



# ON THE FRACTURES AND DISLOCATIONS OF THE SPINE IN RHAZES' *KITĀB AL-ḤĀWĪ* / *LIBER CONTINENS*\*

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## SUMMARY:

Abū Bakr Muḥammad b. Zakariyyā al-Rāzī was one of the most scientific figures during the era called Golden Age of civilization and medicine in Islamic world. He was a scientist who made important contributions to both Eastern and Western medieval scientific world with his works. Evaluation of the sections on spinal fractures and dislocations in Rhazes' *al-Ḥāwī fī al-Ṭibb*, which was a huge work formed by his pupils after his death using his notes recorded by Rhazes when he was alive, is aim of this study.

The sections regarding the spinal fractures and dislocations were determined in the 13<sup>th</sup> part of *al-Ḥāwī fī al-Ṭibb* in Arabic and 15<sup>th</sup> part of *Liber Continens* in Latin, which contain subjects on fractures, dislocations, injuries and their treatments and medicines, and translated from Arabic and Latin into English. Results were presented and what these findings mean in the history of medicine was discussed in the article.

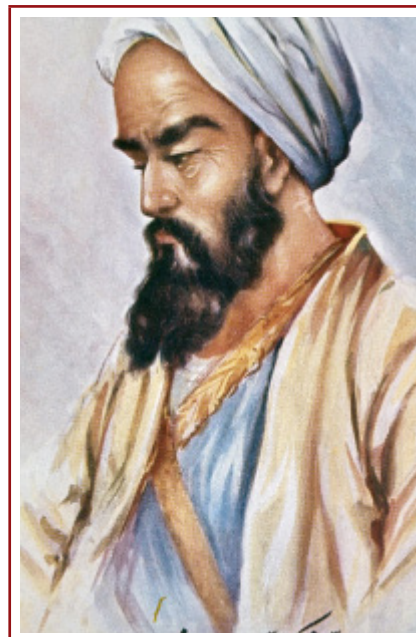
**Key words:** Al-Hawi fi al-Tibb, Al-Razi, Liber Continens, Rhazes, spinal dislocations, spinal fractures.

**Level of Evidence:** Historical article, Level V.

*In memoriam of UNESCO 2016, 1150th anniversary of the birth of Muhammad Zakariyyā Rāzī (also known by his Latinized name: Rhazes or Rasis), physician, chemist and philosopher (866-925).*

## INTRODUCTION:

Abū Bakr Muḥammad b. Zakariyyā al-Rāzī (Figure-1)<sup>(40)</sup>, known as Rhazes in the West, was born in Rey, near Tehran. Historians consider him a gifted physician and a brilliant chemist<sup>(28,38)</sup> and at the same time he is acknowledged as one of the Islam's most freethinking philosophers<sup>(15)</sup>. In his early life Rhazes first dealt with music and then educated philosophy. At a relatively advanced age he started to study medicine in Rey, afterwards he travelled to Syria, Egypt, and Andalusia. Some sources claim that Rhazes stayed in Cordoba for a long time and upon turning back from Andalusia he first worked in Rey and then became director and surgeon general of one of the major hospitals in Baghdad<sup>(5,37)</sup>. One historian of medicine on the other hand argued that the information about Andalusia period is incorrect and that that was mistakenly passed from Africanus Leo<sup>(23)</sup>.



**Figure-1.** Portrait of Abū Bakr Muḥammad b. Zakariyyā al-Rāzī<sup>(40)</sup>.

After working in Baghdad many years he entered the service of Manşūr ibn Işhāq, the ruler of Khorassan and Transaxonia in Central Asia<sup>(5,37)</sup>. Towards the end of his life he developed vision loss due to probably cataract in his both eyes<sup>(5-6,8,18,37)</sup>. Rhazes refused the surgical intervention owing to the doctor's lack of knowledge of the whole anatomy of the eye<sup>(5-6,37)</sup>. The anecdote regarding this event from famous historian Abū al-Faraj is below:

*“The great physician Rhazes became blind in the late phase of his life. He called kahhāl [Eye doctor; oculist]<sup>(11)</sup> for inspection of his eyes. After carefully examining the eyes of Rhazes the doctor found out the cause of blindness and explained that a surgical procedure was needed, and he could carry out this operation as any skillfully eye doctor would perform. In return, Rhazes said that he would only accept the surgical procedure if the eye doctor could name the anatomical layers of the eye. While the doctor knew little about the detailed anatomy of the eye he could not answer the quest properly, whereupon Rhazes said: How could a man open my eyes when he even does not know the thorough anatomy of the eye? I have seen enough of the world; I am tired of seeing it. Without suffering any grief and sorrow I may console myself for being blind<sup>(5)</sup>.”*

This account proved Rhazes' disciplinized and rigorous personality.

On the other hand Abū Rayhān Muḥammad b. Aḥmad al-Bayrūnī (973-1048), known in the West as Alberuni or Alboron, wrote another story about this event. According to al-Bayrūnī<sup>(6)</sup> a disciple of Rhazes had arrived from Ṭaberistān to treat teacher's vision problem. Then, Rhazes asked him how he can cure his eye condition and the disciple explained what he can do. However, Rhazes replied as following:

*“God is my witness that there is nobody who can surpass you as kaddāh [The operator who performs upon the eye the operation of couching]<sup>(22)</sup>. Moreover, you are the best kähil [should be kahhāl]. However as you know this procedure cannot be done without pain. It needs a long lasting course. The soul would get tired. This long time may give tediousness. Sometimes, this long treatment time can outdo man's lifetime. Sometimes, death time comes closer. An ugly man like me shows up and turns the beauty into bitterness or disturbs tranquility with pains<sup>(6)</sup>.”*

According to these accounts Rhazes never underwent an eye surgery.

Rhazes was a very productive writer; he authored more than 200 books in his life span<sup>(35,38)</sup>. Half of them were composed on medicine<sup>(38)</sup>. The best known of his work is *Kitāb al-Hāwī fī al-Ṭibb*, recognized in the West as *Liber Continens* (Figure-2)<sup>(10-11,25,38)</sup>. This work was an extensive medical encyclopedia<sup>(10-11,29,35,38)</sup> and summarized mainly from previous Greek, Syriac, Arabic, Persian, and Hindu physicans' works. Additionally, Rhazes included his own observations and opinions<sup>(29,38,41)</sup>. Rhazes' disciples organized the book and sections in a successive manner after his death<sup>(10,29,41)</sup>. In *Liber Continens* Rhazes quoted

first the former physiscian followed by his own opinion usually under the captioning “To Me” or “My Own” (li) or “I said”<sup>(29)</sup>. The work had affected Eastern and Western medicine greatly starting from its writing time. In Europe, Farragut of Sicilian<sup>(28)</sup> / Antiochian<sup>(4)</sup> first translated *Liber Continens* in 1279 from Arabic into Latin for King Charles of Angevin Dynasty. Much later in 1486 it was published under the name of *Liber dictus Elhavi*, in Brescia, northern Italy<sup>(4,10,29)</sup>, and then in Venice in 1500, 1506 and 1542<sup>(29)</sup>. *Liber Continens* had been one of the essential medical encyclopedic sources in some European universities until 17th century<sup>(4,17,41)</sup>.

One other noteworthy medical work of Rhazes was *Kitāb al-Manşūrī fī al-Ṭibb* that was dedicated to Khorassan governor Manşūr ibn Işhāq<sup>(4,8,36,41)</sup>. It was translated into Latin by Gerard of Cremona under the name *Liber medicinalis ad Almansorem*<sup>(10-11)</sup> and was first published in Milan, 1481<sup>(36)</sup>. Rhazes created *Liber Almonserem* as a short compilation largely based on Greek medicine<sup>(10)</sup> containing only 10 topics over the most important medical issues of the time<sup>(10,36,38)</sup>. The seventh (*On Surgery*)<sup>(11,24)</sup> and the ninth (*On the Treatment of All Diseases*, known also as *Nonus Almansoris*) sections of *Liber Almansorem* are the most valuable sections of this work<sup>(10-11,36,41)</sup>.



**Figure-2.** *Liber Continens*, published by Ottaviano Scotus in Venice in 1529<sup>(25)</sup>.

*Kitāb al-Jadārī wa'l-Ḥaṣba* was considered as the most original one of his works<sup>(10-11,28,35,36)</sup>. It was the first documentation of smallpox and measles in history<sup>(8,36)</sup>. Sarton<sup>(38)</sup> argued that *Kitāb al-Jadārī wa'l-Ḥaṣba* was the masterwork of the Islamic medicine. It was named as *Liber de Pestilentia* in Latin<sup>(8,11)</sup>, however its better known title is *On Smallpox and Measles*<sup>(28,35-36)</sup>. This work proved that how Rhazes was an excellent observer and how he was a skilled compiler and also critic of Greek, Syriac and early Arabic medicine and finally how he became famous<sup>(29)</sup>.

Rhazes was also the first physician in history who wrote specifically on pediatric diseases<sup>(4,33)</sup>. The other work he created was *Kitāb fī Ṣifāt Bimāristān* that essentially dealt with where to establish and built, and also how to organize and manage hospitals<sup>(4-5,34)</sup>. At the same time he wrote on the ethics of physicians, named *Akblāq al-Ṭabīb*<sup>(4,19)</sup> and fought also against quacks and ignorants in his other work<sup>(5,34-35)</sup>.

While Rhazes followed Galen in theory he was a determined Hippocratist in practice. At the same time Rhazes was a well-known alchemist and usually employed newly therapeutic chemical compositions<sup>(29,38)</sup>. Rhazes effectively combined his knowledge of chemistry with medical practice and could be considered therefore as “the Ancestor of Iatrochemists”<sup>(38)</sup>. Rhazes was also the first physician who mentioned about alcohol<sup>(5)</sup>.

This work is designed to consider the sections written on the fractures and dislocations of the spine in *Liber Continens*.

## MATERIAL AND METHOD

Two Arabic copies of Fascicule 13 of *Kitāb al-Hāwī fī al-Ṭibb*<sup>(1,31)</sup> and also one Latin hardcopy of Part 15 of *Liber Continens*<sup>(30)</sup> were studied to obtain the sections related to fractures and dislocations of the spine.

Two Arabic copies of *Kitāb al-Hāwī fī al-Ṭibb* were searched by using keywords “kharaza (vertebra)”, “ṣulb (spine)”, “nukhā‘ (medulla spinalis)” and “fiqarāt (vertebrae)”. While second copy was in PDF the mentioned keywords were searched at the same time electronically on computer. The parts where these words are found were identified and compared with the Latin version. Arabic and Latin texts were included to the text as separate files.

The cases regarding spinal injuries in the first book of *Liber Continens* were omitted in this study because *The Kitāb al-Hāwī of Rāzī (ca. 900 AD), Book One of the Hāwī on Brain, Nerve, and Mental Disorders: studies in the transmission of medical texts from Greek into Arabic into Latin* published in English as doctorate of philosophy thesis by Jennifer S. Bryson already included these sections<sup>(9)</sup>.

All quotations from Arabic and Latin versions were translated in verbatim by being faithful to original texts. All texts in Appendix-2 were quoted from the liber XV of *Liber Elhavi, seu Ars medicinae*<sup>(30)</sup>. Since there were no page numbers in original text, there are no references to the page numbers of the quotations.

In certain parts of those spine related articles Rhazes specified his own thoughts under the captioning “to me” or “my own” (li) after quoting a former physician’s opinion. These sections are presented as following.

## RESULTS

### *The twelfth article from Manafī ‘al-A ‘ḡā’*

This section was excerpted from Galen’s *De usu partium corporis humani libri XVII*<sup>(2)</sup> /περὶ ἰχρῆας τῶν ἐν ἀνθρώπῳ σόματι μοριῶν ιζ<sup>(39)</sup> / *On the Usefulness of the Parts of the Body*<sup>(14)</sup> that concludes that any dislocation at the level of atlanto-occipital joint can induce disfunction of the respiratory nerve that may consequently cause sudden death.

*“He said: When it occurs to the first articulation, i.e. the first one of the cervical vertebra, which conjoined to the head, dislocates, the animal dies immediately, due to the breath arrest, because the breath supplying nerve is deprived of its action*<sup>(1,p.111;30;31,p.1327)</sup>.

Rhazes wrote:

*“I say: When the nerve is knotted, something appears that resembles the nodule on the hand and the foot close to the joints. Frequently this occurs after severe tiredness. There is a distinction between the knot and the nodule, because knot is more inseparable from its place than the nodule and touching it is such as touching the nerve. And when it is compressed violently, it disappears and goes away and some of them come back. The treatment is to oppress on it, if it disperses by oppressing, otherwise it is pounded with a hammer and a wood / (small wooden hammer), then a splint is put on it and lest it does not return it is bound strictly, and if it magnifies or becomes abundant, the body should be purged. And perhaps it may be large but plain such as in inner side of woman’s knee, because it was in bone of the hand, it was dispersed via oppression then it was bound and went away. When you see and doubt about it, ask him if it occurred after tiredness [or not] and look at if touching of it is such as touching of nerve and oppress on it and inspect if this oppression effects it till wither it [or not] (till you have a firm opinion on it)*<sup>(1,p.111-112;30;31,p.1327)</sup>.”

In his remark on this subject Rhazes did not reiterate the disastrous breathing problem, he commented more about the “node of the nerve” or occurrence of a “ganglion cyst”. This description could mean either traumatic edema of the connective tissue (e.g. tendon) or muscle spasm in the neck. In Rhazes’ time the terms nerve and tendon were interchangeably used though the distinction between them had been made centuries ago. Rhazes possibly thought that besides causing breathing

problem a trauma at this location might also induce a disturbing symptom like muscle spasm in the neck. Thus, he focused on solving that condition and offered particular treatment method with hand-massage or cleaning the body through purging.

### **The ninth [section] from 'Arā' Abuqrāf**

Rhazes quoted this section also from Galen's *De Hippocratis et Platonis placitis libri IX* <sup>(38)</sup> / περιτῶν Ἰπποκράτους καὶ Πλάτωνος δογμάτων βιβλία θ' <sup>(39)</sup> and he preferred here the definition "front vertebrae" possibly referring to the anterior column of the spine. The described situation in this part is anterior vertebra dislocation. Galen emphasized that physical examination is essential for the diagnosis of this condition, since processus spinosus would not be spotted by palpation. Galen stated that same finding is also evident in the fracture of processus spinosum and that while anterior dislocation is a deadly situation for causing injury to the spinal cord the latter condition is easy to treat. Galen also explained the underlying mechanism for this type spine injury:

*"He said: The anterior vertebrae dislocate and this location lowers as fractures of processus spinosi, and fracture of the processus spinosi is easy [to treat], and dislocation of the vertebrae is dangerous / fatal, because the dislocated vertebra either tears the medulla spinalis or compress it. If it [vertebra] departs, impels the spinal cord that requires violent insult and falling down a heavy material on it. And if a heavy material falls down on it or pushes it vehemently, processus spinosus of the vertebra is broken, before the vertebra goes in* <sup>(1,p.113;30;31,p.1328).</sup>"

After Galen's opinion Rhazes suggested barely revisiting Hippocrates' work *De artuculis (reponendis) or De articularum repositione* / περὶ ἄρθρων ἐμβολῆς <sup>(39)</sup> without further commenting.

*"I say: Read on this topic and search for Hippokrates' Kitāb al-Mafāsil / Liber articularum* <sup>(1,p.113;30;31,p.1328).</sup>"

In the following paragraph Rhazes included again Galen's views for posterior vertebra dislocation. For this type spine injury Galen recommended 3-treatment-methods all involving compression maneuver over the affected region:

*"He said: The surgeon should mollify with bandage and straighten his head, then he should put a fully stuffed pillow on this place and should bind it in order to impel the head from that part to which it inclined / leaned, because mollifying and repeatedly pushing straighten the head and it is not treated in other way and health is regained. Posterior dislocation of the vertebra is treated in the same way as the bath-attendant seizes [the patient] and by putting knee on patient's back and pushing strongly and violently and returning the vertebra [to its original location] or placing him in prone position and raising up on heel until the vertebra is returned [to its original location] or rubbing with hūmak [probably shawbak: Rolling pin] <sup>(12)</sup> till it becomes straight* <sup>(1,p.113-114;30;31,p.1329).</sup>"

At this point Rhazes placed the following remark also taken from Galen without mentioning his own comment:

*"He said: If the vertebra is separated into the abdomen, certainly there is no cure* <sup>(1,p.114;30;31,p.1329).</sup>

### **The second of the third (the fourth in Latin) [book] from Abi'zimiyyā**

This section excerpted from Hippocrates' *Epidemiorum Libri III* <sup>(38)</sup> / ἐπιδημιῶν βιβλία γ' <sup>(38-39)</sup> / *Epidemics III* <sup>(38)</sup> specified that interior [anterior] dislocation of vertebrae may cause urinary and gaita incontinence mainly due to mechanical compression onto the bladder and the bowels. Rhazes stressed that these symptoms may also occur without vertebrae dislocation when the nerves that are going to internal organs could be damaged at their emerging points from medulla spinalis:

*"If vertebrae of the spine dislocate interiorly, they compress the bladder and cause swelling and retention of the urine and firstly swelling of the rectum and [then] retention of the stool. If the vertebrae do not dislocate, but there is a fault in the spinal cord from which the nerves emerge and proceed to the vertebra, the urine and the stool pass involuntarily and when the dorsal spinal cord is shaken constantly/ continuously movement of his legs weakens and his urine is retained* <sup>(1,p.115;30;31,p.1330).</sup>"

The author of *Epidemics* informed that, spastic and flaccid conditions of some internal organs may occur after spine traumas depending on the anatomic level and also on the mechanism of the injury. The definitions of spastic and flaccid conditions may correspond modern definitions of retention and incontinence in gastrointestinal and urinary tracts, respectively. More interestingly, Hippocrates also pronounced "shaken-spinal cord condition" with which he probably indicated concussion of the medulla spinalis.

### **From Kitāb yunsaba ilā Jālinūs [The book attributed to Galen]**

The first citation Rhazes excerpted from that book is on the treatment of cervical vertebra dislocations:

*"He said: When a man falls down on his head, perhaps his cervical vertebra moves out* <sup>(1,p.120;30;31,p.1333).</sup>"

*"He said: Let the patient lie down in supine position, then extend moderately his head upwards and straighten his vertebra by rubbing and pressing, till it becomes straight. Then put a plaster on it and fill it with the rags and apply a long splint over it from end of the occipital bone to end of the cervical vertebrae and bind it so tightly over the head that the ligature does not fall upon the throat and unbind it every third day* <sup>(1,p.120;30;31,p.1333).</sup>"

*"He said: Always place the ligature on the edge of garment, because the round [ligature] / knot, since it compresses and returns / hurts, is not good* <sup>(1,p.120;30;31,p.1333).</sup>"

In his comment for this part Rhazes opposes the opinion that a cushion should be placed under the armpit when a clavicle fracture accompanies cervical vertebra dislocation. He says that there is no need for supporting the armpit in that occasion:

*"I say: If the particle [of the clavicle] which tends to the humerus is in upper [position], there is no need for cushion, because you wish nothing except to straighten it"* (1,p.120;30;31,p.1333)."

The next paragraph deals with thoracic vertebra dislocations. The quotation from Galen describes how the management should be carried out with the application of corset-like splints in these cases:

*"But in case of the dorsal vertebra, lay the patient down in prone position and straighten the vertebra by impelling. If the vertebra slides laterally, it will be better to place two splints on both sides of the vertebra and if it slides upwards, place a splint over the vertebra in order to compress it downwards. The splints should be placed from the waist / (the thigh) to the scapula, then bind it tightly"* (1,p.121;30;31,p.1333)."

There is also another quotation that mentions about sacrum fractures:

*"But, when the large bone [the sacrum] which is above the coccyx is broken or its muscle is cut into very small particles/pieces, one of the hips is not repositioned [to its former condition] and lessened. And, treatment of patient: He is turned into a prone position and his thighs are separately and forcefully extended by two men, while the other extends his hand not to move downwards. You and another man with you, oppress patient's knees/hips strongly one by you and one by him. When this location become straight, place a plaster on it, and put under him a ball-like solid thing made by rags in order to impel when he lies down on this"* (1,p.121;30;31,p.1334)."

The quotation regarding coccyx fracture seems very explanatory and clarifies bimanual maneuver for this type lesion:

*"In case of the coccyx, insert your middle finger into the anus and oppress it upwards and straighten it with the other hand from outside till it becomes straight, then plaster it and decrease the food to lessen and soften his stool, there is no need to unbind (the ligature) frequently. Regarding the bandage, you will see its mode at practice (The last sentence is not seen in Latin text)"* (1,p.121;30;31,p.1334)."

For these last three statements Rhazes did not expressed his own opinions and moved on with lectures of another antique physician, Paul of Aegina.

### **Būlus [Paul of Aegina]**

Two sections in Rhazes' work regarding symptoms of spine fractures and dislocations were quoted from Paul of Aegina's *Kunnāsh (Kunnāsh al-thuraiyā)* (39) (ὕπόμνημα ἢ ἐπιτομῆς ἰατρικῆς βιβλία ἐπτά) (38). Paul stressed here that the prognosis of the condition is poor if the medulla spinalis is involved. Especially, cervical vertebra fracture is considered a deadly situation due to respiration standstill. He emphasized that

when a bony fragment penetrates medulla spinalis this should be removed and if medulla spinalis is not involved anti-edema therapy is sufficient. He also described a correction method in the case of sacrum fracture (Figure-3 and 4):



**Figure-3.** The page showing quotations from Paul of Aegina on fractures of the vertebra and the sacrum in *Kitāb al-Hāwī fī al-Tibb* (1).

### **On vertebra of the spine**

*"He said: These symptoms which occur with a contusion/fracture, if it reaches to a point of infesting the spinal cord, it will be destructive. If it occurs in the cervical vertebra, it kills quickly, because of the breath arrest. In this case namely if it pricks the spinal cord, incise on it and extract the pricked bone. But, if it does not infest, then you must mitigate the hot swelling"* (1,p.129;30;31,p.1339)."

*"He said: Of the broken bones, the one which is removed, segregated entirely and pricking, should always be extracted, because that bone putrefies within days, then it brings about an ulcer and it provokes the pain and the swelling"* (1,p.129;30;31,p.1339)."



Figure-4. The page showing same quotations from Paul of Aegina in *Liber Continens* (30).

**The sacrum**

“He said: If it becomes concave inwards, insert the finger into the anus, then its voice raises and it becomes straight outwards (1,p.129;30;31,p.1339).”

Another quotation from Paul of Aegina stated that urinary and gaita incontinence may occur in anterior vertebra dislocation and if it happened at cervical level, the author warned, the patient shall die immediately. Paul of Aegina highlighted that after fracture of processus spinosus a concavity could occur in the spine and one who did not know that evolvment would mistake it for anterior vertebra dislocation. For this part Rhazes claimed that Paul of Aegina gave a resembling statement on the treatment of kyphosis, nonetheless, he expressed that the document available is not adequate to make a decision and additional copy of this topic is needed:

**On separation of the vertebra**

“He said: If the vertebra separated inwards, the urine and the stool are retained and if the cervical vertebra is separated, the death

follows quickly. However if the peduncle [processus spinosus] was broken and the spine becomes concave, this casual events do not occur, the ignorant (surgeon) suppose that it is separation of the vertebra inwards, but it is not the case (1,p.134;30;31,p.1344).”

“I say: On correction of the gibbosity, he made a statement, which is similar that was mentioned here, it is needed to inspect another copy (1,p.134-135;30;31,p.1344).”

**The second [section] from Qaḏīriyūn**

In this section the management of pain and weakness following blunt spine trauma is quoted from *Kitāb Buqrāt Al-Ma'rūf Bi-Qaḏīriyūn Ay Ḥanūt Al-Tabīb* (20) / κατ'ἰητροῦν (39):

“He said: One suffered the blow on his back and this disturbed him, therefore he was not strong really. We made a wool rag wet with warm olive oil and we put it on his vertebra, then we lay him down on his bad and we made him sleep on it, then we made both sides of the rag wet [again] and we fastened it (1,p.139;30;31,p.1347).”

In his comment on this topic Rhazes expressed that when vertebra dislocation or fracture is not the case there is no need for treatment except comforting the patient:

“I say: We wrote it in order to teach [you] the mode of severity of relaxation [of the patient] in this disease. There is no other treatment except relaxation, when there is no dislocation and fracture, but laceration. But when there is dislocation and fracture, after applying the bandage, foment it with wax and oil. Lest the hot swelling enlarges, several times a day the ligature should be anointed with hot oil in the winter, and fomented with cold water in the summer. I say: The constructive ligature should not be unbanded in the summer, in order to keep the condition of swelling in security; in the winter the fear will be less. These are the statements on this topic (1,p.139-140;30;31,p.1347).”

**From Kitāb Ārā' Abuqrāḏ wa Afāḏun**

In this part quoted from Galen's *De Hippocratis et Platonis placitis libri IX* (38) / περὶ τῶν Ἱπποκράτους καὶ πλάτωνος δογμάτων βιβλία θ' (39) about the findings of anterior vertebra dislocation and processus spinosus fracture, although the main notion was not different than previous opinions. The referred authors accentuate that both conditions can be mistaken for each other leading the physician to false diagnosis. They indicated that anterior dislocation is a deadly condition whereas fracture of processus spinosus is a mild injury:

“He said: And perhaps the processus spinosi are broken and the spine is interrupted, some think that it is dislocation of vertebra of the spine inwards, but it is not; and dislocation of vertebra of the spine is destructive, but in case of fracture of the processus spinosi, there is no fear (1,p.144;30;31,p.1350).”

In his comment on this part Rhazes only added the findings after clavicle fracture and gave a short explanation:

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*I say: The clavicle has never been separated inwards, but there will be fear that the clavicle goes outwards when it is broken, therefore the splint is placed on this location and oppressed and always bound* (1,p.144;30;31,p.1350).”

With the last statement, the parts related to spine traumas in *Liber Continens* ended.

## DISCUSSION

The earliest written record regarding spine injuries and accompanying paralysis is found in *Edwin-Smith Surgical papyrus* (BC 1700) <sup>(42)</sup>.

The most renowned physician of antiquity, Hippocrates (BC 460-370), wrote detailed knowledge and his own observations about human spine in his different works such as *Mochlikon*, *On Nature of Bones*, *On Places in Man* and especially in *On Joints*. He classified spine injuries in 5 categories: kyphosis (relating either to a disease or trauma), scoliosis, concussion (sisis), vertebra dislocations, and processus spinosum fractures. Besides, Hippocrates described management options <sup>(26)</sup>.

Much later Galen (129-200) introduced a useful knowledge on spine anatomy in his books *On Bones for Beginners* (*De ossibus ad tirones*) and *On the Usefulness Parts of Body* (*On the Usefulness of the Parts of the Body*), and additionally in 4 comments on Hippocrates' work *On Joints* <sup>(27)</sup>. When dealing with spine disorders Galen used Hippocrates' four basic categories: Kyphosis, lordosis, scoliosis, and succession. The thoughts of Galen on spine trauma mechanisms and their managements were in concordance with those of Hippocrates <sup>(27)</sup>. Galen explained his views about medulla spinalis traumas in *On Anatomical Procedures* (*De anatomicis administrationibus*), *On the Causes of Symptoms* (*De symptomatum causis*), and *On Affected Areas* (*De locis affectis*) <sup>(27)</sup>. Other historical important figure, which dealt with spine traumas, was Paul of Aegina (625-690). His work *Epitome* contained two sections on spine fractures and dislocations, respectively <sup>(13)</sup>.

In *Liber Continens*, Rhazes quoted spine injury related parts mainly from the works of Hippocrates, Galen, Paul of Aegina and also *The Book Attributed to Galen*, which is believed to be written by Galen. Rhazes took the knowledge from the mentioned authors in verbatim and then he wrote his own comments on the related topic. In some sections these comments seem irrelevant and his contribution is somehow negligible. Still, the transmission of once forgotten valuable information's by Rhazes had deeply affected western medicine.

Paul of Aegina's work had been accepted one of the fundamental sources for spine injuries during the middle ages. Regarding this issue, Haly Abbas (930-996) <sup>(7)</sup> and Avicenna (980-1037) <sup>(2)</sup>, the other two prominent physicians of Islamic Golden Age, too benefited principally from Paul of Aegina's work. Paul of Aegina's statement about the poor prognosis in the case of

medulla spinalis involvement and likewise deadly outcome when it occurs in cervical level was reiterated in Rhazes work with great emphasis. Paul of Aegina, unlike Hippocrates and Galen, recommended removal of bones when they penetrate medulla spinalis <sup>(13,16,21)</sup>, which account was also recognized by Rhazes and retold in the book. Paul of Aegina's work *Epitome* contained a detailed and extensive section regarding spine dislocations <sup>(32)</sup>. For some unknown reason, Rhazes included only a brief quotation from that work in *Liber Continens* and he commented that the reader should review another copy of *Epitome*. It is probable that Rhazes did not possess the full copy of *Epitome* during creating his work, although he knew much about its contents. Or, he found the knowledge too detailed or complicated for physicians and suggested further reading when they were interested in.

On the other hand, Rhazes quoted the knowledge regarding the management of thoracic and cervical vertebra dislocations from Galen's *Kitāb Ārā' Abūqrāt wa Aflāṭun*, which topic was not included in Paul of Aegina's *Epitome*. Haly Abbas too did not address the treatment of posterior vertebra dislocation in his *Liber Regalis* <sup>(7)</sup> whereas Avicenna included the mentioned issue in his *Canon of Medicine* <sup>(2)</sup>. This may indicate that when writing the *Canon of Medicine* Avicenna may have primarily benefited both from Galen and Rhazes. Same management methods were also included in Ismā'il Jorjani's (1042-1137) *Zākhīra Kh'arazmsāhī* <sup>(3)</sup>, which show that some of the medieval Islamic physicians followed in the footsteps of certain antique pioneers.

In *Liber Continens* when quoting previous writers Rhazes presented either the name of the work or the name of author for the spine injury section. For example, when Rhazes cited Paul of Aegina he did not give the name of *Kunnāsh*. On the other hand, when he quoted *Manafi' al-A'dā'* and *Kitāb Ārā' Abūqrāt wa Aflāṭun* he did not mention Galen or while he gave the name of *Qāṭiriyyūn* and *Abizīmiyyā* he did not name Hippocrates. It seems that this arrangement was designed in an unplanned manner.

## CONCLUSION

Rhazes's *Liber Continens* was an influential medical work during medieval times both in the Islamic geography and in the Western World. When creating *Liber Continens* he mostly benefited from various schools including Greek, Syriac, Arabic, Persian, and Hindu. However, he followed purely Greco-Roman tradition in writing the sections related to spine injury. Rhazes focused essentially on the opinions of Hippocrates, Galen, and Paul of Aegina for classification, underlying mechanisms, and management options of spine traumas, nonetheless, his contributions on this topic were insignificant. Starting with *Liber Continens* Greco-Roman school's views had become more powerful in the Islamic World.

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