claudius Galenus (ca. 129 – ca. 217). Engraving, Georg Paul Busch (eighteenth century)

Pergamon, where he reached the position of physician for the High Priest's gladiators, and he became one of the richest and most influential men in all of Asia. He spent 4 years in that position and provided very important observations about anatomy and surgery. He reported the wounds of the gladiators he treated as "windows into the body". Needing to always keep gladiators healthy, as well as treat their injuries, he also highlighted the importance of diet, hygiene, preventive medicine, and exercise. He provided detailed knowledge about general and brain anatomy, which, unfortunately, came from dissections of monkeys or oxen, a fact which, curiously, was never mentioned in his works. Galen described the ventricles in considerable detail, as four cavities and their connections, two anterior, and two posterior (the third and fourth ventricles). He believed that the ventricles were responsible for storing the animal spirit (*pneumapsychikon*), which was regarded as the active ingredient for the brain and nerves. Although it was believed at the time that the ventricles, particularly the anterior ventricle, were the source of *pneumapsychikon*, Galen argued that the soul and the most important cognitive functions were located in the periventricular brain parenchyma. Such considerations are derived from his clinical observations at the gladiator's school in Pergamon. He noted that when a traumatic injury affected the ventricles, death did not occur, even if sensitivity and strength were lost. Imagination, reason, and memory were regarded as the three constituents of the intellect, and it was thought that they could be affected separately. No illustrations of Galen's anatomical observations exist, as he encouraged his students to seek knowledge by handling structures and not by making illustrations [5, 6].

The cerebroventricular doctrine of the time of Galen was followed by the development of the Cell Doctrine, a curious blending of classical Greek medical concepts with Christian ideologies. In the fourth century AD, the Byzantine physician Poseidon reconfigured the theories of Galen, probably being the first to report concepts of brain localization, stating that anterior brain injuries affect the imagination, medial brain injuries affect reason, and posterior regions, memory [4, 6]. At the same time, church officials, particularly Nemesius, Bishop of Emesa (ca. 390) and St. Augustine (354–430), sought to conceptualize the non-material nature of the soul. Little is known about Nemesius beyond the fact that he was a bishop, and that he innovatively attributed imagination to the connection between the cavity located in the frontal lobe and the five senses. The work attributed to him, *De Natura Hominis,* exerted a significant influence during the scholastic period, although many authors believe the work was written by St. Gregory of Nyssa. In fact, in many ways, the work has ideas that are similar to the thought of the great Nicene doctor. It is a book currently studied in Catholic theology, and is a remarkable work showing the concern of the Bishop of Emesa with the accuracy of the concepts. His way of accepting or rejecting the doctrine of the ancients reveals a person with great knowledge of secular authors. *De Natura Hominis* also contributes to the doctrine of the ventricular localization of mental functions. In fact, a doctrine was created, based on the Alexandrian and Galenic concepts, adapted to Catholic thought. An analogy was made with the Holy Trinity; hence, the division of the brain cavities into three cells. The Cell Doctrine remained in force throughout the Middle Ages. What are known today as the lateral ventricles were considered to be a single cavity, the first cell of which, in its anterior part, received external impulses and other impulses from the rest of the body, characterizing the reception of common sense (*sensus communis*). From this region, imagination (*imaginativa*) and abstractions (*fantasia*) were created, in the posterior part of the first cell. The second cell (now known as the third ventricle), or medial cell, was the site of the cognitive processes, such as reason (*ratio)*, judgment (*aestimativa)*, and thought (*cogitativa*). The function of the posterior cell (now known as the fourth ventricle) was changed from a galenic motor concept to the source of memory (*memorativa*) [6–8] (Fig. 1.4).

Albertus Magnus (ca. 1193–1280) (Fig. 1.5), also within Catholic thought, reinforced Cell Doctrine theory and believed that the brain functions were mediated by a system of ventricles or paired chambers. The front ventricles (*sensus communis*) were associated with the processing of the five senses. Images formed therein passed to the medial ventricles, the seat of reason (*ratio*) and thought (*cogitativa*), and the posterior ventricle, the seat of memory (*memorativa*) [9, 10]. These concepts remained as dogma from the Dark Ages to the Renaissance, when they began to be seriously questioned, as a result of more accurate anatomical descriptions. Interestingly, at the time there were only non-illustrated descriptions of the


162 ΠΕΡΙ ΦΥΣΕΩΣ ΑΝΘΡΩΠΟΥ.

ΚΕΦ. ι΄.

ΠΕΡΙ ΑΚΟΗΣ.

ΚΕΦ. ια΄.

ΠΕΡΙ ΟΣΦΡΗΣΕΩΣ.

De Natura Hominis. 163

vel in iis in quibus una quæpiam ſimplicium qualitatum dominatur, ſapores ſpecie differre notum eſt. Nam in ficubus aridis & uvis paſſis & palmula, una dominatur qualitas, dulcedo, & tamen guſtus in his ſapores ſpecie diſcrepantes cognoſcit.

Cap. X.

De Auditu.

Auditus voces ſentit, & ſonos, eorumq; acumen, & gravitatem; lævitatem etiam & aſperitatem, magnitudinemq; judicat. Inſtrumenta hujus quoque ſenſus, molles ſunt nervi è cerebro ducti, & aurium ſtructura, maximéque quod in iis cartilaginoſum eſt. Nam ad ſonos & ſtrepitus apta cartilago eſt. Solus autem homo & ſimia aures non movent, cum cætera omnia, quæ aures habeant animalia, eas moveant.

Auditus objecta & organa.

Cap. XI.

De Odoratu.

Odoratus fit ille quidem per nares, ſed ad terminos anteriorum ventriculorum cerebri perficitur. Hi enim cum vaporum naturam in primis referant, facilè vapores percipiunt. Dictum eſt enim ſupra, quodque ſenſorium per naturæ conjunctionem ea percipere, quæ propriè ſibi ſubjecta ſint. Veruntamen non ut cæteris ſenſoriis, ita odoratui ſentiendi nervum cerebrum demiſit, ſed ipſum ſuis terminis uſum nervorum explet, vaporeſq; qui afflantur, accipit.

Odoratus organa & objecta.

M 2 Eſt

Fig. 1.4 *De natura hominis*. Oxford; 1671

Fig. 1.5 Albertus Magnus (ca. 1193–1280). Fresco, Tommaso da Modena (1352), Dominican monastery, San Niccolò, Treviso, Italy

Fig. 1.6 Anatomy of the brain and surrounding vessels. Drawing illustrating a text originating in Salerno around 1250, by an unknown artist. Although somewhat simplistically and stylistically rendered, this illustration represents the first known historical attempt at drawing the gyral-sulcal pattern of the cortex

Cell Doctrine. The first known drawing of the brain illustrated a text from around 1250, from Salerno, by an unknown author (Fig. 1.6). The drawing is a full-body design with a representation of the thoracic and abdominal cavities, in addition to representations of the blood vessel systems [11, 12].

Still in the Dark Ages, it is worth highlighting Mondino de Luzzi (ca. 1270–1326). He was the first physician to officially receive authorization to perform dissections at the University of Bologna. His masterpiece, *Anathomia Mundini*, was completed in 1316. It was the first book in medical history devoted entirely to the structure and functioning of the human body, and was used for teaching anatomy for more than 200 years. Mondino personally carried out several dissections on human cadavers, but he also made use of a servant, called a barber, working under his orders (Fig. 1.7). With such work, many questions were raised about the works of Galen, the dogmas of the time. As a result, Mondino is considered the "restorer of anatomy." The editions of *Anathomia Mundini* up to 1478 were only handwritten, but were printed from then on. This because of the invention of the printing press by Johannes Gutenberg (ca. 1398–1468) has ocurred in the 1430s, with the first incunable, the Gutenberg Bible, being ready around 1455 [9, 10]. In the Middle Ages, books had practically no illustrations, and so *Anathomia Mundini* did not have anatomical figures until the edition of 1521 [13–15] (Figs. 1.8, 1.9, and 1.10).