Neurosurgery in the Byzantine Empire: the contributions of Paul of Aegina (625–690 AD)

Historical vignette

SYMEON MISSIONS, M.D.,1 KIMON BEKELIS, M.D.,2 AND DAVID W. ROBERTS, M.D.2

1Neurosurgery, Portsmouth Regional Hospital, Portsmouth; and 2Section of Neurosurgery, Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire

Paul of Aegina (625–690 AD) was born on the island of Aegina and was one of the most prominent physician-writers of the Byzantine Empire. His work Epitome of Medicine, comprised of 7 books, was a comprehensive compendium of the medical and surgical knowledge of his time and was subsequently translated into multiple languages. Paul of Aegina made valuable contributions to neurosurgical subjects and described procedures for the treatment of nerve injuries, hydrocephalus, and fractures of the skull and spine. His work combined the ancient knowledge of Hippocrates and Galen with contemporary medical observations and served as a bridge between Byzantine and Arabic medicine. He is considered to be one of the great ancient Greek medical writers and his work has influenced the subsequent evolution of Western European and Arab medicine. This paper provides an account of his contribution to the management of neurosurgical pathologies during the Byzantine era, as described in his medical compendium, Epitome of Medicine.

Key Words • Paul of Aegina • Byzantine neurosurgery • Paulus Aeginatus • history • Epitome of Medicine

The Byzantine period began in 324 AD with the transfer of the Eastern Roman Empire’s capital to Constantinople by Constantine the Great. Medicine and especially surgery underwent a significant development during the early Byzantine period, especially between the 4th and 7th centuries AD. Byzantine physicians were deeply aware of and influenced by ancient Greek and Roman works, and sought to compile and preserve existing knowledge allowing the preservation of the medical teachings of Hippocrates, Aristotle, Celsus, and Galen for posterity.

The Byzantine Empire lasted for more than 1000 years (324–1453 AD) and during that time there were a number of prominent physicians. Oribasius of Pergamum (4th century AD), Aetius of Amida (6th century AD), Alexander of Tralles (6th century AD), Paul of Aegina (7th century AD), Theophilus Protospatharius (7th century AD), Theophanis Nonnos (10th century AD), Nicholas Myrepsos Actuarius (late 12th century), and Joannes Zacharias Actuarius (13th century AD) were some of the most prolific and influential physicians of this era.

During the 7th century AD, the Byzantine Empire was in a state of turmoil, marked by cultural and geopolitical volatility as well as multiple military campaigns. Greek was introduced as the Byzantine Empire’s official language, replacing Latin and further establishing the Hellenic character of the Eastern Empire. The Byzantine Empire was ruled by emperors of the Heraclian dynasty who reigned from 610 AD to 711 AD and waged long military struggles against the Sassanid Persians and later the Arabs. The latter first appeared in the region of the Mediterranean at this time and solidified their presence by conquering Alexandria in 642 AD and laying siege on Constantinople from 674 AD to 678 AD.

Byzantine Medicine

Byzantine medicine added to the Greco-Roman Hippocratic tradition and in turn influenced and was influenced by Arabic medicine and contributed to the revival of the medical sciences during the Renaissance in Western Europe. Two major contributions of Byzantine medicine are the creation of medical compendiums, which collected the existing medical knowledge, as well as the creation of medical facilities. Modern hospitals evolved from their Byzantine counterparts. The earliest medical establishments were set up by the Christian Church to provide care for monks and nuns. Later their role was expanded to serve the greater population and they became sanctuaries for people who could not receive care at home, including the poor, the terminally ill, and the mentally infirm. A dedicated hierarchy existed and Byzantine hospital staff included chief physicians (archiatroi), professional nurses (hypourgoi), and orderlies (hyperetai).

Humoralism and the Hippocratic Model of Medicine

Medicine in the Byzantine Empire was based on the Hippocratic model of medicine, which was adopted by
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Greek and Roman physicians and philosophers, and later adopted by Islamic physicians as well. The physiology and pathology of health and disease were explained by the balance and interplay of the 4 essentials of life, the 4 humors. The 4 humors were black bile (melan chole), yellow bile (chole), phlegm (phlegma), and blood (haima). Health reflected a state of balance of humors (eucrasia), while the imbalance of humors (dyscrasia) was believed to be the direct cause of disease.

Several factors such as diet, activity, weather, periods of life, geographic regions, or occupations could influence the production of humors and their subsequent balance. Illness occurred when an external cause upset the humoral balance and the qualities of the humor in excess would in turn influence the nature and characteristics of the disease. Faced with such a challenge, the body reacted and attempted to correct the imbalance by mixing the humoral constituents to recreate a perfect fusion of all the humors without any excess, via a process called “coction.” The process of coction created a bodily crisis and the remaining humors in excess were expelled by means of fever, sweating, urination, defecation, expectoration, sternutation (sneezing), and vomiting. When these processes were unsuccessful, then excess humors would accumulate locally, creating collections such as abscesses, boils, or edema. The role of the physician was to identify the particular humoral imbalance and assist the process of coction by helping to restore the appropriate humoral balance by removing the humors in excess via the prescription and administration of cathartics, sternutatories, or bloodletting.14

Paul of Aegina (625–690 AD)

Paul (Fig. 1) was born on the island of Aegina, one of the islands of the Saronic Gulf in Greece, just 17 miles from Athens. Little is known about his early life. He traveled extensively throughout the Byzantine Empire, which at the time encompassed much of modern-day Greece, Turkey, Lebanon, Israel, and Egypt, and was referred to as a “Periodeutis,” a traveling physician in the exercise of his profession.15 He studied medicine in Alexandria and was the author of Epitome of Medicine (Fig. 2), a compendium of medicine composed of 7 books. Paul of Aegina had great knowledge of the ancient writers, which is distilled in his work and enriched with many of his own findings, especially involving surgical techniques.15 He lived and studied in the Byzantine Empire, but during his lifetime he was exposed to Arabic culture and civilization and to its advanced medical knowledge. His work was translated into Arabic and represents a connection between the ancient Greek medical Hippocratic traditions and Islamic medical practice. He is one of the last of the great Greek physician-writers, and his work survived for centuries, remaining as a practical compendium for the practice of medicine, based on the Hippocratic tradition.15 His work was first printed in Greek in Venice in 1528, and Latin translations followed in 1551 and 1567.12 An English translation and excellent commentary by Francis Adams was published in 1843 by the Sydenham Society of London.7 A French translation followed in 1855 by René Briau.8

Francis Adams (1796–1861)

Any discussion about Paul of Aegina would be incomplete without awarding some attention to Francis Adams, whose translation of Paul’s works into English, as well as his excellent commentaries, are remarkable and represent several years’ work. H. B. Porteous provides a colorful portrait of the life and work of Francis Adams in his article published in the Journal of the Royal College of General Practitioners.17 Francis Adams was born in 1796 in Lumphanan on Deeside in Scotland. He studied medicine in Edinburgh and set up his practice in the village of Banchory, where he practiced medicine for 40 years.

Adams was introduced to the ancient Greek medical authors and translated several of their works. His greatest work is the translation of the works of Paul of Aegina. Adams translated this work in an attempt to publicize this knowledge, but he did not confine his efforts to translation alone. His commentary on the works of Paul of Aegina is a remarkable attempt to combine and compare the knowledge presented in Paul’s works with the knowledge of other ancient scholars and place it into the context of his predecessors and successors. His first volume (the first 3 books of the Epitome of Medicine) was published in 1843. The rest of the work was completed between 1844 and 1847, after the Sydenham society became involved. Adams continued his work and in 1849 he published The Genuine Works of Hippocrates and in 1856 The Extant Works of Aretaeus the Cappadocian.

Francis Adams died in 1861 of a chest infection contracted while visiting a patient on a stormy night. He was buried in Banchory churchyard. Several years later, a memorial was erected in the middle of town and the inscription appropriately describes him as a “true votary of Apollo...he devoted himself faithfully to the joint study of medicine and the muses.”

Fig. 1. An engraving of an artist’s interpretation of the portrait of Paul of Aegina, performed several hundred years after his death. Image obtained from the National Library of Medicine.
Synopsis of the Epitome of Medicine

Paul of Aegina starts his book by explaining why he wrote such a compendium of medicine. He states, “It is not because the more ancient writers had omitted anything relative to the Art that I have composed this work, but to give a comprehensive course of instruction.” His compendium is divided into 7 books and 519 chapters. The first book relates to hygiene and the correction of distempers relating to various ages, seasons, and temperaments, as well as the uses of different foods and diets. The second book explains the etiologies, treatment, and consequences of fevers. The third book deals with “topical affections from the crown of the head to the nails of the feet,” and discusses conditions of general pathology from brain infections and epilepsy to ileus, pleurisy, and gonorrhea. The fourth book discusses dermatological conditions such as herpes, gangrene, ulcers, and leprosy, as well as parasitic worms. The fifth book is a toxicology compendium discussing treatment for poisons such as hemlock, poppy, mandrake, and wolfsbane, and bites of venomous animals. The sixth book is a compendium of surgery including ophthalmological, neurosurgical, general, and orthopedic procedures. The seventh book is devoted to pharmacology reciting ointments, antidotes, emetics, and purgatives.
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the cranium, “the pain is greater, the whole head is distended, the forehead projects outwards and the eyes are fixed and shed tears frequently.” He mentions that such collections are typically seen in infants “owing to the enlargement of the sutures and the fluid escapes outwards” and are not amenable to surgical intervention.

Paul recommends surgical evacuation of the fluid when it is outside the skull. One transverse incision is recommended when the fluid is between the skin and the pericranium. Two intersecting or 3 incisions in the shape of an “H” are recommended when the fluid is between the pericranium and the skull, followed by dressings soaked in wine and oil for 3 days.

Paul’s descriptions are consistent with the knowledge and writings of his time, when surgical intervention was recommended only when the fluid was outside the skull; when the fluid was between the brain and the skull, the condition was considered incurable. His descriptions of this “external hydrocephalus” do not actually represent such an entity but rather cases of subgaleal or scalp collections of blood, pus, or other fluid, which would often be the result of external injuries. His recommendations are consistent with the works of Hippocrates and Celsus, who recommended use of emetics, purgatives, and sternutatories, and if those treatments did not succeed, they then recommended surgical drainage.

On Fractures of the Bones of the Head

Chapter 90 of the sixth book of the Epitome of Medicine provides extensive recommendations on the diagnosis, complications, and management of skull fractures. Paul classifies skull fractures into 6 categories: “fissure,” “incision,” “expression,” “depression,” “arched fracture,” and “capillary fracture.” A “fissure” is a linear nondisplaced skull fracture, an “incision” a similar but diastased fracture, whereas an “expression” is a comminuted but non-displaced fracture. On the other hand, “depressions” and “arched fractures” are inward or outward displaced fractures, respectively. Lastly, “capillary fractures” represent hairline fractures. He considers the latter (capillary fractures) a particularly dangerous category because “being often overlooked, owing to the symptoms of it not being obvious, it occasions in death.” He, therefore, appears to clearly understand the notion that devastating traumatic brain injury can occur despite minimal injury to the skull.

He points out that after accidents with significant force, cerebral contusions can occur in areas distant to the site of presumed impact, a notion similar to what we accept today as a contracoup injury. Paul also described full and partial thickness greenstick fractures, which he named “indentations,” looking like “when vessels made with copper are struck on the outside.”

Diagnosis

Paul describes the diagnosis of skull fractures based on particular symptoms and signs. In patients with an appropriate mechanism of injury, he identifies specific symptoms (vertigo, loss of speech, sudden prostration) related to the fractures, which he attributes to “compression of the brain.” He provides one of the first descriptions of the association of neurological symptoms to compression of the brain parenchyma, distancing himself from the humoral dogma that dominated medicine at the time.

If based on these symptoms, physicians have a high suspicion for a skull fracture, Paul recommends the creation of a skin incision, or the use of an existing laceration, to inspect and probe the wound, to confirm the presence of a fracture. To identify “capillary fractures” he recommends pouring black liquid on the wound so that the fracture line appears dark.

Complications

Paul identifies the penetration of the dura as a risk factor for subsequent infection. Especially in cases in which there is a potential space created between the dura and the bone, he describes the risk of developing an epidural empyema. In his own words, “if the membranes are separated the pains increase and the fever in like manner; the bone changes color, and then unconcocted pus is discharged.” Grave symptoms associated with epidural empyemas are the “vomiting of bile, convulsions, disorder of intellect, and acute fever.” He does not consider such patients candidates for surgical intervention. However, for those with “separated membranes” that have not yet developed septic symptoms, Paul recommends wound debridement and bone fragment removal, before suppuration, ideally within 7 or 14 days of the injury in the summer or winter, respectively.

Treatment

For linear nondisplaced fractures Paul recommends “scraping” of the bone edges extending to the depth of the fracture. In cases of comminuted fractures he supports the removal of the loose fractures. For closed head injury, which he recognizes as more dangerous, he recommends trephination.

He provides a very extensive description of his operative technique. After shaving the head he recommends the performance of an X-shaped skin incision integrating any preexisting laceration into one of the arms of the X. He would subsequently scrape the periosteum off the bone and achieve hemostasis with the use of “pledgets moistened in oxycrate,” a mixture of water and vinegar. He would then apply a “compress out of wine and oil” followed by a head wrap. If the patient did not develop any new symptoms overnight he would perform the second stage of the operation the next day.

He performed the second stage in the sitting position after occluding the patient’s ears with wool to block the noise of the perforation. He makes no further recommendations as to the use of any analgesics during the procedure despite multiple entries in Book 7 regarding the analgesic and soporific properties of mandrake (containing atropine, scopolamine, and hyoscyamine), poppy (opium), henbane (containing scopolamine and hyoscyamine), and wine. His assistants would retract the skin edges while he was performing several “perforations,” the modern equivalent of bur holes. Paul, in his description, pays particular attention to avoid any duromy with his perforator, called an “abaptiston.” This was particularly designed with certain emi-
nences “projecting a little above the point that prevent them from sinking down to the membrane” to avoid inadvertent slips that could cause dural tears. He completed his craniotomy with chisels. Subsequently the bones were carefully removed with toothed forceps. He agrees with Galen that loose fractures that are in the brain should not be “pursued to their termination.” During this whole process he protected the dura with a meningesphylax, an equivalent to the modern-day malleable retractor. Paul favors use of a perforator and deems it safer compared with Galen’s instruction of use of a hammer and an incisor called “lenticular,” without a perforator for this operation.

Postoperatively, the use of “balls of wool dipped in oil of roses and wine” directly on the dura and subsequent daily dressing changes are recommended, consistent with Galen’s previous descriptions. Paul praises the antiinflammatory effect of the above ingredients that promotes wound closure. He also warns that often after such an operation the dura becomes inflamed and can herniate out of the open wound, leading to convulsions or death. The use of topical antiinflammatory remedies consisting of rose oil, linseed, chamomile, or barley flour is recommended. Support of all the organ systems is recommended and a warning that the “viscera are not to be neglected.”

Paul’s classification, description, and surgical management of skull fractures and head trauma parallels information presented in the Edwin Smith Papyrus, dating back to the 17th century BC. It is the oldest known surgical treatise on trauma and describes 48 cases involving trauma to the head, neck, arms, spine, and torso. Paul never makes a direct reference to any Egyptian text but the similarities between his descriptions and those in the Edwin Smith Papyrus are interesting and serve to illustrate the evolution of medical knowledge as it propagated from the ancient Egyptians, to the Greeks and the Hippocratic tradition, and later to Byzantine and Arabic medicine.

On Fracture of the Vertebrae, Spine of the Back, and the Sacrum

Chapter 98 of the sixth book describes spinal and sacral fractures. Paul uses information previously described by Celsus and begins by describing burst fractures and their high morbidity and mortality if they involve the cervical spine. “The round bodies of the vertebrae may sometimes be crushed...and death speedily follows, more particularly if the vertebrae of the neck be affected.” In these cases he recommends an “attempt to extract by an incision of the compressing bone or if not we must soothe the part by the anti-inflammatory treatment,” but does not provide any further information about the details of such an undertaking. He then describes fractures of spinal processes which “will readily be felt upon examination with the finger” and recommends proceeding by making “an incision of the skin externally” and extracting the fragment followed by “uniting the wound with sutures.”

Similar treatment is recommended for fractures of the os sacrum, which are diagnosed by rectal digital examination; “the index finger of the left hand is to be introduced into the anus, while with the other we manage as we best can the fractured bone.” Similarly, if any piece is felt (palpated) to be broken off, surgical intervention and removal of the fragment is recommended followed by application of bandages. Such fractures of the os sacrum most likely represented coccygeal fractures.

The association between spine injuries and neurological deficits was known and reported by physicians of the time and described by Galen. In his De Locis Affectis Galen reports retention of urine and feces as a common effect of an injury of the spine. It was also known that when the injury was below the level of the neck, respiration was not affected, while if the fracture involved the cervical spine it was associated with a high risk of death, and the case was considered hopeless. The principles of localization of neurological deficits based on the level of the spine fracture were also known, and Albucasis, a prominent Arab physician of the 10th century AD, describes that fractures of the cervical spine produced paralysis and insensitivity of the arms while fractures of the thoracic spine involved lower-extremity paralysis and insensitivity as well as bowel and bladder dysfunction.

On Dislocations of the Vertebrae and the Spine

Chapter 117 of the sixth book discusses dislocations of the spine. Paul identifies the severity of such injuries and their high mortality risk. He states that “the vertebrae of the spine, when completely dislocated by accident, occasion instant death,” the reason for which was that the “spinal marrow undergoes extraordinary compression.” He describes 3 types of subluxations: anterior (“repanation”), posterior (“gibbosity”), and sideways (“wryneckedness”). He warns against prior proposed methods of reduction that advocated use of cupping, sternutation, or traction upon a ladder and explains that such treatments have been proven to be ineffective as explained in the works of Hippocrates. He identifies the high frequency of nerve injury with spinal dislocations and discusses that they are sometimes accompanied by “retention of urine and feces...with coldness of the body...followed afterwards by an involuntary discharge of the excrements...and the patients soon die...if the upper parts and the vertebrae of the neck be affected.” He makes a distinction between dislocations of a traumatic nature versus abnormal spine alignment that develops from infancy, which “leads to disease and is incurable.”

The method that he proposes for rectification of such ailments is the same as recommended by Hippocrates, which Paul states “will alone be sufficient.” The treatment involves placing the patient prone upon a flat board and using thongs of cloth wrapped around the patient’s chest, waist, and feet and secured to pillars of wood on the ground, and apply countertraction as a means to extend the spine and reduce the dislocation (Fig. 3). Sometimes the traction was applied using devices called aselli, which were axles turning around an erect piece of wood that the thongs wrapped around. During the extension he recommends pressing upon the patient’s back or even “we may sit upon it without apprehension.” The reduction can be enhanced by forming a trench or “furrow” along the board and placing one extremity of the board into the fur-
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Paul of Aegina remains one of the last great Greek physician-writers, and his work survived over the centuries, serving as a source of great inspiration and influence for future generations of physicians. His work constituted a bridge between the ancient Greco-Roman medical tradition and Arabic medicine. Several of the works of Haly Abbas, Albulcas,Settings, and Rhazes are influenced and based on observations by Paul’s Epitome of Medicine. In his works, Paul of Aegina handles ancient medical knowledge with respect, reminds us of its importance for future generations, and warns about the dangers of disregarding the works of the past. The following quotation distills and crystallizes his approach to medicine and the importance he placed on the works of his predecessors:

But, when an acquaintance with former authors is despised, what need be expected from the efforts of a single person? For, however much he may surpass others in abilities, how is it to be supposed that his private stock of knowledge should be at all worthy to compare with the accumulated treasures of antiquity? In a word, he who has never turned over the pages of the ancient physicians...before he enters the chambers of the sick, will find that, from ignorance and misapprehension, he will confound one complaint with another, for this obvious reason, that he has come to his task unprepared and uninstructed.

Conclusions

Paul of Aegina remains one of the last great Greek physician-writers, and his work survived over the centuries, serving as a source of great inspiration and influence for future generations of physicians. His work constituted a bridge between the ancient Greco-Roman medical tradition and Arabic medicine. Several of the works of Haly Abbas, Albulcas, and Rhazes are influenced and based on observations by Paul’s Epitome of Medicine. In his works, Paul of Aegina handles ancient medical knowledge with respect, reminds us of its importance for future generations, and warns about the dangers of disregarding the works of the past. The following quotation distills and crystallizes his approach to medicine and the importance he placed on the works of his predecessors:

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Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Address correspondence to: Kimon Bekelis, M.D., Dartmouth-Hitchcock Medical Center, One Medical Center Dr., Lebanon, NH 03756, email: kbekelis@gmail.com.