The journey to the modern understanding of the pathophysiology of hydrocephalus and its effective treatment took a long time through history. With its relatively high incidence rate and notorious appearance in the head, hydrocephalus broadly amazed physicians in the past. Although anthropologists have discovered older hydrocephalic skulls, the first documentation of the disease was made by Hippocrates (460–370 BC), who gave a detailed description of the underlying mechanisms of hydrocephalus and explained additional symptoms and signs of the presented cases; moreover, he used the term “hydrocephalus” for the first time.\(^2,3\)

Hippocrates postulated that hydrocephalus manifested secondarily to fluid collection over the brain, particularly outside the skull. Even if this first account by Hippocrates was inaccurate when compared with the current explanation, it influenced medical knowledge for more than 1000 years before any description of internal hydrocephalus. Thus, physicians of antiquity and medieval times dealt essentially with caput succedaneum, cephalhematoma, and rarely with external hydrocephalus and convexity arachnoid cysts.\(^2,3\)

Galen of Pergamon (AD 129–200) later categorized fluid accumulation in the head in a compartmental fashion, as intracranial (subdural or extradural) or extracranial (subperiosteal or subgaleal).\(^2,3\) Antyllus (late third and early fourth centuries AD) was the first to recommend surgical evacuation of scalp swellings.\(^3\) Surprisingly, after a considerably long period of time, Oribasius (AD 325–400) and Paul of Aegina (AD 625–690) recognized only extradural fluid collection as intracranial-type hydrocephalus,\(^9\) which was basically accepted as a key concept by medieval Islamic physicians. Among them Albucasis (AD 936–1013) in Cordoba described hydrocephalic newborns in detail and was the first to study intracranial hydrocephalus.\(^1\) Contrary to Albucasis, Avicenna (AD 980–1037) (Fig. 1) did not agree with the idea that intracranial hydrocephalus should be treated, because of the high mortality rate of the surgical procedure.\(^11,14\) On the other hand, Serefeddin Sabuncuoglu, who was a strict follower of the Albucasis and Avicenna schools of thought and worked as royal physician during the Ottoman Empire in Anatolia, in the 15th century was the first to drain cerebral ventricles transcutaneously in hydrocephalic children.\(^5,7,9,18\)

The first scientific description of internal hydrocephalus was made by Vesalius in the 16th century. Vesalius stated that the disease was a result of dilatation of both cerebral ventricles.\(^2,3,16\) A century later Paré differentiated hydrocephalus cases as subgaleal, subperiosteal, subdural, and intraventricular,\(^19\) and did not suggest surgical intervention for internal hydrocephalus.\(^9\) Hydrocephalus became a curable condition in the 20th century after further scientific discoveries and technical advances, although substantial complications with shunting devices persisted.
Avicenna and the Canon of Medicine

Avicenna’s principal medical work, the *Canon of Medicine*, was translated into Latin by Gerard of Cremona in the 12th century and was taught in medical schools as one of the primary textbooks until the 16th and 19th centuries in the West and East, respectively (Fig. 2). The *Canon* is divided into five large books. Each book is divided into treatises (fen), each of which in turn is subdivided into chapters and paragraphs (sections). In this paper, we try to illuminate an exciting era during the scientific history of hydrocephalus by quoting Avicenna, the most prominent medieval physician. The following text from the *Canon* concerning hydrocephalus and its treatment is found in two sections in the Third Volume, First Fen, Third Chapter.

Ninth Section: Water in the Skull

A fluid having a similar quality as clear water may accumulate either inside or outside the skull (secondary to a variety of causes). When the fluid accumulates inside the skull and is located over the dura mater, the patient exhibits irritability and feels weight in the head, keeps the eyes almost always open and can only shut his/her eyes with difficulty. The patient suffers from downward-directed eyes. This type of hydrocephalic child looks cheerless and cries incessantly. There is no remedy for this situation.

Tenth Section: Swelling and Water on the Skull

Some children present with swellings in the scalp, which may impart either cold or warm inflammatory properties. These lesions are usually located under one of the external membranes of the skull; however, in some cases, water may simultaneously accumulate under two external membranes. In the latter situation, the child always stays alert over the course of the healing process and cries incessantly. Although these conditions are frequently seen in children, they are also encountered in adults.

Scalp swellings may also occur in newborns when the midwife unintentionally pushes down on the baby’s head during delivery. Skull bones around the anterior fontanel may be separated by that maneuver and blood vessels may rupture (when they travel across the separation line). In this occasion, a bloody substance usually accumulates in the head instead of watery liquid. However, blood may be replaced by another humor (or fluid) of the body in the following days.

Diagnosis. Besides observation, palpation is a useful method for diagnosing hydrocephalus. Using palpation both the hardness and hotness of the swelling can be distinguished. If there is no color change in the scalp, the swelling can be mobilized by palpation; the contrary is also true if the color of the skin has changed. In the latter situation the patient usually feels pain during palpation; moreover, a burning sensation is noticeable. This type of swelling is mostly located outside the skull. If the bones are also movable, fluid is expected to accumulate inside the skull.

Management of Hydrocephalus. The physician must carefully examine the children who present with hydrocephalus. The following points should be clarified cautiously: 1) the amount...
of water accumulated in the scalp, and 2) the rigidity of the swelling. For instance, if the accumulation can be depressed by gentle pressure with the fingers, there is no need for treatment.

The treatment option for hydrocephalus in certain cases is surgical intervention. Surgery for the water accumulation between the skin and skull can be performed according to the volume and localization of the water. In small volume accumulations, the fluid can simply be evacuated by a unilateral coronal scalp incision. In medium volume accumulations, a cross-shaped scalp incision is necessary. In large volume accumulations, three intersecting scalp incisions should be used for complete drainage (Fig. 3). Some physicians prefer a cupping procedure for this condition, which is more effective than venesection.

After the evacuation of fluid, the wound should be closed using sutures and a bandage dressing should be applied. The patient may be followed up for 3 days with locally applied wine and olive oil therapy. In conditions with minimal fluid accumulation, surgical therapy is not necessary. For painful lesions, the drugs given for meningitis can be successfully used.12,15

Discussion

Ibn Sina (AD 980–1037), known in the West as Avicenna, lived in Persia and was the leading scientific figure during the Islamic Golden Age. He also played an influential role in Europe as a medical author when major scientific advancements moved westward. Although Ibn Sina was primarily influenced by the Hippocratic and Galenic schools of thought, he widened his knowledge with Indian medical practice.4 Ibn Sina had extensive knowledge and incredible skill in almost every major science, and made important contributions to the medical sciences as well.

A large part of the Canon of Medicine is devoted to brain and spinal anatomy and diseases. The anatomical information written by Avicenna in the Canon reflects a review of the treatises written by the earlier Greco–Roman authors and Galen, as well as Avicenna’s own observations and considerations. It is not known, however, how much of Avicenna’s anatomical knowledge is original and based on his own studies. Because of the tradition against anatomical dissections of humans in Islamic cultures, Avicenna’s anatomical considerations might be based on his clinical observations.17

The third volume of the Canon includes a “head and brain disorders” fen, which comprises a chapter titled “Swellings and Disintegrations of Continuity in the Head by Disease,” containing sections “Water in the skull” and “Swelling and water on the skull.” The first chapter of this fen contains a section bearing the title “Brain dissection.” In this part Avicenna examines the brain in three components: cover matter, brain matter, and cavities. He further divides the cover layer into the thin (leptomeninges) and the thick (dura mater) sections. Avicenna categorizes the cavities as two frontal ventricles and one posterior ventricle, together with a middle one (which he describes as a “corridor,” possibly referring to the third ventricle and aqueductus Sylvii collectively) that connect all three ventricles. 10,13 Although Avicenna presented accurate information concerning brain anatomy and conveyed acceptable clinical observations of hydrocephalic patients, he could not identify the correct location of liquid accumulation, clearly indicating that he did not perform autopsies in hydrocephalic cases. Yet the assumption that he did not perform anatomical dissections may not be true; although the contrary can also be concluded.

Like many physicians of antiquity, Avicenna accepted hydrocephalus as an extracerebral fluid accumulation with no mention of cerebral ventricular dilation. Avicenna classified hydrocephalus essentially into intracranial and extra-cranial types and he furthermore divided extracranial hydrocephalus into subperiosteal and subgaleal fluid collections. He emphasized the importance of a physical examination in this disease and also highlighted the value of palpation in the diagnosis of hydrocephalus. In his description of movable bones in hydrocephalic children he noted the separated thin cranial bones seen in infantile internal hydrocephalus. Differing from other physicians, Avicenna analyzed scalp abscesses under painful head fluid collections besides subperiosteal hematoma, and stressed the scalp color changes observed in these lesions.

Avicenna stated that the location of intracranial hydrocephalus was extradural. He would have acquired this statement most likely from the texts by Oribasius and Paul of Aegina.9 Considering the description of the membranous brain in hydrocephalic cases given by Vesalius centuries later, it might be possible that Avicenna could not have differentiated whether tissue was part of the cerebral cortex or dura mater in progressive hydrocephalus. Due to the misinterpretation of anatomical structures and poor results in treated cases, intracranial hydrocephalus was considered an incurable condition in the Canon. In this manner, Avicenna differs from Albucasis, who boldly offered surgery for intracranial hydrocephalus. Albucasis preferred a middle cranial incision, using the anterior fontanelle to evacuate the fluid collection under the skull, and thus most of the patients would have died of hemorrhagic complications secondary to superior sagittal sinus rupture.9 Although Avicenna recommended surgery for fluid collection between the skull and the skin and illustrated clear incision types according to the volume of fluid, he did not describe the significance of the amount of fluid and the way to measure it. It is possible that those kinds of measurements were transmitted verbally throughout generations during the medieval ages.

Conclusions

Although Albucasis and Serefeddin Sabuncuoğlu are widely cited in the English literature when the scientific history of hydrocephalus is considered,5–9,16,18 the work of Avicenna has not sufficiently received the recognition it deserves. Avicenna made important contributions to this field during the Islamic Golden Age. He emphasized the high mortality rate of internal hydrocephalus and warned physicians not to intervene surgically. Time proved Avicenna correct to some extent, because the anatomical and pathological understanding of hydrocephalus and the technical developments for its effective treatment took more than 1000 years, whereas internal hydrocephalus remained an untreatable disease until the 20th century.
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References