

# A Critical Review of the Works of Pioneer Physicians on Kidney Diseases in Ancient Iran

## Avicenna, Rhazes, Al-Akhawayni, and Jorjani

Saeed Changizi Ashtiyani,<sup>1</sup> Mohsen Shamsi,<sup>2</sup> Ali Cyrus,<sup>3</sup>  
Bahar Bastani,<sup>4</sup> Seyed Mohammad Tabatabayi<sup>5</sup>

<sup>1</sup>Departments of Physiology, Arak University of Medical Sciences, Arak, Iran

<sup>2</sup>Department of Public Health, Arak University of Medical Sciences, Arak, Iran

<sup>3</sup>Department of Urology, Arak University of Medical Sciences, Arak, Iran

<sup>4</sup>Division of Nephrology, Saint Louis University School of Medicine, Saint Louis, Missouri, USA

<sup>5</sup>Departments of Psychology, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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The history of kidney and urologic disorders dates back to the dawn of civilization. Throughout history of medicine, urine, the first bodily fluid to be examined, has continuously been studied as a means of understanding inner bodily function. The purpose of this review was to appraise the contributions of the ancient Iranian physician pioneers in the field of kidney and urological disorders, and to compare their beliefs and clinical methods with the modern medicine. We searched all available reliable electronic and published sources for the views of ancient Iranian physicians, Avicenna, Rhazes, Al-Akhawayni, and Jorjani, and compared them with recent medical literature. Our findings showed that ancient Iranian physicians described the symptoms, signs, and treatment of kidney and urological disorders; addressed bladder anatomy and physiology; and performed bladder catheterization and stone removal procedures in accordance with contemporary medicine. Ancient Iranian physicians pursued a comprehensive scientific methodology based on experiment, which is in compliance with the bases of modern medicine.

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### INTRODUCTION

In the ancient times, Iranian Muslim physicians had performed numerous experiments concerning the urinary tract system and had acquired valuable knowledge and clinical expertise in this field. Causes of urinary retention are clearly referenced in Rhazes' *Al-Hawi* (854 to 932, AD), Avicenna's *Al-Canon* (980 to 1037, AD), and Jorjani's *Zakhir-e-Kharazmshahi* (1041 to 1136, AD). In writings of ancient Iranian physicians, topics like oliguria, anuria, and kidney calculus disease are described in detail. Analysis of urine, as the first bodily fluid to be examined, has been described in detail and provided medicine with an increasing body of knowledge about the workings of inner bodily functions. The purpose of this report is to appraise the contributions of the ancient Iranian physician

pioneers in the fields of nephrology and urology, and to compare their findings and clinical techniques with the modern medicine. As a starting point, the scholars and their works that we have evaluated are briefly presented.

### Avicenna

Avicenna, an Iranian philosopher and physician of the 10th and 11th centuries (4th and 5th centuries AH) was born in 980 AD in a village near Bokhara (a city in old Persia) and died in 1037 AD in Hamadan, Iran. He was one of the most eminent scientists and talented scholars of his time. His fame was not only widespread in Iran and in the Muslim world, but extended to the whole world. He is still recognized as an eminent scientist, particularly in the field of medicine.

The United Nations Educational, Scientific and Cultural Organization declared 1952 and 1980 as the International Year of Avicenna<sup>1,2</sup> and held various international congresses and festivals in different countries from 1937 to 2004.<sup>1,3,4</sup> It is estimated that about 750 articles and books, in different European languages, have been published about Avicenna since 1906.<sup>5</sup>

He educated himself in Arabic language, which was the formal language of the Muslim territories at that time.<sup>6</sup> His medical techniques and writings, which became representative of Muslim's contribution to medicine, are predominantly reflected in his masterpiece *Al-Canon fi al Tibb* (*The Canon on Medicine*). His other valuable contributions are in the fields of angelology,<sup>7</sup> cardiology, and treatment of kidney diseases.<sup>8</sup>

*The Canon of Medicine* has widely been used in the West, and its subjects, irrespective of being outdated in some areas, are similar to modern medical text books. For instance, a 30-page chapter on examination of urine, is similar to the *Campbell-Walsh's Textbook of Urology*,<sup>9</sup> describing collection of urine specimens, methods of examination, characteristics of urine (color, turbidity, consistency, odor, sediments, volume, presence of foam, etc), and urine characteristics in healthy and sick individuals. He also described surgery via transperineal route and warns the surgeons of the proximity of the vasa deferentia, the prostate gland, and neurovascular bundles, and their exposure in this position.<sup>10,11</sup>

### Rhazes

Rhazes, also known as *Ibn Zakariya*, *Al-Razi*, and *Razi*, was born in Ray, a city a few miles south of modern Tehran, in 865 AD. He is famous for his statement: "I never write about things unless I first examine them myself."<sup>12,13</sup> Rhazes was not only one of the most prominent Persian physicians and philosophers of his era, but also the writer of the fundamental teaching texts in European medical schools for centuries. He is best known for his contributions in the fields of chemistry, medicine, philosophy, medical ethics, metaphysics, and theology. He authored 184 books and treatises in these fields.<sup>14</sup> August 27th, the birth date of Rhazes, is now proclaimed as the day of the Pharmacist in Iran. The two major contributions of Rhazes in medicine are the *Kitab al-Mansuri* (*Liber Al Mansuri*) and *Kitab al-Hawi*

(*Liber Continens*, meaning comprehensive book or encyclopedia).<sup>15</sup> He is a renowned physician in the history of medicine. He followed Hippocrates and Galen, and greatly extended the analytical approach of his predecessors. He was known as the most distinguished character in the world of medicine up to the 17th century. A great number of innovations and pioneering works in the medical science have been attributed to Rhazes. His fundamental contribution to the field of urology is in the pathophysiology of the urinary tract and venereal diseases, and in the treatment of kidney and bladder calculi. He also pioneered techniques for diagnosis and treatment of kidney calculi. In this report, we will review some of his important contributions in the field of urology.<sup>14,15</sup>

### Al-Akhawayni

The flourishing of sciences in the Near East, following the rise of Islamic Civilization, stands in sharp contrast to their disastrous decline in the West during the Middle Ages. The medicine that developed during this era has been variously named as Islamic, Arabian, Arab, and Arab-Islamic.<sup>16-19</sup> Al-Akhawayni is another famous ancient Iranian physician in this era. Little is known about his life.<sup>20</sup> He was born, trained, and practiced in Bokhara, and hence, became known as *Al-Bokhari*. Bokhara, a city currently at the Republic of Uzbekistan, was located along the Silk Road, in the vicinity of the ancient Samarkand. It prospered during the Samanid era, when it became one of the intellectual centers of the Islamic world, and for a period of time was also the residence of Avicenna.<sup>20</sup>

The first three medical authors who wrote in Persian language (Farsi) were Hakim Maysari, who wrote *Danishnameh* in 980 AD; Abu Mansur Muwaffaqi Haravi, who compiled two books on remedies (*Al-Abniyah* and *Haqaiq al-Adwiyah*) at approximately the same time. By far, however, the most substantial work was that of al-Bokhari, the *Hidayat al-Mutallimin fi-al-Tibb* (*Learner's Guide to Medicine*) written in the closing decades of the 10th century.<sup>21</sup> It was written in Persian and was a relatively short and simplified book that provided a glimpse of the teachings of medicine of its period.

There are 3 known manuscripts of the *Hidayat*; all three were copied some years after the death of the author.<sup>22</sup> Dr Jalal Matini, a contemporary Persian writer, compared the three manuscripts

and published a literary edition of the *Hidayat* in 1965 that was used in this article.<sup>22</sup> The *Hidayat* is written in Middle Persian or Farsi-e-Dari,<sup>19</sup> and it consists of 184 chapters (*Bab*), which are arranged in 5 major sections. There are 3 main chapters on the kidney and urinary tract anatomy, 7 chapters on the kidney and urinary tract diseases, and a single closing chapter on uroscopy.<sup>23</sup> These sections provide insight into the care of patients with kidney diseases during the Middle Ages in general, and in Persia in particular.

### Jorjani

Another ancient Iranian physician scientist in the field of urology is Esmail Jorjani. He was born in Jorjan, north-eastern Persia, in 1042 AD, and died in Marve, in 1136 AD.<sup>24-26</sup> He belonged to the second generation of physicians like Avicenna, having an important role in the preservation and transmission of Greco-Roman medical heritage.<sup>27</sup> Almost 1000 years ago, he made valuable contributions in the field of medicine, and many of his medical views are, to a great extent, in line with the recent notions. His most famous work is *Zakhir-e-Kharazmshahi*. His innovations and practices in various branches of medicine were novel and unique. Jorjani was very efficient in surgery and, in his *Zakhir-e-Kharazmshahi*, introduced different methods and instruments of surgery in a way that it shows his dexterity and depth of experience. In urology, he proposed catheterization for the treatment of patients with difficulty in urination and explained vesicotomy in cases of failed catheterization.<sup>28,29</sup>

### MATERIALS AND METHODS

In this paper we searched all available reliable electronic and published sources, using appropriate keywords, about the views of the Iranian pioneer physicians, Avicenna, Razes, Al-Akhawayni, and Jorjani, in the fields of kidney and urological disorders, and compared them with modern medical practice.

Avicenna's *Canon fi Teb*, Rhazes' *Al-Hawi*, and Jorjani's *Zakhir-e-Kharazmshahi* in their original language (Arabic) were compared with the Persian and English translations to provide a more accurate text.<sup>10,30-32</sup> The edited Persian version of Al-Akhawayni's *Hidayat* was used as the most reliable text available.<sup>22</sup> We did not focus on the domains of traditional medicine, such as, the four

cardinal humors or herbal therapy, since they were beyond the scope of this paper. We only dealt with items that corresponded with modern fields of nephrology and urology.

### RESULTS AND DISCUSSION

#### Avicenna

Part 19 of book III of the *Canon of Medicine* is about the bladder (*urocyst*) and urine. This part has 2 treatises: treatise 1, on the status of the urinary bladder and treatise 2, on timing of urine. In treatise 1, chapter 1, Avicenna describes the anatomy of the urinary bladder and its physiology and pathophysiology<sup>10,30</sup>:

*God has created an organ similar to cyst in human body to remove the useless and removable liquids [urine]. This allows the urine to gradually pour into the bladder and at a necessary time, it can completely be expelled from the body. Otherwise, the humans would have to urinate every minute and every hour, so as in patients with urinary dribbling [tagtirol bol in Arabic and chakmizak in Persian]. This leather-like bottle is named the bladder in which the removable liquid accumulates.*<sup>10,30</sup>

The 2-phase function of the bladder to which Avicenna pointed out 10 centuries ago, has been described by Yoshimora and Chancellor as 2 separate phases of bladder filling (storage phase) and bladder emptying (voiding).<sup>33</sup> According to Avicenna's following description of the external urethral sphincter, we understand that the fleshy and sensitive material is the prostate gland which is adjacent to the bladder: "The bladder has 2 layers: the internal and external layers. The internal layer is undercoat of the bladder and its power and firmness is twice as much as the external layer, because the internal layer has to be in touch with the astringent urine."<sup>10,30</sup> Today, we know that the bladder has 3 layers: the most inner layer is the urothelium, which is in contact with the urine. This layer, because of tight junctions between its adjacent apical cells, is impermeable to water. The middle layer is muscular and the external layer is adventitia. The first and the second layers of the bladder have been discussed as one layer by Avicenna.

The 2nd chapter of part 19, book III of the *Canon of Medicine* is on the diseases of the urinary bladder. In this chapter, classification of bladder disorders is stated as below<sup>10,30</sup>:

[...] (1) diseases due to bladder inflammation; (2) diseases due to bladder outlet obstruction, which includes bladder calculi; (3) diseases due to bladder volume abnormalities, in which the bladder is smaller or larger than normal; (4) local diseases, such as lumpy lesions and descent of the bladder; (5) disorders due to ulceration or rupture of the bladder, bladder splitting, etc; (6) bladder disorders which are due to nervous system disorders; and (7) disorders due to temperamental changes.

The current bladder disease classification is almost similar to the *Canon's* classification<sup>9</sup>: (1) bladder inflammatory disorders that include specific infections (eg, tuberculosis), nonspecific cystitis (bacterial and viral), and interstitial cystitis (including Hunner's ulcer); (2) bladder neck and infravesical obstructions that affect the bladder (including benign prostatic hyperplasia and bladder calculi); (3) congenital bladder disorders, including congenital megacystis, congenital bladder hypoplasia, and epispadias-extrophy complex; (4) bladder tumors; (5) bladder diverticulum and pelvic floor laxity (including cystocele); (6) bladder trauma; (7) neurogenic bladder due to central and peripheral nervous system diseases. Interestingly, Avicenna has acknowledged most of the disorders of the bladder. Even he points out to bladder tumors in item 4 as "lumpy lesions" and in item 5 as "bladder ulcers."

Chapter 5 of part 19 book III of the *Canon of Medicine* is on urinary bladder calculi. Below are some extracts of this chapter:

*Bladder calculi are larger and harder than kidney calculi. Their color is yellow to black, and occasionally, grayish to whitish. Sometimes there are multiple smaller pieces in the bladder. Bladder calculi are usually diagnosed after passage through the urethra. These calculi usually occur in thin persons, while kidney calculi mostly develop in obese people. Children, adolescents, and young people usually have bladder rather than kidney calculi.*<sup>10,30</sup>

It should be noted that the epidemiology of bladder calculi that Avicenna describes so accurately accords to the findings of modern urology.<sup>34</sup> In the developing countries, bladder calculi are more prevalent in children, which can be attributed to malnutrition and phosphate deficiency in children's diet.<sup>35</sup> At the time of Avicenna, there were no radiological or ultrasonographic facilities; thus, as he has stated, they could only be diagnosed

after their passage.<sup>36</sup> Urology text books state that bladder calculi are usually single, but there are numerous calculi in 25% of patients, which accords to the *Canon*.<sup>36</sup>

*If the bladder calculus is small, it can be expelled out by hand pressure, but if it is large, the incision line must be expanded, and it is possible that you need grasping pincers to grasp and extract the calculus. Sometimes, the calculus can be very large, and it is not possible that you induce a very large incision fit for the calculus size. What would you do in these conditions is to grasp the large calculus with pincers, and little by little, to break the calculus and expel all of the fragments of the crushed calculus. And you must not leave any fragments in the bladder albeit very small. Because, if even a very small fragment of the calculus is not extracted from the bladder, it will grow and enlarge.*<sup>10,30</sup>

Today in endourology, calculus grasping instruments have their special place,<sup>37</sup> and for very large calculi, there are modern lithotripsy methods similar to what Avicenna pointed 10 centuries ago; however, urologists have expanded options for lithotripsy to pneumatic, electro hydraulic, and ultrasonic methods.<sup>38</sup> As Avicenna mentions, calculus fragments remaining in the bladder after lithotripsy, even if very small act as foreign bodies and a nidus that grows and forms large calculi again.<sup>38,39</sup>

Avicenna has mentioned that "the symptoms that originate from abnormal status of urine are: (1) dysuria, (2) difficult voiding, (3) urinary retention, (4) frequency, (5) dribbling, and (6) polyuria in disorders such as diabetes.<sup>10,30</sup>" He has also enumerated some lower urinary tract symptoms that include symptoms of bladder outlet obstruction.<sup>40</sup>

*Oliguria can be due to the following causes: (1) drinking inadequate liquids; (2) body porosity; (3) effect of diarrhea on the body; (4) disability of the kidneys, resulting in impaired absorption of fluids; and (5) disability of the liver in separation of the fluid and sending it to the kidneys, so as in hepatic cirrhosis [sou of gonieh in Arabic] and dropsy state [estesgha in Arabic]. You should know that sour diets are harmful to the patient, and sexual intercourse aggravates the disease.*<sup>10,30</sup>

In modern urology and nephrology oliguria resulted from kidney failure is caused by (1) prerenal azotemia due to dehydration, sepsis, or

reduced cardiac output; (2) hepatorenal syndrome; (3) iatrogenic causes including drug side effects; (4) vascular disorders; (5) intrarenal (parenchymal) diseases such as nephritis and acute tubular and cortical necrosis; and (6) postrenal causes.<sup>41</sup> Avicenna points to most of these causes and also recommends avoiding stringent and “sour” (acidic) diets, which reminds us that kidney failure causes metabolic acidosis.

Scientific methodology of Avicenna’s *Canon of Medicine* and its comparison with modern urology indicate that Avicenna’s technique in diagnosis and treatment of patients was really experimental and far from superstitious beliefs of his time.

### Rhazes

Another ancient Iranian physician scientist in the field of urology is Rhazes. He wrote more than 224 books on various subjects, but his most renowned manuscript was the medical encyclopedia, *Al-Hawi fi al-Tibb*, known in Europe as *Liber Continens*. It was a compilation of Greek and Roman medicine, his own clinical observations, and case studies and his personal medical practice. Rhaze’s extensively exploited case histories were an educational aid for the documentation of different diseases he diagnosed and treated.<sup>42</sup>

Part 7, book I of *Al-Hawi fi al-Tibb* covers anatomy, physiology, and physiopathology of urinary tract diseases:

[...] kidneys can have stones and their pain resembles this pain of colon and these two must be differentiated. Pain in the loins, sediment in urine, passage of stone or black urine passed with pain several months before denotes stone pain. If there is nausea or the pain follows a meal or is located in the abdomen and more to the front than the back, then it is more likely to be colonic pain. The site of the pain is important: in abdominal colic, the pain is more generalized and tends to be anterior, while in kidney stones, the pain is more limited and tends to be in the back.<sup>31</sup>

His recommendations for prevention of kidney calculi were quite applicable and not much different from current suggestions, such as avoidance of hypercalciuria and increased saturation of urine: “[...] by avoiding heavy food which we have mentioned. Do not lie long on your back. Avoid cheese, milk derivatives, especially fresh cheese, hard-boiled eggs, unleavened bread. Use diuretics

like cucumbers, melons, figs, grapes, and crystal clear water from natural sources.<sup>43</sup>”

Rhazes introduced, for the first time, pre-operative preparation of the patient by an enema<sup>44</sup>: “[...] because stool in the rectum may render palpating for and locating of bladder stones difficult or impossible, it is essential that the patient should be given an enema beforehand. When the bowel empties out its content, feeling the stone and also abdominal palpation becomes easier.<sup>45</sup>” As it can be observed, he was referring to suprapubic abdominal palpation, and in those days, due to prevalent malnutrition, most of the patients were young thin children in whom the bladder could be palpated quite easily and at the time of diagnosis, the calculi were usually very large in size.

Rhazes describes the discrimination between vesical and renal hematuria in a very scientific and up-to-date manner:

[...] Sudden hematuria is due to a ruptured renal vessel but this cannot be the case in the bladder because it cannot be for a vesical vessel to rupture due to plenty of blood coming to it as it happens in the kidney. This is because blood is not filtered in the vessels of the bladder as it does in the vessels of the kidney. But, the amount of blood that comes to the bladder is only enough for its nutrition, while in the kidney, because blood is filtered in it, and then, large blood vessels and plenty of blood comes to it, far more than its need for nutrition. Also the vessels in the bladder are not close to the interior and unsupported as the vessels which enter deep into the kidney.<sup>31</sup>

His elucidation of renal hematuria observed in glomerulonephritis due to congestion and increased permeability was also precise.<sup>45</sup>

Rhazes very accurately describes symptoms of distal ureteral calculi: “[...] among these symptoms are a simple abdominal irritation, tingling pain in the pelvic area, and pricking sensation in the urethra. Occasionally, the pain can extend to the inguines as the renal calculus passes through the ureters and moves towards the bladder.” He also clearly pictures kidney calculus signs: “[...] the darkness of urine, deposition of calculus materials in the urine, feelings of heaviness and discomfort in the abdomen, and stretching sensations in this area while lying are the symptoms which can indicate the formation of calculus.<sup>31</sup>”

In accordance to modern medical knowledge, both Avenenna and Rhazes believed that pain becomes worse when the calculi are passing through the ureters; otherwise, patients just “feel heaviness in the flanks.”<sup>14</sup>

Since, in those days, new laboratory analyses for urine examination were not available, Muslim physicians had to observe physical characteristics of urine and draw their clinical decisions from its appearance. Rhazes believed that urine mirrored the circulation in the urinary system. He scrutinized urine for color, consistency, deposits, taste, clarity, touch, etc, and classified each finding into various subdivisions and specified the underlying cause and significance of each. Hematuria, foul smelling urine, with debris in a patient with suprapubic pain, indicated cystitis. Urethral discharge and dysuria denoted urethritis.<sup>46</sup>

### Al-Akhawayni

In *Hidayat*, Al-Akhawayni provides insight into his knowledge of urinary tract physiology during the Middle Ages in general, and in Persia in particular:

*The urinary bladder is located between the pubis and rectum, and consists of two layers. Urine comes to the bladder from the kidneys through the ducts that are named the ureters, the ureter penetrates one of the bladder layers and traverses between these two layers until it reaches the bladder neck where it penetrates the other layer and urine enters the bladder. The reason for the creation of this part in such a way is that urine cannot return to the same duct as upon the reversion of the urine, the inner layer compresses that intramural part [of the ureter] against the outer layer to tighten the passage, and for the urine not to return into the ureters. There is a large muscle at the head of bladder, which completely wraps it so as to prevent involuntary urination. Upon the urge [for urination], the head of the bladder dilates voluntarily and the urine is excreted. The constitution of the bladder substance is neural, and within it are arteries and veins.*<sup>22</sup>

This accurate description of the structure and function of the bladder, ureterovesical junction, and the bladder neck was consistent with the prevailing notions expounded in Greek texts. Both Galen (130 to 200 BC) and Rufus of Ephesus (1st to 2nd century CE) have also made note of the antireflux mechanisms of the bladder.<sup>47,48</sup>

On kidney diseases, Al-Akhawayni states, “The kidney is subject to diseases like any other organ including functional impairment [dysfunction], structural disorders and disruption, and some specific disorders like stones and inflammation, and renal weakness and atrophy, namely, *hozal*. *Khoon Raftan* [hematuria] and *rim raftan* [pyuria] are due to the inflammation involving the kidney, and [in which the pus] is excreted with the urine from the urethra and [there is] difficulty in urination [dysuria].”<sup>22</sup>

His descriptions of kidney diseases are not easy to follow, but considering its entirety, they indicate the occurrence of progressive kidney disease of various etiologies with symptoms of cachexia, weakness, and dropsy. What he refers to as renal atrophy (*hozal*), suggests end-stage kidney disease with cachexia, polyuria, edema, and dropsy. Relevant in this regard is his referral to the inflamed kidneys that might heal, form an abscess, or fail to heal and become “hard” which seems to suggest the small hardened kidneys of end-stage kidney failure. Credit for reference to hardened end-stage kidneys has been given to William Gulielmus of Saliceto (1210 to 1277 CE), when in fact it was described by Rufus of Ephesus in the 2nd century and re-stated 200 years earlier than Gulielmus by Al-Akhawayni.<sup>48,49</sup>

His description of nephrolithiasis is similar to that of other physicians of the period and all mention the fact that heavy foods and dairy products could cause calculi and that urethral calculi are predominantly seen in males because females have a shorter bladder neck.<sup>47,50,51</sup> He also underscores the role of thermotherapy and physical activity in the alleviation of ureteral colics:

*Beware that when the stone enlarges in the kidney it hinders the urine, causes intolerable pain, and may lead to mental confusion from pain. Each occasion of the pain is called an episode [the pain is intermittent]. During the episode of pain, the patient should sit in a tub of warm water in which the leaves of cabbage [Brassica oleracea], leaves of marsh-mallow [Althaea officinalis], chamomile [Anthemis nobilis], dwarf yellow [Astragalus hamosus], fenugreek [Trigonella foenum graecum], flaxseed [Linum usitatissimum], seed of mingwort [Artemisia absinthium], and star-thistle [Centaurea calcitrapa] have been brewed. And after getting out of the water tub, the back [of the patient] should be massaged gently with the oil of*

*wallflower [Cheiranthus cheiri], and then he should jump [up and down] on one foot, or ride a horse trotting in place, or climb fast down a ladder until the stone comes out of there [...].<sup>22</sup>*

One of the features of the *Hidayat* is its systematic and structured guidelines for treatment.<sup>51</sup> Al-Akhawayni presents a long list of natural substances that are lithoclastic and urinary tract dilators, arranged from less toxic but less effective to more effective but with higher toxicity. Several of these substances are mentioned by Dioscorides (1st century) and in other Greek texts.<sup>51</sup> Al-Akhawayni frequently uses Persian, but occasionally Greek, Arabic, and Urdu terms for herbs which are sometimes hard to find in modern dictionaries.<sup>53</sup>

Al-Akhawayni described complicated urinary tract infection with septicemia, high fever delirium, and confusion. He characterized this condition as being similar to meningitis and recommended bleeding from the basilic vein, a recommendation similar to that found in *Byzantine medical texts*<sup>54</sup>: “Bladder inflammation is warm [in nature], and its manifestations are great irritation and severe pain, urine is halted, fever is high with delirium and tongue blackens and those symptoms [of confusion] that are [seen] in brain inflammation [meningitis] are brought about. Its cure is with the same [way] I mentioned for brain inflammation: firstly, a basilic venesection must be done [...].<sup>22</sup>”

### Jorjani

Jorjani describes the physiology of the bladder and urethra as follows:

*Bladder is an instrument of voiding and it resembles a chestnut with two layers. The inner layer is woven from retaining and expelling nerves and the outer layer consists of a strong membrane that holds the inner layer when the bladder is full [...]. The bladder has a neck that through it comes out the water and male bladder has three curves while others [women] have just one curve. That is the reason why men are cleansed from urine more laboriously. There is a muscle on the bladder neck and its fibers enter the bladder through its circular os. Containing urine and timely expulsion of it are the functions of this muscle and when people want to void voluntarily, its fibers become lax and bladder neck widens as God willing.<sup>32</sup>*

Evidently, his description of bladder anatomy and physiology is in concordance with modern

scientific findings.<sup>55,56</sup>

He proposed catheterization for the treatment of patients with difficulty in urination. However, he indicated that if, due to swelling, injury or bladder calculus, using catheter is not possible, there will be no way other than vesicotomy and discharging the obstructing agent<sup>29,57</sup>: “[...] If the cause of difficulty in urination is obstruction and weakness in expulsion, the treatment is using *gathatir* [metal catheter] [...] and if due to inflammation, ulcer or bladder stone, it was not effective, there is no contrivance other than splitting the bladder for excretion of water [urine] and stone extraction. The only peril is nonclosure of the wound site which is superior to abandoning the patient to die.”

### CONCLUSIONS

Kidney and bladder calculi diseases have been discussed in great deal in the history of medicine by Rhazes, Avicenna, Al-Akhawayni, and Jorjani. There was no place for nonscientific, ignorant, or foolish modalities in the approaches of these scientists to kidney diseases. Scientific methodology of ancient Iranian physicians and its comparison with modern urology findings indicate that Avicenna’s and Rhaze’s methods in the diagnosis and treatment of patients were based on experiments and no where near superstitious beliefs of their times. Their elucidations about etiology, diagnosis, and treatment of these calculi did not basically differ from that of modern concepts. Differential diagnoses between colitis and renal colic and between kidney and bladder calculi were very clearly illustrated. We hope our work would generate new enthusiasm for future more comprehensive and in dept studies in this field.

### CONFLICT OF INTEREST

None declared.

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Correspondence to:  
Changizi Ashtiyani, PhD  
Departments of Physiology, Arak University of Medical Sciences,  
Arak, Iran  
Tel: +98 861 417 3526  
Fax: +98 861 417 3526  
E-mail: ashtiyani@sums.ac.ir

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