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Istoriya meditsiny (History of Medicine) 2015. Vol. 2. № 1

GENERAL ASPECTS OF HISTORY AND PHILOSOPHY OF MEDICINE

FROM THE HISTORY OF HEALTHCARE

INTERDISCIPLINARY RESEARCH

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Istoriya meditsiny
(History of Medicine)
2015. Vol. 2. № 1.
DOI: 10.17720/2409-5834.v2.1.2015.08g

Hippocrates, Celsus and Galen: Head Injury, the Brain, and the Bone

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The works of Hippocrates, Celsus and Galen are taken as information sources for a proposed approach to the treatment of traumatic brain injury. All three authors point to changes in the level of consciousness in cases of traumatic brain injury. According to modern concepts, the classification of fractures proposed by Hippocrates is somewhat unusual. He spoke of hedra and bruises and noted that the latter may not be identified under examination. This view has nowadays been rejected. Discussing damage he called a depressed fracture, Hippocrates describes an extensive comminuted fracture in which the bone fragments can be moved in or out. He advised not to touch these fragments. Celsus described in detail the manipulations that needed to be carried out on depressed fractures, a technique comparable to modern ones. However, he did not mention extensive comminuted fractures and did not give a classification of fractures. Galen described new tools and new methods. He perfected the technique of craniotomy, promoted the use of cycliscus and a special tool with a blunt tip – the lentiform knife, which protected the dura from damage when removing bone fragments. His method of treating extensive depressed fractures seems too radical these days. Hippocrates, Celsus and Galen made significant contributions to the development of treatment methods for traumatic brain injury and the development of medical practice. The unusually high level of treatment performed by these scientists, without any proven scientific basis and proven medical research techniques, is striking.

Keywords*: Hippocrates, Celsus, Galen, skull fracture, depressed fracture, soul, brain function*

Introduction

From classical times, the management of patients with head injuries was based on teachings from Hippocrates (ca.460 BC – ca.370 BC), Celsus (ca.25 BC – ca.50 AD) and Galen (ca.130 AD – ca.210 AD). Hippocrates was first with 'On Injuries to the Head' and therein described the technique of trepanation and suggested appropriate indications for this operation. He died 345 years before Celsus was born and Celsus died eighty years before Galen was born. The present paper is concerned with the different approaches of these three surgical giants of the ancient world.

Before Hippocrates, health care in Ancient Greece was conducted at Asklepia (single Asklepion); the name deriving from the god Asklepios. This probably mythical personage was said to be the son of Apollon with a mortal woman. Apollon was the son of Zeus. He was taught medicine by the centaur Chiron and was so successful at keeping people alive he worried Hades, god of the underworld who complained to Zeus who in turn killed Asklepios with a thunderbolt. Nonetheless, he later became immortal. In the Asklepia founded in his honour, the medicine originally practised was religious, mystical and magical. However, over the passage of time more rational treatments came to be introduced [1]. Even so, the basic direction of these places was religious. Magic, priests and votive offerings were important components. They taught Hippocrates, as well as his father and grandfather. They were Asklepiads even though the now famous Asklepion in Kos was not built until after Hippocrates death[1]. There is no evidence, but one can easily imagine that there were many testy arguments within the paternal home between father and maybe grandfather and this upstart son, with his denial of the origins of disease accepted by his elders. Hippocrates was to become a precise observer and taught that disease had a natural and not a supernatural origin. His contribution to medicine remains unsurpassed.

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Little if anything is known of Celsus' life though it has been suggested that he came from Verona, although there is no convincing evidence of this [2]. It has also been claimed that the purity of his literary style suggests that he spent much time in Rome. His full name was Aulus Cornelius Celsus. According to Roman naming conventions, it meant the he came from the Cornelius family which was distinguished and aristocratic; hence the assumption that he was of noble birth. He wrote an encyclopedia of which only the section on medicine 'De Medicina' remains. There has been debate as to the status of his medical education. This is not the place to pursue this ancient debate. However, it would not be unreasonable to believe he practiced medicine, which would have been an unusual occupation for one of noble birth in the Rome of his time. He wrote elegant structured prose which even in translation is easier to follow than much of the translated Greek of Hippocrates and Galen. However, he wrote in Latin and that had an effect on his relevance to subsequent generations. In general, in his times physicians wrote in Greek. It was considered unlikely that an aristocrat would practice medicine or surgery. Thus he was neglected in his own society. Furthermore, because his work was in Latin, his work was not taught in the centuries that followed. Serious writers on medicine wrote in Greek. Nonetheless, 'De Medicina' was the first medical text to be printed following the invention of the printing press with moveable type. Being in Latin, it was more accessible for early Renaissance readers and he became a considerable influence on medical teaching.

More is known of Galen than of Hippocrates and Celsus. He was a Greek born into a well to do family in Pergamon, in what is now Turkey and which was at the time the location for the largest library outside Alexandria. His father was an architect who invested time and money into his son's education. His mother, it has been rumored, bit the servants. He never married and would appear to have been a misogynist. Galen learned surgery based on gladiators in his home city. He inevitably gravitated to Rome and became its foremost medical practitioner [3]. He writes about a huge range of topics but, in contrast with both Hippocrates and Celsus, a great deal of his writing is in the form of polemics. Moreover, his language is, at least in available English translations, by no means as lucid as that of Hippocrates and especially that of Celsus.

Material and Methods

The writings of Hippocrates, Celsus and Galen are examined to determine how they managed cranial injury. With regard to Galen, the insights of various commentators will be used to clarify his often complex and diffuse concepts and intentions. Moreover, it is necessary to use the work of commentators on Galen, since so much of his writings remain available only in Greek or Latin. The material is presented in terms of management of the brain and management of the bone and membranes. Since head injuries can induce changes in consciousness, the basis for these changes will be discussed and, in view of the concepts current in ancient times, some mention will be made of the authors' understanding of the soul. Additionally, available texts will be examined from the point of view of modern clinical experience and considered according to the technology available to those who translated the texts into English.

Management of Injury to the Brain

Hippocrates

It is possible to say that Hippocrates' account of head injury concentrates on the cranium [4]. Nonetheless, in section 2 there is consideration that the brain is more at risk where the skull is thin and where most of the brain is located. There is also one brief mention in section 19 which provides "*And, for the most part, convulsions seize the other side of the body; for, if the wound be situated on the left side, the convulsions will seize the right side of the body; or if the wound be on the right side of the head, the convulsion attacks the left side of the body. And some become apoplectic*". Thus, Hippocrates was aware of crossed lateralization, though hardly of localization. He did in another context note the association of a paralyzed right arm with dysphasia, but there was no account of how this might have occurred. He merely accurately describes the clinical association. The following is written "*she immediately lost the power of speech; was paralyzed in the right hand*" [5]. The writers of the Hippocratic Corpus later mention loss of consciousness after trauma but make no comment on its nature or management

[6, 7]. There is further mention of the importance of the brain in his book on epilepsy, irronically called "The Sacred Disease" [8].

In the writings on Head Injury and in the Epidemics, where he mentions loss of consciousness, Hippocrates does not discuss the soul. Nor does he mention the soul in 'The Sacred Disease. However, he does state in that book: "*Men ought to know that from nothing else but the brain come joys, delights, laughter and sports, and sorrows, griefs, despondency, and lamentations. And by this, in an especial manner, we acquire wisdom and knowledge, and see and hear, and know what are foul and what are fair, what are bad and what are good, what are sweet, and what unsavory; some we discriminate by habit, and some we perceive by their utility*" [8]. This is a pretty fair description of the functions of the soul but they are considered without using the concept of soul. In the same document, he insists in very precise terms that while others consider the heart to be the seat of understanding this cannot be true and that this function resides in the brain. "*Wherefore the heart and the diaphragm are particularly sensitive, they have nothing to do, however, with the operations of the understanding, but of all these the brain is the cause*" [8]. Thus, while the Hippocrates Corpus notes some brain related symptomatology both generalized (disturbance of consciousness) and focal (contralateral convulsions) it is far from clear if the writers had any notion of the structures involved in these symptoms.

Celsus

A search through an electronic version of Celsus' 'De Medicina' demonstrates the word soul is absent from his writings. He further states that like the marrow and brain, the omentum is without feeling [9]. There is no mention of paralyses or other neurological disturbance. Thus, it seems clear that Celsus was mostly concerned with the cranium and membranes in his management of cranial injury and not the brain. He does note that "*It is impossible to save a patient when the base of the brain, the heart, the gullet, the porta of the liver, or the spinal marrow has been pierced"* [10]. He does not however explain this astute clinical observation.

Elsewhere Celsus states "*After a blow on the head we must enquire whether the patient has had bilious vomiting, whether there has been obscurity of vision, whether he has become speechless.... whether he fell to the ground, whether he has lain senseless as if asleep; for such signs do not occur unless with a fractured bone...*". This indicates an accurate knowledge of the symptoms following injury but it includes the attribution of alterations of consciousness to bony injury. Celsus goes on to state "*If in addition there is also stupor, if the mind wanders, if either paralysis or spasm has followed, it is probable that the cerebral membrane has also been lacerated; and then there is little hope*" [11]. These texts show awareness of the importance of alterations in consciousness but still attribute it to bony or meningeal injury. He has one other remarkably astute observation. "*Rarely, but now and then, it happens, however, that whilst the bone remains whole and sound, yet within the skull a blood-vessel in the cerebral membrane has been ruptured by the blow and some blood has escaped, and this having formed a clot, causes great pains, or sometimes obscures vision*" [12]. Interestingly, he observes clouding of consciousness and a disturbance of vision but no paralysis. Thus, unlike Hippocrates, Celsus does not attribute symptoms to the brain. He attributes generalized symptoms after cranial injury to lesions of the bone or meninges. He avoids mention of the soul.

Galen

Galen did not attribute any specific function to the cerebral cortex [13]. The pioneer for that insight was Thomas Willis [14]. According to Galen, the brain was a receptacle for the rational soul, the nature of which he professed ignorance [15]. He believed that there was a mysterious substance 'pneuma' in the body which existed in three forms. There was natural spirit, elaborated in the liver and together with food carried in the blood to the heart where a higher pneuma called vital spirit was formed. This in turn was converted in into animal spirit. (Please note that animal here is not related to beasts but to animus as in animated) [16]. This animal pneuma was constituted in the rete mirabilis and the choroid plexuses [17]. In most non-primate mammals, the rete is a network of vessels under the brain. This is not so in humans, as with primates, there is no such rete in human heads. However, as he could not

dissect humans, Galen maintained the error that humans also have a rete.

He believed that psychic pneuma embodied a means of reacting with the rational soul [15], and that the Pressure on the pneuma could affect the functions of the soul, leading to alterations of consciousness. He brilliantly demonstrated an experimental basis for such a notion [17]. However, this was not perceived in terms of damage to cerebral tissue. None of this seems very sensible to our modern understanding but it was a model of cerebral function which, with minor variations, persisted until the beginning of the 18th century. Unlike the works of Hippocrates and Celsus, there are no English translations of the Galenic texts relating to his management of the brain which are to be found in De Usu Partium book VIII. Thus, at present the author has to state his indebtedness to Julius Rocca, who has carefully reported and commented upon elements of Galen's neuroanatomy with the clinical interpretation mentioned above [17].

Galen differed from Hippocrates and Celsus in one important respect. They observed and recorded. He experimented and analyzed and his writings are in consequence more speculative. Hippocrates has no explanation for the mechanism of loss of consciousness in his writings on head injury. On the other hand his writing on epilepsy would tend to place the location for this phenomenon in the brain, thought there is no suggestion of a mechanism producing the clinical changes. Celsus proposes that loss of consciousness indicates injury to the meninges in keeping with the teachings of Erasistratus [17]. Galen on the other hand can induce and reverse loss of consciousness in the experimental animal by applying and releasing pressure in different parts of the ventricles. This is a far more modern approach, even if his explanation is strange to our way of thinking.

However, in the current context, there is no advance in terms of practical management to be gained from available Galenic texts. It is one thing to be told that he had a patient from Smyrna with an injury that extended into the ventricles and survived [17]. While Galen can compare the clinical findings in such a patient with what he observes in the laboratory with animals, it still does not help us to understand how he would manage brain injuries in general.

Management of Injury to the Cranium

This section will be limited to bony injury. Injuries of the skin and scalp will be ignored. Before we begin, it is necessary to mention a few things which are quite unfamiliar to modern surgeons. Two of the authors describe bony changes we don't see today but which were described repeatedly as late as the eighteenth century by Percival Pott (1714–1788) [18]. Galen doesn't mention them, presumably because he specifies that his writing on the subject of skull fractures is an expansion of the writings of Hippocrates, including only new material. The changes are described by Celsus who states: "*A diseased bone generally first becomes fatty, next either blackened or rotten; and this occurs in cases of severe ulceration or fistula, when these have become chronic or even gangrenous. And it is necessary in the first place to expose diseased bone by cutting out the ulcer and if the bone disease extends beyond the margins of the ulcer to cut away the flesh until sound bone is exposed. Then if the diseased bone appears merely fatty it is enough to apply a cautery once or twice until a scale of bone comes away; or to scrape it away until there is bleeding, which is a sign of sound bone; for diseased bone is necessarily dry*" [19, p. 493] Hippocrates in less detail mentions the same problem. He wrote "*When a bone is broken, or cleft, or contused, or otherwise injured, and when by mistake it has not been discovered, and neither the raspatory nor trepan has been applied as required, but the case has been neglected as if the bone were sound, fever will generally come on before the fourteenth day if in winter, and in summer the fever usually seizes after seven days. And when this happens, the wound loses its colour, and the inflammation dies in it; it becomes glutinous and appears like a pickle, being of a tawny and somewhat livid colour; and the bone then begins to sphacelate, and turns black where it was white before, and at last becomes pale and blanched*" [4].

The second unfamiliar phenomenon Hippocrates mentions is contused bones, an expression found in later writings, including those of Percival Pott mentioned above [18]. It is less clear what is meant by the expression. Celsus does not mention contused bone. This confusion probably relates to changing use of terms. Today a contusion means multiple small hemorrhages into

a tissue following trauma. It may be a minor matter like a bruise of the skin following a fall. It may be lethal if it is a large lesion of the brain. However, the term is limited to this particular pathogenetic mechanism. On this basis it is hard to understand how bone can be contused as such, because it only suffers hemorrhages if fractured. Otherwise, hemorrhage is limited to the membranes covering and attached to bone. These concepts are not the same as those pertaining in the ancient world, where nobody knew or could know exactly what happened. It should be mentioned that since the introduction of the magnetic resonance imaging the term has re-emerged in the literature and at the time of writing there are 45 references on MEDLINE. However, they relate to MR findings dealing with joint injuries, the majority of which are in the knee. There is no paper on MEDLINE relating to bone contusion as a result of direct trauma as considered here and none relating to the cranium. It is worth noting that Hippocrates repeatedly states that contusions may not be apparent.

Hippocrates

With regard to cranial injury, Hippocrates spends a lot of time describing different trauma mechanisms and their relationship to the bony changes produced. Many of the injuries described seem to be more the result of fighting than of accident. He describes the shape of the skull and where it is thickest and thinnest. He describes the sutures. He describes five types of fracture; fissure surrounded by contusion, contusion without fracture, depressed fracture, hedra with or without contusion or fracture, contre-coup injury. It is not clear what these contusions are, as mentioned above. We shall return to the hedra mentioned. He recommended trepanation for contusions, for fissures, and for hedra with a fracture or hedra with a contusion and no fracture. Depressed fractures and hedra without fracture or contusion did not require trepanation. He insists that, as far as possible, wounds on the head should be kept dry.

Also included are detailed comments on taking a patient's history and examining trauma inorder to determine the type of injury according to the aforementioned classification. There is no advice about treating an injury if the skin is intact. However, in the presence of any skin deficit the wound should be extended to ensure adequate examination of the bone. This examination includes scraping the bone with a raspatory to follow the injury deeper (fig. 1). It provides that will reveals lesions not apparent upon superficial examination. If there is doubt about the presence of a fracture or contusion, a black die may be applied to the wound and kept in place with a poultice of flour and vinegar. The next day the raspatory is again used, since the fissure will be revealed stained black with die. Moreover, contused bone will be revealed having imbibed the die. If the scraping shows the fracture is not full thickness, it is less important. If it is full thickness, the trepan will be needed. In the general text, the rationale for trepanation is not given. There is one exception to this rule found in section 18 about children, where it mentions that trepanation could allow the escape of blood trapped under the bone.

Hippocrates, as is well known, gives detailed instruction of the correct method in which trepanation should be undertaken including the need to irrigate the instrument. Moreover, if the wound is fresh, the trepanation should cease before full penetration and the disk so created should be allowed to separate of itself. On the other hand, if the operation has been delayed, then the trepan should be intermittently removed and the penetration tested with a probe. This is presumably because in such cases there is the likelihood that matter has accumulated between bone and dura, making complete penetration safer.

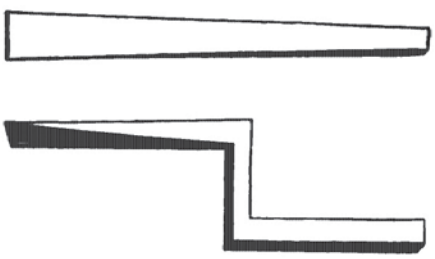

Fig. 1. Raspatories.

This image is repeated in Loeb Library texts. It is found in Adams' translation of Hippocrates. The images are not from the ancient world but from a text by Vidius Vidio (1509–1569), a surgeon contemporary with Ambroise Paré. No raspatories from classical times have been unearthed. However, this diagram gives an adequate impression of how such instruments might have worked.

Hippocrates was clear that depressed fractures should not be elevated and that the trepan should not be used in such cases. He states that the depressed fragments will regain their position spontaneously given time. However, this advice requires further consideration. Hippocrates description of a depressed fracture is in fact a widespread comminuted fracture. For injuries of this kind his advice is sound and there is reason to believe this this is a correct interpretation. The precise wording is "*Such pieces of bone as are depressed from their natural position, either being broken off or chopped off to a considerable extent, are attended with less danger, provided the membrane be safe; and bones which are broken by numerous and broader fractures are still less dangerous and more easily extracted*" [4]. This sort of injury is also consistent with the battlefield and there were over 20 battles in Greece during his lifetime. It should also perhaps be remembered that one of his sayings is said to have been either "*War is the only proper school for the surgeon*" or "*He who wishes to be a surgeon should go to war*". However, this quotation comes from an essay called 'De Medico' which is part of the Hippocratic corpus. It is to be found in section 14 of the essay and deals with military surgery. In that context it provides, "*Thus, the person intending to practice this kind of surgery must serve in the army, and accompany it on expeditions abroad, for in this way he would become experienced in this practice*" [20]. While not having the force of the above quoted aphorisms, this text does indicate the importance to Hippocrates and/or his school of battle surgery in the context of head injuries. In the current context this is important because head injuries in battles fought before gunpowder would be sustained from sharp instruments not the blunt instruments of modern civilian practice.

It should be remembered that the Adams translation was made before X-rays were available and the Withington translation in 1928 at a time when quality skull X-rays would not have been universally available. Thus, these translations are made at a time when modern understanding had not yet been achieved. Bearing this in mind, we can reconsider the depressed fracture and the hedra. It would be a very unusual though not impossible event for a weapon to produce a dent in the outer table of the skull and not affect the inner table. However, viewed from the exterior, without the benefit of images, it would be easy to believe that the injury did not extend through the bone when in fact it did. There are two aspects to consider.

One source of confusion is a soft tissue injury illustrated in figure 2. The finger palpates what feels like a dent. The base of the dent is firm

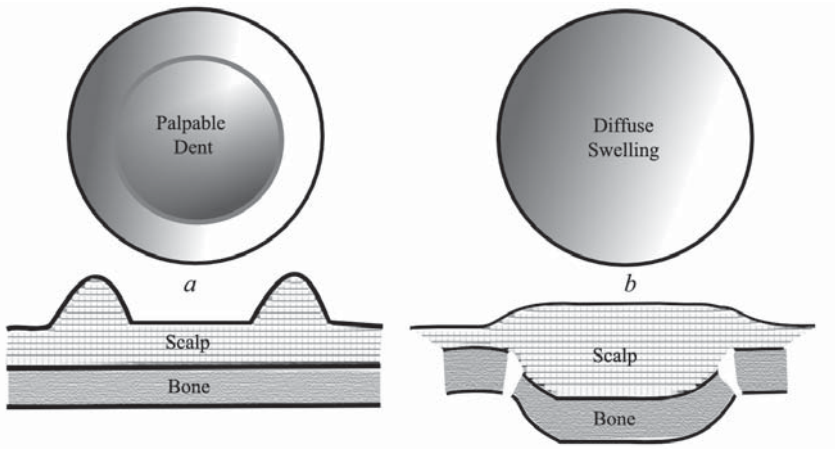

Fig. 2. Hedra.

a – on the left a palpable dent as is commonly found after head injuries is illustrated. The elements of this dent feel hard and firm. This is not a finding with depressed fractures but with contusions and occasionally linear fractures. In the ancient world it would easily be taken for a depressed fracture;

b – on the right is shown the clinical findings usually associated with a depressed fracture consisting of a diffuse swelling, due to bleeding from fractured bone margins. The base of the area sometimes feels firm and sometimes diffuse. This varies from injury to injury.

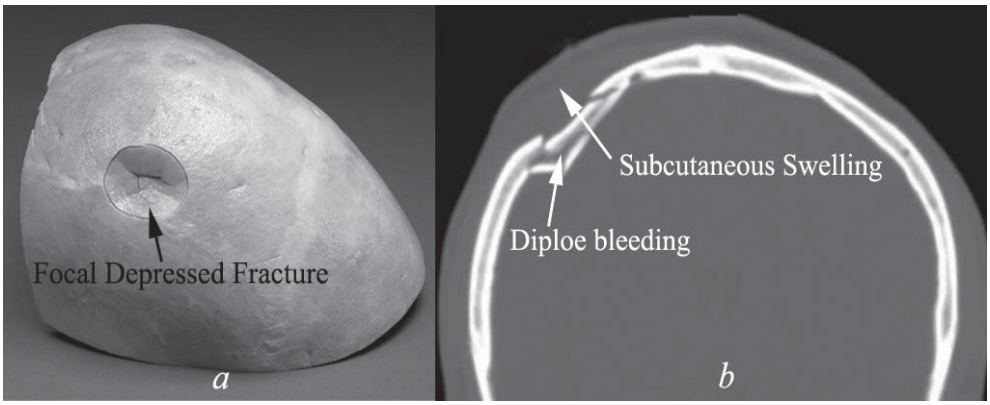

Fig. 3. Depressed skull fracture.
a – shows a skull with a localized depressed fracture;
b – shows a bone window CT of such a fracture though not the one in 'a'. The involvement of all layers of the skull should be noted. Also the diffuse swelling arising from blood escaping from the diploe; the spongy substance between the two solid layers outside and inside called the tables. The spaces in the network of the diploe are usually filled with blood that can escape during a fracture, producing the soft diffuse swelling. Also note that the condition of the inner table is not necessarily apparent when observed from the outside.

and there is a more or less hard circular swelling around the central dent. This is almost invariably either a soft tissue injury or associated with a linear fissure. Although it feels like a depressed fracture, it is not. Moreover, this is a relatively common finding. This is one possible source of the lesions called hedra, but as will be shown below it cannot be the only one.

The other source of confusion associated with the interpretation of findings concerning depressed fractures is illustrated in figure 3. This is based on the modern understanding that fractures, depressed or otherwise, are seldom limited to the outer table of the skull. It thus seems impossible that hedra were in fact what we today would call a localized depressed fracture. This would be dealt with as Hippocrates dealt with it, by removing loose fragments. Hippocrates strengthens this interpretation with the statement "*A piece of bone that must separate from the rest of the bone, in consequence of a wound in the head, either from the indentation (hedra) of a blow in the bone, or from the bone being otherwise denuded for a long time, separates mostly by becoming exsanguous*". If a hedra was merely a dent, perhaps limited to the outer table, there is no reason for loose fragments to develop.

Most of the trauma recounted in this text could be military injuries associated with an overlying skin lesion. It should be noted that the word weapon occurs over twenty times in the text. Hippocrates, by modern standards, was very eager to open the scalp and scrape the bone in order to determine the extent of an injury and to determine the need for trepanation. His indications for surgery with or without the trepan are by modern standards unusually enthusiastic. However, while the indications are dubious, the methodology described is precise, imaginative and technically commendable.

Moreover, if hedra were in fact focal depressed fractures, his treatment is similar to modern practice.

The only instruments mentioned are a raspatory and a trephine. The details of the instruments are not mentioned.

Celsus

Celsus was much concerned with the ethics and humanity of the surgeon. He states. "*Now a surgeon should be youthful or at any rate nearer youth than age; with a strong and steady hand which never trembles, and ready to use the left hand as well as the right; with vision sharp and clear, and spirit undaunted; filled with pity, so that he wishes to cure his patient, yet is not moved by his cries, to go too fast, or cut less than is necessary; but he does everything just as if the cries of pain cause him no emotion*" [2].

He was also a loyal devotee of the teachings of Hippocrates. Thus, his introductory remarks on the management of injuries repeat in principle

the advice of Hippocrates, to open and explore and to determine whether a fracture is present or not. He repeats Hippocrates advice on distinguishing between the sutures and a fracture, using ink as described above. He also advises that if the superficial wound is too small it should be extended and suggests that a cruciate incision is optimal for that purpose; this practice persisted to the 18th century.

He was against surgical interference with fissures and advocated the use of dressings and ointments. This is much more conservative than the methods of Hippocrates. He describes the risk of the skull being split or depressed. If there was a split skull, the fragments could interlock preventing the escape of fluids (humors) trapped beneath, presumably produced by irritation of the dura caused by the fractured fragments. For this he advocated chiseling away overlapping bone margins, thus producing a space between the fragments and permitting fluids to escape. His description of the management of depressed fractures is comprehensive, elegant and simple. In principle, it was no different from current practice. It was described in some detail in an earlier paper [22]. During the operation he described how bone fragments impacted. He employed the correct accepted surgical principal of proceeding from normal tissue to abnormal in order accurately to define the limits of bone to be removed. Then, in the normal adjacent bone, he drills a series of burr holes around the part to be removed. He then joins these burr holes with a chisel to produce a fragment which may be removed [19, p. 513–514]. This involves freeing the underlying dura adhering to the bone by placing an instrument called a meningophylax between the chisel and the dura, preventing dural injury. The precise form of the meningophylax is uncertain but its description is elegant. He states "*..... a guard of the membrane which the Greeks call meningophylax. This consists of a plate of bronze, its end slightly concave, smooth on the outer side; this is so inserted that the smooth side is next the brain, and is gradually pushed in under the part where the bone is being cut through by the chisel. If it is knocked by the corner of the chisel it, stops the chisel going further in. Therefore, the surgeon goes on striking the chisel with the mallet more boldly and more safely, until the bone, having been divided all round, is lifted by the same plate and can be removed without any injury to the brain.*"

It would be difficult to imagine a more precise description of a surgical procedure. A further detail of his writing on depressed fracture is to specify that it is not necessary to elevate every depressed fragment but it is important to remove spicules of bone which stick in the brain.

Celsus treatment is based on the treatement of Hippocrates, but is more precisely described. His surgical technique differs little from modern practice, although he does not have the benefit of a Kerrison punch and needs to use a chisel and protective instrument to widen openings started with burr holes. Moreover, the kind of fracture for which he is describing treatment is the kind which may practically be surrounded with a ring of burr holes. This is what is commonly seen in modern practice and is different from the multiple extended fractures described by Hippocrates. It would be no easy matter to improve on the clarity of expression of Celsus text.

Galen

Galen writes the following about Hippocrates. "*Of course, a whole book has been written about fractures in the head by Hippocrate ....For the present, since I add in this treatise the things discovered other than those mentioned by that man, let me define those things he stated vaguely*" [23, p. 215]. He reclassifies the fractures as extending to the diploe, extending to the internal surface, simple, comminuted and depressed. This is much more modern than the classification of Hippocrates. He also advocated drying poultices as Hippocrates did. He also specified that raspatories should be used, but introduces a new instrument called a cycliscus. This is defined in Chambers Cyclopaedia of Arts and Science, Volume 1 in 1728 as "*An Instrument in the form of an half moon; used by surgeons to scrape away rottenness*" [24]. An approximation to the relevant shape is shown in figure 4. The raspatories will scrape away bone and show the depth of the fracture. He very sensibly mentions that a large number of raspatories will be needed, indicating that he starts with a broad one and then uses increasingly narrow ones as the process moves deeper. If the fracture is not full thickness, then nothing more needs to be surgically done. If it extends through to the dura and is no more than a fissure, no more surgery

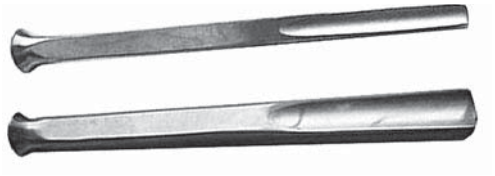

Fig. 4. Cyclisci.

No definite examples of these instruments have been discovered. However, from the description in Galen and the definition in the Chambers dictionary, it is quite likely they looked like the modern instruments shown above. According to Galen, instruments of various sizes will be required.

is required. If there is crushed bone it must be removed. This can be done as described by Celsus, using the trephine or using the cyclisci to scrape channels in the bone. He likes neither method, being concerned that the trephine may penetrate too far and damage underlying tissues. He dislikes the cyclisci, in this context, because they shake the head too much. His preferred method is to use the cyclisci to get enough space and thereafter to use the lentiform knife to cut away the bone as illustrated in figure 5. He then makes a characteristic surgeon's comment, "*The thick membrane (dura mater) cannot, in fact, be injured even if the person operating is half asleep*". Many surgeons will remember comments in this style from their teachers. He concludes by saying "*It is impossible to discover any other method of trepanning that is less dangerous or quicker*" [23].

He mentions thereafter bone forceps for the removal or turning back of depressed bone fragments, but is unclear about how extensive such a removal should be. This elevation of fragments facilitates the introduction of the lentiform knife. However, there are some concerns, "*One might almost repeat that dictum which has been well said in regard to all other matters 'Beginning is half of the hole'. Here, however you would not have half of the whole, but either the whole or only slightly less than the whole after you have inserted the lentiform knife*". This leaves the impression that the introduction of the knife permits extensive bone resection, but typically for Galen the style is prolix enough to cloud the meaning. In addition, he instructs that everything severely shattered should be removed but that it is not necessary to follow every fracture to the entirety of its extent. The rest of the text on this topic concerns bandaging and ointments and lies outside the range of the current paper.

Galen's fracture classification is superior. His surgical technique, in so far as it is possible to understand it is also superior. He introduces more instruments than his predecessors and is sensible in how they should be used. However, it seems that some of the depressed fractures he is describing are the same types of fracture which Hippocrates advised to leave alone. Modern practice would tend in the direction of Hippocrates, not least because Galen's method would result in extensive skull defects needing to be filled. It is noteworthy that this would would not have been an option in Galen's time. The procedure of cranioplasty required to replace extensive skull defects remains a considerable challenge even today.

Conclusions

Traumatic brain damage is expressed clinically in terms of changes in levels of consciousness and focal neurological deficit. The latter is beyond the scope of this paper. Changes in leves of consciousness are mentioned by all three authors. Hippocrates merely mentions them as an expression of brain damage without theorizing as to the underlying mechanism. Celsus considers them an expression of damage to the meninges. Neither mentions the soul

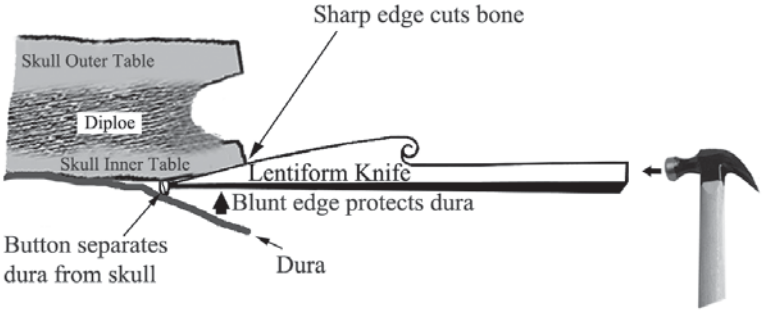

Fig. 5. This shows the use of the lentiform knife in cross section. Space is made to insert it under the inner surface of the bone. The hard membrane (dura) which is attached to the skull is loosened to introduce the tip of the knife. This is then tapped in deeper and deeper with a mallet which resuls in cutting of the bone while avoiding penetration of the dura and damage to the underlying bone.

in this context. Since an unresponsive loss of consciousness is a component of the clinical picture of death, it is logical to consider changes in the level of consciousness as expressions of disturbances of the soul. Galen examines the location and nature of the soul and considers the rational soul lies in the brain in the parenchyma. However, he is adamant at not knowing its nature. This is elegant philosophy but clinically unhelpful.

The classification of fractures according to Hippocrates is strange by modern standards. He mentions the hedra and contusion. He notes that the latter may be invisible to observation and it is a concept no longer in use in the clinic. However, the hedra has been suggested as a dent. For the reasons given above it is suggested that a hedra was in fact a focal depressed fracture for which he advised trepanation. The lesion he calls a depressed fracture is followed by a description of an extensive comminuted fracture, the fragments of which may or may not be displaced inwards or outwards. These he suggests should not be touched. It is sound advice. Celsus elegantly describes a technique for the management of focal depressed fractures which, with the exception of the Kerrison punch, is in keeping with modern practice. He does not mention the extensive comminuted fractures, nor does he classify fractures. He does not mention contusions either. Galen describes new instruments and elegant technique in principal, but not in the detail which Celsus provides. His practice with extended depressed fractures would seem to be overly radical by modern standards.

All three authors made individual contributions of great value. It is truly astounding that such a high quality of treatment could have been achieved in the absence of any accurate scientific conceptual framework and in the absence of any useful technology for investigation. It is also fascinating how their writings reflect their very different personalities. Hippocrates is the quiet observer and analyzer and pioneer of a rational basis for learning. Celsus is the highly educated truly academic presenter of observation and practice with a genius for clarity of expression. Galen is at once the first medical experimental scientist, a highly experienced surgeon and a tireless polemicist.

REFERENCES

1. Porter R. *The Greatest Benefit to Mankind*. London, Harper Collings, 1997. P. 52.
2. Elliott J.S. *Outlines of Greek and Roman Medicine*. Boston, Milford House, 1971.
3. Hankinson R.J. *The man and his work*. Ed. Hankinson R.J. The Cambridge Companion to Galen. Cambridge, Cambridge University Press, 2008. P. 1–33.
4. Hippocrates. *On injuries of the head*. In: Neurosurgical Classics. Ed. Wilkins R.H. Rowling Meadows, IL, AANS Publications, 1972. P. 8–14.
5. Adams F. *The Genuine Works of Hippocrates Translated from the Greek with a Preliminary Discourse and Annotations*. In 2 volumes. Vol. 1. London: The Sydenham Society, 1849. 380 p.
6. Hippocrates. *Epidemics V.* No. 28. In: Hippocrates. Vol. VII. Transl. W.D. Smith. Cambridge Massachussetts, Harvard University Press, 1994. 169 p.
7. Hippocrates. *Epidemics V.* Transl. Smith W.D. Cambridge Massachusetts, Harvard University Press, 1994. 179 p.
8. Adams F. *On the Sacred Disease by Hippocrates* [http://classics.mit.edu/Hippocrates/sacred.html, accessed 30 Jul 2014]
9. Celsus. *De Medicina IV.* Transl. Spencer W.G. Cambridge Massachusetts, Harvard University Press, 1938. 361.
10. Celsus. *De Medicina V.* Transl. Spencer W.G. Cambridge Massachusetts, Harvard University Press, 1938. P. 69.
11. Celsus. *De Medicina*. Transl. Spencer W.G. Cambridge Massachusetts, Harvard University Press, 1938. P. 475–518.
12. Celsus. *De Medicina VIII.* Transl. Spencer W.G. Cambridge Massachusetts, Harvard University Press, 1938. P. 509.
13. Finger S. *The Era of Cortical Localization*. In: Origins of Neuroscience. Oxford: Oxford University Press, 1994. P. 32–51.
14. Rengachary S.S., Xavier A., Manjila S., Smerdon U., Parker B., Hadwan S., Guthikonda M. *The legendary contributions of Thomas Willis (1621–1675), the arterial circle and beyond*. J. Neurosurg. 2008. Vol. 109. P. 765–775.
15. Donini P. *Pscychology*. In: The Cambridge Companion to Galen. Ed. Hankinson R.J. Cambridge: Cambridge University Press, 2008. P. 184–209.
16. Springer C. *A Short History of Anatomy from the Greeks to Harvey*. New York: Dover Publications, 1957. P. 58–62.
17. Rocca J. *Anatomy*. In: The Cambridge Companion to Galen. Ed. Hankinson R.J. Cambridge: Cambridge University Press, 2008. P. 242–262.

18. Pott P. *Observations on the Nature and Consequences of Those Injuries to Which the Head is Liable From External Violence*. London, Hawes, Clarke, and Collins, 1768.
19. Celsus. De Medicina. Book VIII, 4. Transl. Spencer W.G. Cambridge Massachussetts, Harvard University Press, 1938.
20. Hippocrates. *Physicians in Hippocrates*. The Loeb Classical Library. Transl. Potter P. Cambridge Massachusetts, Harvard University Press, 1995. P. 311.
21. Celsus. *De Medicina VII*. Transl. Spencer W.G. Cambridge Massachusetts, Harvard University Press, 1938. P. 297.
22. Ganz J.C., Arndt J. *A History of Depressed Skull Fractures from Ancient Times to 1800*. Journal of the History of the Neurosciences. 2014. Vol. 23. N 3. P. 233–251.
23. Galen. *Method of Medicine VI*. Eds., transl. Johnston I., Horsely G.H.R. Cambridge Massachussetts, Harvard University Press, 2011. P. 215–235.
24. Chambers E. *Chambers Cyclopaedia of Arts and Sciences*. Vol 1. London: Longman Charles Rivington, 1728. P. 364.

Received: 18.08.14

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The name of the article for quotation: *Hippocrates, Celsus and Galen: Head Injury, the Brain, and the Bone. Istoriya meditsiny (History of Medicine). 2015. Vol. 2. № 1. P. 92–103.*