

Avicenna's Canon of Medicine and Modern Urology

Part I: Bladder and Its Diseases

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Studying the Avicenna's *Canon of Medicine*, provides noteworthy information on the subjects related to urology. Some examples of these amazing items have been confirmed by the modern urology: explaining the 2-stage function of the bladder (filling and emptying stages); indirect pointing to a scientific law, named later as the Laplace's law, which is applicable to bladder physiology and explains intravesical pressure stability; describing the bladder layers and strength of the urothelial layer, which was later proved to be due to the tight junctions; describing the intramural ureter and its antireflux mechanism; scientific classifying the urethral and bladder diseases; and describing meticulously the semiology and epidemiology of bladder calculi. Avicenna has also pointed to *inversion therapy* in the treatment of urinary calculi, grating sign in bladder calculi, manipulation methods for treatment of bladder calculi, and finally, the *Crede maneuver*. His methodology is completely scientific, based on experiments and truly a basis of the modern medicine. This article is a review of Avicenna's views in medicine and their comparison with the modern urology.

Key words: bladder stones, percutaneous cystolithotripsy, children

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INTRODUCTION

The Persian Muslim scientist and physician, Abu Ali (Ibn) Sina, namely *Avicenna* in Europe is the most famous Islamic scientist and medical scholar in the history. He was born in 980 AD in a village near Bokhara (which was a city of old Persia) and died in 1037 AD in Hamadan, Iran. George Sarton describes Avicenna as one of "the most famous scientist of Islam and one of the most famous of all races, places, and times."⁽¹⁾ He is known as "doctor of doctors," "prince of the physicians," and "Galenus of Islam," because of his immense medical encyclopedia,⁽²⁾ the *Canon of Medicine* which is the first text book of medicine on earth.⁽²⁾ *Canon of Medicine* has widely been used in the West. William Osler wrote: "*Canon*

was a medical bible for a longer period than any other work."⁽³⁾

Avicenna was also a great philosopher with several books in the field of philosophy. However in *the Canon*, similar to scientists in the modern era, he discusses on human body and its disorders based experimental methods and his practical experiences in his articles. The subjects of *the Canon*, irrespective of being dated in some issues, are similar to subjects of modern medical text books such as *Harrison's Text Book of Internal Medicine* or the *Campbell's Urology*. Concerning the 30-page chapter of *the Canon* about urinary examination, for instance, similar topics to those in the Campbell-Walsh's *Urology*⁽⁴⁾

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are reviewed; Avicenna discusses collection of urinary specimens first, and then tells us about the methods of examination and several characteristics of urine such as color, turbidity, consistency, odor, sediments, volume, and finally, presence of foam. Then, he describes urine color in healthy and sick individuals along with the respective etiologies (Table).^(5,6)

Comparison of *the Canon* with the contemporary literature does not mean that its context can be revived. The 2002 edition of the Campbell's Urology was abolished by the new edition in 2007, and more than half of its contents became out of date. Thus, we cannot expect a place for *the Canon's* theories and contents in the modern medicine with its overwhelming fast pace.

However, a comparative study of this treasure can shed light on the history of medicine to see that how foundation of the new medical science was made in the Renaissance by the influence of the theories of Avicenna and other scientists of the Islamic renaissance age. A German scientist in the 16th century, Heinrich Cornelius Agrippa von Nettesheim believed that Avicenna had the same authority in medicine as Hippocrates and Galenus. He went even further by saying that medical practice without Avicenna's books endangers public health.⁽⁷⁾ At that time, medicine and other sciences were at their zenith in the Middle East and the oriental references were translated to European languages. This made the basis of new experimental science that had a more or less same methodology and dynamic thinking.

On the other hand, in the way knowledge progresses, questions, tentative solutions, conjectures, and refutations play their own role. Karl Popper believes that "these conjectures are controlled by criticism, ie, by attempted refutations which include severely critical tests."⁽⁸⁾ He quotes from Sir John Eccles, the Australian great neuroscientist (1903 to 1997) who was the owner of multiple theories in neuroscience wrote: "I can now rejoice even in the falsification of a cherished theory, because even this is a scientific success."⁽⁸⁾ In reality, science is the result of these theories and their refutations. A trace of these attempts in the history of medicine can be found by studying books such as *the Canon*. This is

Table of Contents of *Canon of Medicine* Under the Subject of Urine⁽⁶⁾

Table of the Contents on Urine
General Remarks about Urine
The Examination of the Urine
The Significance of the Color of Urine
The Degrees of Yellowness
The Degrees of Redness
The Degrees of Greenness
The Degrees of Blackness
Whiteness
The Compound Colors of Urine
Like Raw Meat Washings (Blood Stained)
Oleaginous Oily
Purple (Black)
Ruddy Color Mixed With a Tinge of Blackness
The Signs Afforded By the Density, Quality, Clearness or Turbidity of the Urine
Transparent (Limpid) Urine
Opaque (Thick) Urine
Clearness and Turbidity
The States to Note
Good Signs
The Signs Derived From the Odor of the Urine
Fetid Odor
Sweetish Odor
Putrid Odor
The Indications Afforded By the Foam on Urine
The Indications Derived From the Diverse Kinds of Sediment Structure
Natural Sediments
Abnormal Sediments
Flaky or Squamous Sediments
Fleshy Sediment
Fatty Sediment
Mucoid Sediment
Ichorous Sediment
Hair-Like Sediment
Sandy or Gritty Sediment (Gravel)
Cinerital Sediment
Hirudiniform
The Quantity of Sediment
The Quality of Sediment, Color Odor
Black Color
Red Color
Yellow Color
Green Color
White Color
Odor
The Constitution, Coherence and Consistency of Particles
Position
The Occupied Sedimentation
The Form
The Signs Relative to the Daily Quantity of Urine
A Description of Normal Healthy Urine
The Variations According to Age
The Urine of Animals and Differences From Human Urine
Fluids Resembling Urine and How to Distinguish Them

interesting to see what they knew centuries ago, what they did not, and what were their approach to explain the dark side of the human body. Such points are can also be investigated in our today text books by our successors. Avicenna's *Canon* which belongs to 10 centuries ago has its value in history of medicine, so as the Campbell's and Harrison's text books would have in future centuries despite refutations of their multiple theories.

MATERIALS AND METHODS

This study is the comparison of modern urology to the urological chapters of Avicenna's *Canon of Medicine*. I used *the Canon* in its original language (Arabic),⁽⁹⁾ along with its Persian and English translations (Figure 1).^(6,10) Part 19 of the 3rd book



Figure 1. The Canon of Medicine in Arabic which was published in Rome in 1593. Adapted from the web site of the Saab Medical Library of the American University of Beirut.

and some parts of the 1st book contain subjects related to urine, urinary tract, and urological diseases. I compared these sections to the current urological findings. Selected topics from *the Canon* are presented and a brief discussion follows each subject. A translation from the Arabic version and comparison with the Persian translation was done to present an accurate text.

I did not enter the domain of traditional and herbal medicine such as the four cardinal humours (blood, phlegm, choler, and melancholy), temperaments, and herbal therapy which have been extensively discussed in Avicenna's books and his contemporaries. These subjects were beyond the aim of this paper, and I was only engaged to the items that the current modern medicine obviously and clearly proceeds with them. Although I tried not to deviate from mere scientific discussion, there is, undoubtedly, the probability of error and mistake due to the difficult nature of such historical studies. This article can be an opening to comprehensive studies on better exploring our ancestors' works. It should be noted that this paper is a revised version of an article by the author in Persian which was published in the *Iranian Journal of Urology* in 1995.⁽¹¹⁾

DISCUSSION

Book III, Part 19, Treatise 1, Chapter 1

Book III of the *Canon of Medicine* is on "specialized pathology: disease inflicting the human organs from head to foot, the external and internal manifestations (medical and surgical)." Part 19 of this book is on the bladder (urocyst) and urine (Figure 2). This part has two treatises: treatise 1, on the status of the urinary bladder (urocyst) and treatise 2, on timing of urine.

In treatise 1, chapter 1, Avicenna describes the anatomy of the urinary bladder and its physiology and patophysiology^(9,10):

The god on high has created an organ similar to cyst in human body to remove the useless and removable liquids (or urine). This allows the urine to gradually pour into the bladder and at a necessary time, it can completely be expelled from

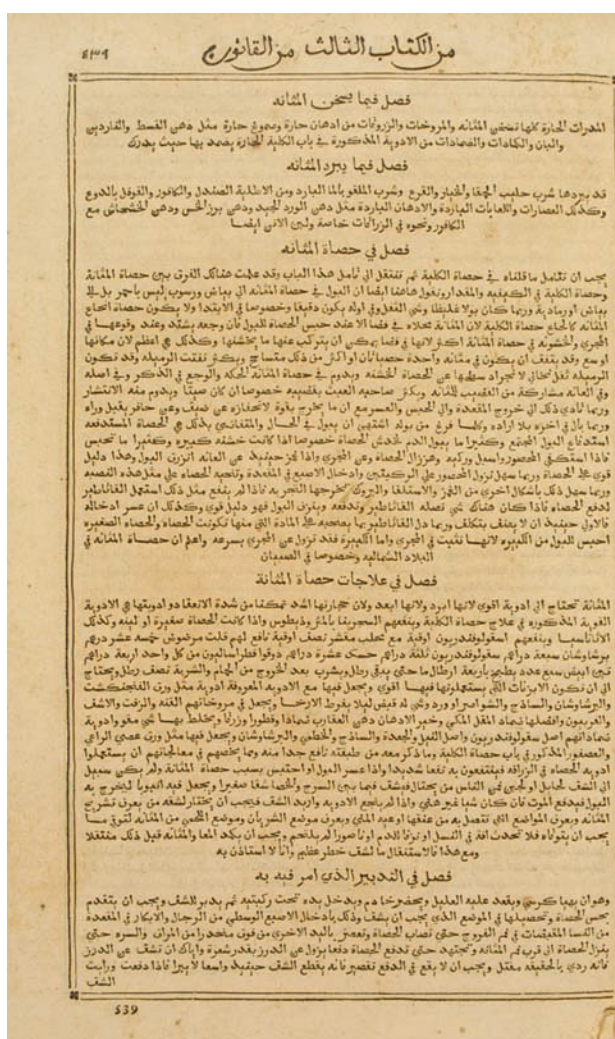


Figure 2. The third book of the Canon of Medicine in Arabic on bladder. Adapted from the web site of the Saab Medical Library of the American University of Beirut.

the body. Otherwise, the human would have to urinate every minute and every hour, so as in patients with urinary dribbling [tagtirol bol in Arabic; chakmizak in Persian]. This leather-like bottle is named the bladder (urocyst) in which the removable liquid (or urine) accumulates.^(9,10)

Discussion 1. The 2-phase function of the bladder to which Avicenna pointed, has lately been described by Yoshimura and Chancellor as a premise.⁽¹²⁾ According to this premise, function of the bladder has 2 separate phases of bladder filling (storage phase) and bladder emptying (voiding, urination, or emptying phase). It is noticeable that Avicenna described this premise 10 centuries ago.

Discussion 2. Urinary dribbling had been

scrutinized and described by Avicenna as a symptom.

The bladder has been made by interlaced tendons [asab-ol-robot in Arabic] and there are 2 real hidden reasons for this composition. First, the bladder becomes more fortifiable and inseparable; second, it becomes elastic. When the bladder is filled with urine, it extends and remains fixed, and the human can expel urine voluntarily when the bladder is full.^(9,10)

Discussion 1. The bladder is a muscular organ which has been made by smooth muscle layers. Bladder is an elastic organ and it obeys the *Laplace's Law*. According to this law in physics, when the bladder extends and dilates by urine, its diameter increases. Thus, its intramural pressure does not increase. Pierre Simon Marquis de Laplace (1779 to 1827) has been called the "Newton of France." Laplace made the statement that the tension in the wall of a container necessary to contain a given pressure is directly proportional to the radius of the curvature at any point.⁽¹³⁾ Laplace's equation means that there is direct relationship between wall tension and intravesical pressure and bladder size. This equation is established between tension (T), intravesical pressure (P), bladder radius (R), and wall thickness (d). During bladder filling P is relatively constant. With a fully distended bladder, d is ignored because of its relative thinness unless a hypertrophied wall exists. Thus the equation in the form of $T = P \times R/2$ approximates tension in a normal bladder.⁽¹²⁾

Discussion 2. Urination is done under the control of the brain voluntarily.

Discussion 3. Tendons are made of collagen. Excess collagen decreases elasticity of the bladder and increases intravesical pressure. At the time of Avicenna, there was no microscope, and thus, differentiation of the connective tissue from smooth muscles was impossible.

In the bladder neck, there is a fleshy and sensitive material which is adjacent to the muscles related to the bladder.^(9,10)

Discussion 1. Just following the bladder neck and around the prostatic urethra, there is the prostate gland that is mainly a glandular and

secretory tissue, and there are some connective and muscular tissue too. The prostate, prostatic urethra, and bladder neck are innervated by the autonomic nervous system.

Discussion 2. 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-related muscles.

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.^(9,10)

Discussion 1. The bladder has 3 layers: the first 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.

Discussion 2. The second and third layers of bladder have been discussed as one layer by Avicenna in *the Canon*. At that time, there was no progression in the facilities for histological examination methods.

The god on high, because of his grace and wisdom, has decided that the removable liquid (urine) pours into the bladder and then be expelled out. For this purpose, 2 water-transporting tubes or ureters [halebain in Arabic] descend from the kidneys to the bladder. When the ureters reach the bladder, the bladder opens its two layers and includes the ureters in it. First, these tubes pass the hiatus of the first layer, and then, they pass between the two layers at the necessary distance. Then, they perforate the lining undercoat layer and reach the depth and the cavity of the bladder.

Removable and useless liquid (urine) pours into the bladder until the bladder become full. The internal layer adheres to the external layer and these two layers are in contact together as if they are united originally and there is no pore and passage between them. Because of this unity and adherence, the retained urine in the bladder has no retrograde pathway to the ureters or antergrade pathway to the urethra.^(9,10)

Discussion 1. Two ureters laterally descend from the kidneys towards the bladder, and then, the urine produced in the kidneys pours into the bladder, being ready to be expelled during urination through the urethra. Anatomically, the ureteral pathway in the bladder wall is very interesting. The ureters first pass through the ureteral hiatus, and then, the seromuscular layers of the bladder (external and middle layers). After reaching the suburothelium, they traverse about 1 cm in the submucosa. Ureteral submucosal pathway and its opening to the bladder are important in prevention of urinary reflux from the bladder to the ureters and kidneys known as *antireflux mechanism*. When the bladder becomes full of urine intravesical pressure increases. This pressure increase shifts to the submucosal pathway of the ureters and causes closure of the submucosal ureters. Any abnormalities in this mechanism cause vesicoureteral reflux.

Discussion 2. Antireflux mechanism of ureterovesical junction that Avicenna accurately discusses in *the Canon* is one of the most important and interesting items in bladder physiology and pathophysiology, and a large chapter in urological textbooks is about its abnormalities. Ten centuries ago, Avicenna who was not armored with microscope or voiding cystourethrography, pointed to the antireflux mechanism. Astonishingly, he was the first to become familiar with this mechanism with anatomic details.

The god on high his power, has made a gullet-like organ [angha in Arabic] to eliminate the removable liquids (urine) through the penile urethra. Thus, this organ that is similar to water pipe [tanbousheh in Persian] is continuous from the bladder to the penile urethra toward out and it has multiple curvatures. The philosophy of creation of these curvatures is that the liquid material would not be expelled out suddenly and totally. These curvatures in the male's urethra are more than those in the female's. There are 3 curvatures in males and only 1 in females, because the female's bladder is very near to the uterus.^(9,10)

Discussion 1. Male urethra has 5 parts: prostatic urethra, membranous urethra, bulbar urethra,

penile urethra, and glandular urethra. There are 35-degree curvatures between the beginning and the end of the prostatic urethra and the anterior concavity between the membranous and bulbar parts of the urethra, and also the anterior concavity between the bulbar and penile urethra. Male urethra is long and meandering, and its length is 25 cm. Female urethra is only 4 cm and has only 1 angle in the bladder neck that is very important in competency against urinary incontinence during crying sneezing, coughing, and laughing.

Discussion 2. This should be taken into consideration that Avicenna describes the urethral anatomy carefully and according to the modern urologic descriptions.

There is a gullet-like organ which is encircled at its origin in the proximal part by a muscle, the function of which is to compress and obstruct the urethra, so that urine is not expelled out without the human being's willing. When human being intends to urinate, this guarding and obstructing muscle becomes loose. This gate-keeping muscle is helped by abdominal muscles. This work is done very regularly unless this gate keeper and water distributor muscle [mirab in Persian] or its helper muscles are traumatized.^(9,10)

Discussion 1. Around the proximal urethra (membranous urethra), 1.5 cm from its beginning, there is a striated muscle (voluntary sphincter) that is voluntarily, which is innervated by the pudendal nerves. In the filling phase of the bladder function, when the human being does not intend to urinate, there is a guarding reflex that causes compression of this sphincter against urinary incontinence. Sphincteric compression increases when the bladder volume increases by urinary filling. Vice versa, this sphincter relaxes under the human being's control during voiding, so that urine is expelled out. This striated sphincter is supported by the pelvic floor muscles. An impaired striated sphincter or pelvic floor muscle can lead to urinary incontinence.

Discussion 2. Avicenna's accurately description of the voluntary striated sphincter of the urethra accords with modern urologic findings.

Book III, Part 19, Treatise 1, Chapter 2

The second chapter of part 19, book III is on the diseases of the urinary bladder. In this chapter, classification of bladder disorders is stated as below^(9,10):

- (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.

In Avicenna's opinion, bladder disorders usually happen in cold weather, in wind-blowing seasons, in northern areas, and in cold seasons of the year. For the 6th item of the above, he explains "occasionally there is headache and vertigo along with bladder disorders, and sometime delirium or liver disease develop in bladder diseases. Often, dropsy or thirstiness [*estesgha* in Arabic] is associated with some bladder disorders.^(9,10)"

Discussion 1. Current bladder disease classification is almost similar to *the Canon's* classification⁽⁴⁾:

- (1) bladder inflammatory disorders (cystitis) that include specific infections (eg, tuberculosis), nonspecific cystitis (bacterial and viral), interstitial cystitis (including Hunner's ulcer), and acute urethral syndrome;
- (2) bladder neck and infravesical obstructions that affect the bladder (including bladder calculi);
- (3) congenital bladder disorders, including congenital megacystis, congenital bladder hypoplasia, and epispadias-extrophy complex;

- (4) bladder tumors, bladder diverticulum, pelvic floor laxity (including cystocele);
- (5) bladder trauma; and
- (6) neurogenic bladder due to central and peripheral nervous system diseases, neurological symptoms such as delirium in urosepsis, metastases of bladder tumor to the brain (rare); and neurological impairment of the bladder due to systemic disorders such as diabetes mellitus.

Discussion 2. Please pay attention to the similarities of these two classifications! Avicenna has knowledge on most disorders of the bladder except that there is no place in modern medicine for the 7th item he mentions in his article (temperamental changes). Even he points out to bladder tumors in item 4 as “lumpy lesions” and in item 5 as “bladder ulcers.”

Book III, Part 19, Treatise 1, Chapter 5

Chapter 3 (on what “warms up” the bladder) and chapter 4 (on what “cools off” the bladder) are about bladder temperamental alterations which are beyond the scope of this comparative study. Chapter 5 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.^(9,10)

Discussion 1. The epidemiology of bladder calculi stated in *the Canon* is approximately similar to recent findings in modern urology.⁽¹⁴⁾ In summary, in underdeveloped and developing countries and in poor and malnourished patients, bladder calculi are more prevalent, and in developed countries and wealthy people, the prevalence of bladder calculi decreases, while the prevalence of kidney calculi increases. Bladder calculi are more prevalent in children

that sometimes can be attributed to childhood malnutrition. Probably, phosphate deficiency in children’s diet is related to bladder calculus formation. The most common causes of bladder calculi in children are metabolic disorders.

Discussion 2. It should be noted that the epidemiology of bladder calculi Avicenna describes accurately accords to the findings of modern urology. However, at the time of Avicenna, there were no radiological or ultrasonographic sources; thus, as he has stated, they could diagnose bladder calculi after their passage. In addition, a large percentage of bladder calculi are radiolucent (uric acid) and even today, they do not expose themselves in plain radiography, and we need ultrasonography or cystoscopy for definite diagnosis.⁽¹⁵⁾

Discussion 3. We read in one of the urology text books that “a solitary bladder stone is the rule but there are numerous stones in 25% of patients” which accords to the Canon.⁽¹⁵⁾

The urine of the patient with bladder calculus is totally whitish or grayish.^(9,10)

Discussion . Sometimes phosphaturia is seen in patients with bladder calculi, especially in those with alkaline urine. In this situation, the appearance of urine is turbid, and small granules in urine and some crystals are seen in the urinary sediment. Occasionally, bladder calculi are associated with severe urinary tract infection, especially in obstructive uropathy in which sometimes urine is completely purulent and white.

A bladder calculus causes pain that is not more severe than the pain due to kidney calculi, because bladder calculi are located in a hollow organ. But, if a bladder calculus obstructs the outflow of urine, its discomfort will be greater and its pain will be more severe than the pain due to kidney calculi. Also, if the bladder calculus passes through the urethra, its pain is severe. Bladder calculi are more likely than kidney calculi to become coarse, because bladder calculi are formed in a hollow space and it is more possible that the coarsening substance contact it. A bladder calculus is usually larger than a kidney calculus because its space is larger. Sometimes, there are 2 or more calculi

in the bladder or the calculi can scratch each other and as a result, multiple small fragments appear in urine. Sometimes there is bran-like dross associated with sandy substances. In this condition, bladder undercoat might be scratched and desquamated because of the calculus.

Discussion 1. Very large bladder calculi have been described for example, a giant bladder calculus reported in a 37-year-old woman and 2 large calculi in a 26-year-old man were reported.^(16,17) Also, we removed a 7-cm calculus (about 700 g) from the bladder of a 56-year-old man with benign prostatic hyperplasia (Figure 3; unpublished). The “bran-like dross” explained by Avicenna can be the matrix calculi that must be differentiated macroscopically from purulent material due to secondary infection, and also must be differentiated from desquamated material in bladder cancers associated with chronic infection and bladder calculi due to irritation of bladder mucosa. Cloudy sandy urine produced by children in endemic areas indicates the early stages of calculus formation. Girls are able to pass most of the debris through their urethra, but boys may retain these potential nidi. You notice that the similarities between debris in modern text books and bran-like dross in the *Canon*.

Pain and discomfort caused by bladder calculi are less severe than renal colic or severe pain due to kidney or urethral calculi. If the calculus obstructs



Figure 3. A 7-cm calculus (about 700 g) from the bladder of a 56-year-old man with benign prostatic hyperplasia (operated by the author; unpublished).

the bladder neck or urethra, it causes urinary retention and its pain is more severe. Bladder calculi in long-term can cause obstruction, urinary tract infection, bladder mucosal irritation, squamous metaplasia of the urothelium, and even bladder cancer, especially in association with chronic irritation and infection.

Discussion 2. Direct or indirect indication of almost all complications of bladder calculi is an amazing point in the *Canon*.

In the presence of bladder calculi, there is pain in the penile urethra in sympathy with the pain in the vesical area (suprapubic), and also itching and pain is present in the penile urethra, penile base, and suprapubic area. The patient, especially the child, who has a bladder calculus, may play with his penis. Itching and pain at the penile urethra due to bladder calculus is continuous and it diffuses repeatedly and refers to the anal area. The anus may protrude outside, urine may be obstructed, and difficult urination may be a symptom. The patient has straining in urination in which the urine can pass through the obstructed urethra. The patient may have urinary retention and may pass urine with difficulty. In most cases of bladder calculus, there is bloody urine because of scratching the vesical undercoat, especially if the calculus is large and coarse.

Discussion. Because of common innervations of the bladder, scrotum, penis, and especially glans penis (S2-S3), bladder calculi causes suprapubic pain which is referred to the penile urethra, scrotum, and penile base. Bladder calculi, especially in children, are one of the causes of priapism.⁽¹⁸⁾ Hematuria, overflow incontinence, and frequency are the symptoms of bladder calculi. Anal diseases such as hemorrhoid and anal prolapse can induce lower urinary tract symptoms. Also, benign prostatic hyperplasia that is sometimes associated with bladder calculus can induce or aggravate the symptoms of anal disorders because of straining in urination. It is notable how the Avicenna's description of the symptoms of bladder calculi is compatible with modern urology's description.

Sometimes, urinary retention occurs. In this condition, if the patient lies down in supine

position with both buttocks elevated and shook, the calculus can move away from the obstructed pathway and urine finds its route out. In this position, if the pressure is applied to the suprapubic area, the patient can urinate and this is the true evidence of bladder calculus.

In the treatment of urinary retention, there is a method other than elevation of the buttocks. In this method, the patient takes the knee-chest position and squeezes his or her whole body or by entering the finger into the rectum, the calculus can be moved away from the urinary pathway. You can test these methods and succeed.

In difficult cases, there is no other method than inserting a catheter [gasathir in Arabic] into the penile urethra. You must not insert it forcefully. You can move the calculus away from the urethral lumen by this method. If the calculus obstructs the urinary lumen, the catheter can reach it and you can feel the contact of the catheter to a solid thing. This contact is a reason itself for the presence of the calculus. The head of the catheter can move it away and can open the pathway for urinary flow. Sometimes, the calculus substance can be extracted by the catheter and you can recognize the original composition of the calculus by its examination. Small calculi obstruct the urinary system more than larger ones because small calculi can access the urethral lumen, but the larger ones only obstruct the bladder neck and can be easily deviated away from lumen.

Discussion 1. After extracorporeal shock wave lithotripsy of the lower caliceal calculi, there is a method named *inversion therapy*, in which the head of the patient is downward and buttocks elevated; thus, the fragmented calculi can pass through the ureter. This method is very similar to the abovementioned method in *the Canon* for bladder calculi. Of course, Avicenna stated that this method is for the relief of urinary retention caused by bladder calculi.

Discussion 2. Putting pressure on the suprapubic area as stated by Avicenna is indeed the *Crede maneuver* that can be used for the relief of urinary retention due to neurogenic bladder, which is frequently associated with bladder calculi and is a

familiar method for every urologist.

Discussion 3. Digital rectal examination with mild pressure together with insertion of metallic bougies or catheter with good urethral lubrication can be used for bypassing or retrograde pushup of urethral calculi to relieve urinary retention before the definite treatment. Interestingly, Avicenna has pointed to all of these methods.

Discussion 4. Grating sign due to contact of the head of metallic bougies with the calculus is a famous sign in urology which has been described by Avicenna centuries ago.

Discussion 5. we can diagnose the type of the calculus by urinary examination or examination of the stony substances passed through the urethra.

Discussion 6. Avicenna's direct pointing to inversion therapy, Crede maneuver, manipulation of calculi by catheterization and retrograde pushing up, grating sign, and determination of the calculus composition by urinary examination 1000 years ago is really amazing.

CONCLUSION

Scientific methodology of Avicenna's *Canon of Medicine* and its comparison with modern urologic articles indicate that Avicenna's method in diagnosis and treatment of patients is really experimental and away from superstitious beliefs of his time. There is no place for nonscientific, ignorant, or foolish methods in Avicenna's approach to the diseases.

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