

Avicenna's Canon of Medicine and Modern Urology

Part II: Bladder Calculi

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In the previous issue of the *Urology Journal*, a comparison of Avicenna's *Canon of Medicine* with modern urologic findings was done in part I of this article, addressing bladder anatomy and physiology and bladder calculi. In part II of this review, the remaining chapters of *the Canon of Medicine* on bladder calculi are reviewed. Avicenna points to perineal urethrostomy (perineostomy), which is today performed as the last therapeutic line or as a temporary remedy before surgical treatment. He also describes surgery via transperineal route and warns the surgeon of the proximity of vasa deferentia, prostate gland, and neurovascular bundle and their exposure in this position. Usage of grasping forceps for removal of bladder calculus and emphasis on removing all calculus fragments are the interesting points of this chapter. Avicenna explains a technique similar to the use of a Babcock forceps for prevention of calculus migration. Complications of bladder calculus surgery and cystotomy are also addressed with scientific precision in the *Canon*. It is noteworthy that 8 centuries before Fournier described necrotizing fasciitis in male genitalia, Avicenna had described Fournier gangrene in his book.

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INTRODUCTION

The famous Iranian scientist and philosopher, Avicenna, continued for centuries to have a great influence on the medical knowledge of the world by writing the *Canon of Medicine* (Figure 1). In part I of this article, I compared chapters of Avicenna's book with modern urological findings which were on bladder physiology and anatomy as well as bladder calculi.⁽¹⁾ In part II, review of book 3, part 19 is continued focusing on surgical treatment of bladder calculus.

original language (Arabic),⁽²⁾ along with its Persian translation.⁽³⁾ Part 19 of the 3rd book contains subjects related to surgical treatment of bladder calculi. I compared the text 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.

MATERIALS AND METHODS

This study is the comparison of modern urology with the urological chapters of Avicenna's *Canon of Medicine*. I used *the Canon* in its

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Figure 1. Avicenna's tomb in Hamedan, Iran. He was born in 980 AD in a village near Bokhara (which was a city of old Persia) and died in 1037 AD in Hamedan, Iran.

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. 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 1996.⁽⁴⁾

DISCUSSION

Book III, Part 19, Treatise 1, Chapter 6

In this chapter, entitled “Treatment of Bladder Calculi,” Avicenna first explains the medical (herbal) therapy for bladder calculi (Figure 2). I pass aside this subject as I mentioned in the Material and Methods. Then, he describes the manipulation and surgical treatment of bladder calculi:

If urinary retention occurs in the presence of bladder calculus and it is not possible to incise



Figure 2. The third book (Part 19, Treatise 1, Chapter 6) of the *Canon of Medicine* in Arabic on surgical treatment of bladder calculi. Adapted from the web site of the Saab Medical Library of the American University of Beirut.

the bladder—in other words, if there is an obstructive pathway or you are afraid of incising the bladder—in this state, some physicians make a very small incision between the rectum and the testes [perineum] by lancet and then insert a small tube and evacuate urine via that tube, and thus, they rescue the patient from death. The patient may have much discomfort due to this operation, but there is no other remedy.^(2,3)

Discussion. In this stage, Avicenna delineates 2 indications of perineal urethrostomy (perineostomy). Bladder calculus secondary to infravesical obstruction such as urethral stricture is a very important and prevalent condition in

which there is an obstruction in the urinary pathway. In this case, vesicolithotomy is not the definite treatment itself, and we must relieve the obstruction first. Also, there are conditions in which the operation poses a high risk, eg, long urethral strictures or obstructions in which operative time is long or conditions in which complete operation cannot be done. As further examples, the use of flap or graft in the urethra is associated with infection, severe refractory diabetes mellitus, or chronic kidney failure, especially in old patients with low cardiopulmonary reservoir. In these conditions, the urologist can use temporary diversion options such as peineal urethrostomy, as Avicenna proposes for rescuing the patient's life. Perineal urethrostomy even rarely can be used as a last treatment line in high-risk patients, as Avicenna says, "there is no other remedy." This operation is done as a permanent remedy by if we cannot carry out definite surgery.⁽⁵⁾

If medical therapy failed and there was no remedy other than incision, operation must be done by a person who knows the situation and condition of the bladder best and by the one who has the knowledge of bladder anatomy. Also, he must know the anatomic relations of the semen-carrier vessels [vasa deferentia] and the seminal vesicles to the bladder neck and junction of them to the bladder and the position of the fleshy substance [prostate]. Otherwise due to negligence and lack of talent, he can damage the genitalia or can cause hemorrhage or incurable fistula.^(2,3)

Discussion 1. Today, urologists first use the conservative medical therapy for small urinary calculi to facilitate their spontaneous passage. If medical therapy fails and the calculus does not pass, they use minimally invasive methods (endourologic techniques such as transurethral lithotripsy by pneumatic, ultrasonic, or laser lithotripters; extracorporeal shock wave lithotripsy by ultrasonic, electrohydraulic, or electromagnetic instruments; and mechanical transurethral lithotripsy) and at last invasive open surgery.⁽⁶⁾

Discussion 2. These operations must be done by an experienced urologist who has the insight into urogenital tract anatomy and had adequate

qualifications. At Avicenna's time, bladder calculus surgery would be done transperineally in the lithotomy position (and it is obvious why this position is named so). This is noteworthy that Avicenna emphasizes the anatomic relations of the posterior and lateral surfaces of the bladder base with the vasa deferentia and blood vessels. He states that in this surgical approach, the prostate (named as "fleshy substance") is exposed, make it prone to trauma to the neurovascular bundles, impotence, hemorrhage, and fistula (eg, rectovesical fistula).⁽⁷⁾

The physician who does the operation must secure the patient in the supine position preoperatively and do prepare his or her intestine and bladder. Yet, in my opinion, the incision [operation] is a great risk and I never recommend it. But, if the operation is inevitable, you conform all of my orders. You should prepare a chair and sit the patient on it. The nurse places his or her hand below the patient's knees (and elevates them).

Then you remark the incision site. You should locate the calculus site in the bladder before incision, and you should fix it in its place. In men or in virgin girls, insert your finger in their anus, and in women with perforated hymen, insert your finger to their vagina up to the cervix until it reaches the bladder calculus. Compress the calculus with your other hand superiorly and descend it by hand compression from up to down until it reaches the bladder neck. Then, you should be very careful to stabilize the calculus about a grain size far from the incision line. You should not do something else at that time and you should not neglect that the calculus must not move directly to the incision line and exit via the incision. It is not suitable that the calculus is expelled out directly from the incision because this has the risk of death. You should not fail to care for controlling the calculus exit, because if it comes out directly from the incision, the incision expands and causes incurable fistula. After you push the calculus skillfully near the incision line, you can see that the incision line is too small for extraction of the calculus. At this time, expand the exit site slightly with lancet. Re-incision must be done in a way that you ensure it does not cause severe pain and does not damage the bladder neck and the patient does not lose his or her power and force

and continues his or her movements and speaking with you and it does not cause depression and closing of the eyes. Otherwise, you immediately cause the patient's death. If the incision is so deep that it reaches the bladder body, there is no hope in the patient's recovery and wellbeing, and the incision line will not heal. Incision must be done in the bladder neck, but it must not reach the bladder body, and you must take the necessary precautionary measures not to incise the vessels.^(2,3)

Discussion 1. In this part, Avicenna states the technique and some intra-operative and postoperative complications of transperineal access to bladder calculi. It is obvious that 1000 years ago and in the state of no progressive anesthetic techniques, the bladder calculus surgery had been a high risk and fatal operation, and as Avicenna said, it can cause severe pain, shock, and death, especially in patients with cardiovascular disorders which can be associated with myocardial infarction and sudden death. Apart from being out of date, Avicenna's describing the perineal technique of vesicolithotomy in the medieval time is surprisingly accurate and experimentally similar to the modern description of operational techniques and this is very interesting in.

Discussion 2. Bladder and urethral operation with transperineal approach, can cause urinary fistula (no healing of the incision line as stated by Avicenna), especially vesicovaginal or urethrovaginal fistula in women. Today, there is no place for open surgery through perineal access for treatment of bladder or urethral calculus removal. Today, transvaginal access to ureteral calculi is rarely recommended in women.⁽⁸⁾ And overall, by progression of extracorporeal shock wave lithotripsy and endourological methods, there is little place for this approach.

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.^(2,3)

Discussion 1. Today in endourology, calculus grasping instruments have their special place.⁽⁹⁾ For very large calculi, there are modern lithotripsy methods to the basis of which Avicenna pointed 10 centuries ago: mechanical lithotripsy. In all of these methods, the calculus is crushed into small pieces and then exits from the body. Today, the Avicenna's cited mechanical lithotripsy is used for bladder calculi too. However, urologists have expanded options for lithotripsy in addition to mechanical lithotripsy, such as laser, pneumatic, electrohydraulic, ultrasonic, and combined pneumatic plus ultrasonic lithotripsy.⁽⁶⁾

Discussion 2. As Avicenna mentions, calculus fragments remaining in the bladder after lithotripsy, even if very small, lead to continuing calculus formation process. These small calculus remnants act as a foreign body and a nidus that grows and forms large calculi after a few time.^(6,10)

Sometimes, there is a calculus in the bladder neck or infravesical (below penile urethral) area. In these conditions you must touch and compress the suprapubic area with your hand and there must be an assistant with you. At this stage, he must incise the place in which the calculus is fixed and he must expel the calculus out. In this situation, it is suitable that you close the proximal part of the fixed calculus by a thread, so that it is not pushed up. If the calculus descends down from the bladder and reaches the distal part of the urethra, you should not push it out with pressure; otherwise, it can cause an ulcer that will not heal. You should move the calculus to a suitable place in the urethra, close the proximal part of urethra by a thread, and incise the lower surface of the distal penis (urethral meatus) with lancet and expel the calculus out.^(2,3)

Discussion 1. Impacted calculi in the bladder neck or urethra can cause urinary retention which must be managed immediately. There are several methods to treat them. Penile urethral calculi in men can be diagnosed by palpation of the urethral

side of the penis.⁽⁶⁾ As Avicenna points out, we should not expel the calculus out forcefully at this stage. Otherwise, it causes urethral injury, hemorrhage, delayed stricture, and even cutaneous fistula. In a sterile condition, we can fill the urethra with lubricating and anesthetizing gel, and then, we can gently milk the calculus out towards the urethral meatus.⁽⁶⁾

Discussion 2. For large proximal urethral calculi that cannot be milked out, the urologist can fill the urethra with gel, and then, he or she can push up the calculus by a urethral catheter and manage it as a bladder calculus. Today, urethral calculi can be fragmented by various transurethral lithotripsy methods and be extracted.

Discussion 3. Today for palpable large chronically impacted calculi in men's urethra, external urethrotomy can be used.⁽⁶⁾ In this method, the penile urethra is opened by incising the skin and underlying anatomic layers, and the calculus can be removed and the urethra be closed in 2 layers. This method is not recommended because of increasing the risk of urethral cutaneous fistula.⁽¹¹⁾ Today, thanks to modern lithotripsy methods, there is a small place for external urethrotomy to extract penile urethral calculi.

Discussion 4. If the urethral calculus is impacted in the fossa navicularis or near the urethral meatus, we can incise the urethral meatus (*meatotomy*) and remove it.⁽⁶⁾ Avicenna has pointed this method in his book, too.

Discussion 5. In open removing of urethral and especially ureteral calculi, we can close their lumen proximally or distally by a Babcock forceps to prevent upward or downward migration of the calculus during the operation and then remove it. This modern method is similar to closing the urethra by a thread during operation as Avicenna described.⁽¹²⁾

One of these situations may occur intra-operatively or postoperatively:

(1) Occasionally, blood does not flow throughout the incision site as necessary. In this situation, there is a risk of inflammation that is due to ruining [fesad in Arabic] of the organ in which

blood accumulates, but blood cannot be drained out especially if the organ loses its redness and thus its color converts to black. In this situation that the blood does not drip from the operation site as necessary and accumulates inside the organ and the organ starts being ruined and its color converts to black, you must immediately incise the site in which blood accumulates and you must drain the accumulated blood out.

(2) Occasionally, blood flows more than necessary from the wound. In this situation, there is risk of hemorrhage that is dangerous. If you notice that one of the great vessels or one of arteries is injured or disrupted and causes the hemorrhage, you must tightly close it, so that the hemorrhage stops and blood does not leak.

(3) Occasionally, blood from incision site can flow towards the bladder and coagulates in the bladder neck and causes difficulty in voiding. In this situation, you must insert your finger into incision site and free the bladder neck from this coagulated blood and extract the coagulated blood out and wash the incision site by water and vinegar [acetic acid], so that coagulated blood dissolves and exits.

(4) Sometimes, the operation causes infertility [engheta-e-nasl in Arabic].

(5) There are signs in patients with bladder calculus that indicate a severe illness and bad condition, and they are the alarms of patient's death. When they appear, the doctor knows that the patient's death is imminent. These signs are: severe infra-umbilical pain, coldness of the extremities, severe fever, fever and rigor, and weakness and loss of power. There are other signs such as severe pain in the incision site, hiccup and severe malodorous diarrhea. In such situations, death of the patient is near. However, if mental state of the patient is normal and the patient has complete normal appetite and the color of his or her face is normal, these are the promises of recovery.^(2,3)

Discussion 1. In this part, Avicenna describes intra-operative and postoperative complications of transperineal operations, Fournier gangrene, and mortality. In this stage, perineal and scrotal skin progresses to ruin and becomes gangrenous.

In the presence of hematoma and abscess, blood and pus must be drained. At Avicenna's era with no antibiotics, the Fournier gangrene, septicemia, and surgical mortality used to be common. As he states, blood accumulation or hematoma in the operation site can cause the propensity to infection, and it can ultimately increase the risk of the Fournier gangrene, and septicemia. Today with complete drainage and antibiotic administration, these complications are rarely seen. This is astonishing that 8 centuries before Fournier described the signs and complications of necrotizing fasciitis in male genitalia,⁽¹³⁾ Fournier gangrene is described in the *Canon*.

Discussion 2. In Fournier gangrene, the injured site is ruined and blood flow is low, and thus, the anaerobic bacteria grow over there. The organ loses its healthy red color and turns into black (the name gangrene points to this sign). In this case, we should drain hematoma and pus, and we should do debridement of the ruined tissues towards the healthy and normal circulated tissues.⁽¹³⁾

Discussion 3. In continuous hemorrhage from the incision site and hematoma, we should open the site and find the origin of hemorrhage in order to ligate the vessel. Avicenna has precisely elucidated these.

Discussion 4. As Avicenna states, in severe hemorrhage from the bladder incision site or from any place in the bladder or prostatic fossa (eg, in open prostatectomy), there is high probability of urinary retention due to blood coagulation and clot retention in the bladder. Today, we first insert a 3-way catheter and wash the bladder by hypertonic saline solution. In severe cases, we should open the incision line and reoperate and ligate the related vessel. Today, most of the bladder and prostatic operations are endoscopic without the need to open the bladder.⁽¹⁴⁾

Discussion 5. Ten centuries ago, in the area with no antibiotics and no preparation and draping techniques in the operating room, infection, septicemia, and thus, septic shock were one of the most prevalent and important causes of mortality following surgeries. Fever, rigor, extremity coldness, and severe weakness were the signs of these conditions as Avicenna explains.

Occasionally, in uremic conditions associated with bladder calculi, for example in kidney failure due to benign prostatic hypertrophy and obstructive bladder calculi, hiccup is one of the worst symptoms. To Avicenna, hiccup meant association with poor prognosis in the area with no dialysis facility and no antibiotics.

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