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Urolithiasis management and treatment: Exploring historical vistas of Greco-arabic contribution

Salman Ahmed, Muhammad Mohtasheemul Hasan and Zafar Alam Mahmood

Abstract
The purpose of presenting review was to share the medicinal and surgical contribution of Greco-Arabic Muslim scientists in diagnosis, surgery and natural medicines for the management and treatment of urolithiasis. The contribution of Al-Antaki, Al-Baghdadi, Al-Baitar, Al-Bokhari, Al-Razi, Al-Zahrawi, Ibn Sina, Ibn Zuhr was highlighted. The data compilation was preliminary and much more efforts are still needed to restore the missing continuity in the history of medicine.

Keywords: Greco-arab, medicine, muslims, kidney stone

Introduction
Historical vistas create an important link in the globally continuous line of progress and evolution of world civilizations, especially in the history of science. George Alfred Leon Sarton, a Belgian-American chemist and historian wrote, "*We shall not be able to understand our science of to-day, if we do not succeed in penetrating its genesis and its evolution……..and if we do not understand our science of today we will not be able to add to it.*" According to Al-Razi, the scholar who attains complete knowledge of the achievement of those who came before him will be able to add original contributions to it. History of medicine is continuous and uninterrupted and gives the medicine of today by a joint global contribution of the whole world. It can be divided into following six phases [1].

1. Creation of Adam (Peace Be Upon Him) and prehistory.
2. Ancient civilizations: Assuro-Babylonian, Ancient Egyptian, Indian, Persian, and Far Eastern.
3. Greco-Roman and Alexandrian.
4. Greco-Arabic or Greco-Islamic medicine (7^{th} to 16^{th} century the Golden age of Arab-Islamic civilization): In Europe, this period is usually referred to as the Dark Ages, in which the great era of the Greco-Roman medicine came to an end and no progress in medical science was made until the Renaissance.
5. Renaissance (14^{th} to 17^{th} century): It is regarded as the cultural bridge between the middle ages and modern history.
6. Western civilization: It comprises of Industrial revolution (18^{th} to 19^{th} centuries) and Modern day civilization (20^{th} century).

Urolithiasis is a major global health problem with complex pathophysiology, multifactorial etiology and high recurrence rate. It is one of the oldest diseases of modern era which has increased in both the developed and the developing countries during the past decades. In 1901 English archeologist E Smith found a bladder stone from a 5000 year old mummy dated back to 4800BC in El Amrah, Egypt. The medical texts of Asutu in Mesopotamia, between 3200 BC and 1200 BC are the earliest literature, for describing symptoms and prescribing treatments to dissolve the calculus [2]. Ancient Mesopotamia were using opium (*Papaver somniferum* L.) and cannabis (*Cannabis sativa* L.) in case of pain and bleeding caused by kidney or bladder stones [3]. In Ancient Greek periods, Hippocrates (460 BC to 370 BC) in his famous book *Oath of Medical Ethics for Physicians* quoted *"I will not cut for calculus, even for the patients in whom the disease is manifest; I will leave this operation to be performed by practitioners."* This statement, suggested surgery as one of the way of urolithiasis management [2]. Hippocrates in his book *internal affections* wrote, *"From the kidneys these four diseases arise. In the first one, the patient suffers the following: a sharp pain attacks his kidneys, loin, flank, and his testicle on the same side as the kidney; he urinates frequently, and drips urine a little at a time; together with the urine, sand, too, is passed, and when the sand*

discharges through the urethra, it provides violent pain in it. When the patient has finished urinating, the pain stops; later, though, he labors under the same distress again. When he is passing urine, he rubs his penis because of pain. Many physicians that do not understand the diseases, when they see the sand, think the patient is suffering from stones of the bladder, which he is not, but rather from the stones of the kidneys…….. When the case is such, clean the patient downwards with scammony juice (obtained by incision of the living root of Convolvulus scammonia L.*) or the root itself, first applying vapor-baths to the whole body. On the following day, clean downwards with juice from white chick-peas (Cicer arietinum* L.*) to the amount of two choes (6.55Liters); add salt and give this drink"* [4]. Aristotle (382-322 BCE) in his book *Problems* wrote about the actions of drugs affected urination, "*Why are sweet-smelling seeds and plants diuretic? It is because they are warm and easily absorbed, and such things are diuretic? For the internal heat digests quickly and the smell is not corporeal, since even the strong-smelling plants like garlic (Allium sativum L.), which by their heat cure diuretic, produce more excretions. Sweet smelling seeds are also hot"* [4]. Greek Dioscorides in his book *De Materia Medica* (50-70 AD) and Pliny the Elder (an ancient Roman naturalist) in *Naturalis Historis* (70-79 AD) have shared number of medicinal plants used against urolithiasis along their mode of action (Table-1).

"Greco-Arabic" or "Greco-Islamic" medicine extended from Spain to Central Asia and India. Arab-Islamic physicians and scholars developed a large and complex medical literature exploring and synthesizing the theory and practice of medicine. They introduced many new ideas and upgraded the knowledge about herbs and their therapeutic effects and safety. The Arabs and Muslims appreciated Greco-Roman culture and learning, and translated tens of thousands of scientific and medical texts into Arabic for further study [5]. After the end of Greco-Roman times till the Renaissance as stated by John Howard Lidgett Cumpston (1880-1954 AD), the first director-general of the Australian Department of Health, "*At the time when the Arabs appeared in the Orient, Greek sciences were in total decadence and the practice of magic reigned supreme* [1]." In the 7th century, Islam emerged from the desert of the Arabian Peninsula, conquering the old Egyptian, Persian, Roman, and Near Eastern Empires with Arabic language and added its culture to the heritage of Greece, Rome, Judaism, Christianity, and the Near East. After the 16th century, Crusades, Mongol invasions, natural disasters, loss of international trade, the capitulations of the Ottoman Empire to Western interests, and the rise of European imperialism contributed to political and economic decline of Islamic world. Bertrand Russell (1872-1970 AD) the British philosopher, mathematician, historian, and social critic wrote, "*Islamic science, while admirable in many technical ways, lacked the intellectual energy required for innovation and was chiefly important as a preserver of ancient knowledge and transmitter to medieval Europe* [6]". The statement of Bertrand Russell is completely wrong. It has confirmed that Greco-Arabic Muslim scientist were not just preserve, compile or transmit the Greco-Roman medical literature. They critically reviewed the translated heritage of previous civilizations and accepting only what proves to be true [1]. The famous statement of Al-Razi is: "*I never write about things unless I first examine them myself* [7]". He further wrote, "*I prayed to God to direct and lead me to the truth in writing this book. It grieves me to oppose and criticize the man, Galen, from whose sea of knowledge I have drawn much. Indeed, he is the Master and I am the disciple. Although this reverence and appreciation will and should not prevent me from doubting, as I did, what is erroneous in his theories. I imagine and feel deeply in my heart that Galen has chosen me to undertake this task, and if he were alive, he would have congratulated me on what I am doing. I say this because Galen's aim was to seek and find the truth and bring light out of darkness. I wish indeed he were alive to read what I have published* [8]." Muhadhdhab al-Deen Al-Baghdadi in his book *Al Mukhtar Fi Al Tibb* wrote, "*I will also avoid including anything mentioned which is not proven by experiment as narrated to me by my teacher and through my own experience (obtained) by experimenting and testing* [9]"**.** Multidimensional development of Arab–Islamic thought, provided the stimulus for developing the human intellect further, and for bringing about the forces of rationalism and humanism that led to the twelfth century Medieval Renaissance, the fifteenth century Italian Renaissance, and indeed, for sowing the seeds of European Reformation. This multidimensional approach comprised of Greco-Roman medicinal heritage, Prophetic medicines that were derived from Quran and Ahadith and the practical experience of Greco-Arabic Muslim scientists. According to Dickinson, Sarton, Cumston, and Margota, in the East the development of botany, pharmacy, and chemistry and revival of other branches of science was the major contribution of that Greco–Arabic school of medicine [1]. Ibn Sina introduced sublingual and intra nasal route of drug administration for faster and easier drug delivery of cardiac drugs and reported in his book *Al-Advia Wal Qalbiya* [10]. Al-Zahrawi packed single doses of drugs in cat-gut parcels, ready for swallowing and drug gradually seeped out of the parcel, known today as capsule [11]. These are few examples. However, Greco-Arabic-Islamic medicines influenced Western medical circles to such an extent that it was included in the curriculum of European medical schools for many centuries [5]. Unfortunately, many original authentic medical manuscripts written by famous scholars of the Islamic era were plagiarized, authoritatively edited, published the Latinized works of the Islamic scholars under the names of medieval European authors. The famous example for that is Constantinus Africanus, who as stated by Campbell, suppressed the names of the Arabic authors whose works he produced Latin versions of in the eleventh century. The number of primary source studies based on them by historians or medical researchers remained few and were limited to individual efforts. Therefore, we focused on this missing-link era [1].

In present review, the contribution of following Greco-Arabic Muslim scientist has shared with special reference of urolithiasis, its diagnosis, management and treatment.

1. Abu Bakr Mohammad Ibn Zakariya Al-Razi (Rhazes, 864–930 AD) --- *Al-Hawi fi al-Tibb* (Comprehensive Book on Medicine).
2. Abubakr Al-Akawayni Al-Bokhari (?–983 AD) --- *Hidayat al-Mutallimin fi-al-Tibb* (Learner's Guide to Medicine).
3. Abul Qasim Khalaf Ibn al-Abbas Al-Zahrawi (Abulcasis, 936–1013 AD) --- *Kitab Al-Tasrif* (The Method of Medicine).
4. Sheikh Bu Ali Sina / Ibn Sina (Avicenna, 980–1037 AD) --- *Al Qanoon Fit Tibb* (Canon of Medicine).
5. Abu Marwan Abd Al-Malik Ibn Zuhr (Avenzoar, 1091–1161 AD) --- *Kitab al Tasir fi al-Mudawat wa al-Tadbir*

(Book of Simplification Concerning Therapeutics and Diet).

6. Muhadhdhab Al-Deen Al-Baghdadi (1117-1213 AD) --- *Al Mukhtar Fi Al Tibb* (Choice Book on Medicine).
7. Ziya Al-Din Abdullah Ibn Al-Baitar (1188-1248 AD) --- *Al-Jaame'-il-Mufradaat-al-Advia-wal-Aghzia* (Compendium on Simple Medicaments and Foods).
8. Daoud Al-Antaki (David of Antioch, 1543-1599 AD) --- *Tadhkirat Uli l-al-Bab-wa l-Jami li-L-'Ajab Al-'Ujab.*

Al-Razi

Al-Razi in his book named *Al-Hawi fi al-Tibb* (part 7, book I) precisely explained the anatomy, physiology and pathophysiology of urinary tract diseases, specially the diagnosis and management of urolithiasis [2]. He stated, "*…….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…….. 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 inguinal as the renal calculus passes through the ureter and moves towards the bladder…… 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…… The urine stops either because the kidney lacks it and the sign of this is the stoppage of urine and no heavy pains in the back and not in the loin, ureter, and bladder, any discomfort and not at the bladder neck, any cause of obstruction as we will show and together with this, the abdomen is lax and in the body, there is swelling and dropsy or profuse sweating. Or urine is within the kidney which is obstructed, and in it, the lesion which is swelling or stone or clots of blood or pus. Common to all of them is the pain in the lumbar region with emptiness of the bladder. But if it be a stone, the signs of the stone would appear before that. And if it be a hot swelling, with the pain, there is some throbbing. And if it be diseases in the kidney, then it is only heaviness. And if it be a solid swelling, the urine does not stop suddenly but gradually and with heaviness only. And if it be clots of blood or pus, then it would be preceded by ulcer. And if the urine is stopped because of the urinary passages from the kidney, the bladder will be empty and the pain in the ureter along its course with pricking and stitching as the ureteric pain is continuous and pricking, after this, use the previous criteria as in the kidney. ……..and the differentiation between kidney calculi and renal obstruction or pyelonephritis is that; with inflammation, (there are) mixed fevers, rigors, and polyuria with frequency; with obstruction, (there is) oliguria and the urine is clear and with stones, the urine is either clear or not and with sandy sedimentation..……...Do not lie long on your back. Avoid cheese, milk derivatives, especially fresh cheese, hard-boiled eggs, unleavened bread. Use diuretics— cucumbers (Cucumis sativus* L.*), melons (Cucumis melo* L.*), figs (Ficus carica* L.*), grapes (Vitis vinifera* L.*), and crystal — clear water from natural sources. …… Sedatives for renal colic attacks are useful and after the pain had subsided, a number of herbal remedies including wormwood (Artemisia absinthium* L.*), birthwort (Aristolochia clementis* Alain.*), and pepper (Piper nigrum* L.*) to help calculi's expulsion. Juice of radish leaves (Raphanus sativus* L.*), caper (Capparis spinosa* L.*), Prunus mahaleb* L.**,** *water of soaked chick peas* **(***Cicer arietinum* L.*) and bitter almonds (Prunus amygdalus var. amara* (DC.) Focke.*) are effective for breaking the calculi. This recommendation of "diet, hydration, and diuresis" is what is currently advised for patients with urinary calculi.……During such times (having kidney calculus), the frequency of bathing and the number of times that one enters Khazineh (A big bathtub full of hot water) should be increased, prescriptions should be followed and medications should be used. If such orders be followed consistently, the patients will not feel the pain and before its complete formation, calculus will be broken into small pieces and pain will not be intensified.……After getting out of bath or Khazineh, the patient should be ordered to move and jump around incessantly and for a long duration of time. Having done this, the patient should enter Khazineh again and stay there till the time he feels that the pain has been displaced and it is running down the inguinal"*. Al-Razi for the first time introduced preoperative preparation of the patient by an enema and meatotomy for impacted urethral calculi. He wrote, "*Because stools 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 empty out its content, feeling the stone and also abdominal palpation (suprapubic abdominal palpation) becomes easier.……If a stone is impacted in the tip of the urethra be aware not to force it out by pushing as this causes laceration and subsequent severe pains and infections, but incise the end of the penis and remove the stone"*. He further stated, "*Urine mirrored the circulation in the urinary system"*. He observes physical characteristics of urine and draw clinical decisions from its appearance in those days, when new laboratory analyses for urine examination were not available. He used to scrutinize 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. Al-Razi believed that pain becomes worse when the calculi are passing through the ureters; otherwise, patients just "*feel heaviness in the flanks"*. Differential diagnoses between colitis and renal colic and between kidney and bladder calculi were very clearly made by him [7, 12]. The contribution of Al-Razi in the field of medicine and surgery for the management and treatment of urolithiasis is highlighted in table-1 & 4.

Abubakr Al-Akawayni Al-Bokhari

In *Hidayat al-Mutallimin fi-al-Tibb* about urolithiasis and its management he stated, "*Now I mention the chapter on urine obstruction, which could be from the kidney or from the bladder also, or ureters, or penile duct (urethra), and the one that is from the urethra could be due to the stone, tissue overgrowth, inflammation, blood clot, or pus. Now I describe them one by one. But urine obstruction when it is from the ureters, manifests in (a way) that the bladder is empty and devoid of urine, and there is heaviness in the back. And if the obstruction is in the penis, its sign is that the bladder is full, and also, if the stone is in the bladder. And if the stone is in the kidney, the bladder is empty. Remember these rules for not making mistakes. And when the bladder is full, on palpation it*

appears like an inflated bag, and the pain is severe, the bladder is stretched, and this pain may extend to the scrotum. The (obstruction) of the urethra, may be due to the stone, which I have already mentioned its treatment, or from (granulation) tissue grown within the urethra following its ulceration, or from a wart like the one that appears on the skin, and its treatment is difficult. Its sign is that the urine flows scanty, (but) as time passes, the urine decreases until it completely ceases. For treatment, put (the patient) in water tub and use softener pomades (pomades made with fatty ingredients to hold the drug) and rub the oil of Cruciferae (Brassica spp.*) until urine starts to come out and the duct (ureter) becomes dilated. When (the obstruction) is not at the ureters but in the urethra, it could be cured with the ''Mabowleh'', which is a hollow pin made of silver or gold or brass over the head of which are many holes resembling a lance ……..It is possible for the urinary obstruction to be due to a stone lodged at the bladder outlet. Its sign is that when the patient lies down on their back, and elevates the feet and wags them, the stone is dislodged and the urine comes out. Its treatment is with those agents that bring the stone out of the bladder, which I will mention in the chapter on the bladder stone. It is possible for urine retention to be secondary to the bladder weakness when its expulsive force is decreased, the sign of which is that if you put your hand on (the bladder) and compress it, the urine comes out …….. Again when the bladder is full, avoid using the diuretic agents as it brings death. Again, when the stone is in the bladder this is more common in children, while in the elderly it occurs in the kidney, the signs are that the urine is white and of a fair appearance and when (the patient) wants to urinate, penile erection occurs, and in such a child the penis is mostly erect. He scratches the base of the penis. The pain is so severe and occasionally, the (penile) base may be pulled off from the extensive scratching. When the bladder is full, the patient lie on his back and elevate his legs and shakes them, urine comes out. And this stone has several types: one type is soft and is removed with medications, and another is hard and is not removed with medications. For one month, treat (the patient) with medicines, may be (the stone) is abated, unless (the patient) develops hectic fever and dies. If so, and you treated for one month, (but the stone) does not come out, now you must handle (it) with iron and apply those things that bring the stone out as I mentioned previously…….. 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* L.), *leaves of marsh-mallow* (*Althaea officinalis* L.), *chamomile* (*Anthemis nobilis* L.), *dwarf yellow* (*Astragalus hamosus* L.), *fenugreek* (*Trigonella foenum-graecum* L.), *flaxseed* (*Linum usitatissimum* L.), *seed of mingwort* (*Artemisia absinthium* L.), *and starthistle* (*Centaurea calcitrapa* L.) *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* L.), *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……..If the stone lodges in the penis, its sign is that of penile pain. If so, (the penis) must be sucked with the mouth to expel (the stone), or (the patient must) put the penis in the warm water and massage it to expel (the stone) and even have marsh-mallow (Althaea officinalis* L.*) decoction and violet oil (essential oil extracted from the flowers of Viola odorata* L.*) instilled in the urethra and milked outward to expel the stone. If the stone is large or lodged transversely and cannot be expelled then an incision (of the urethra) has to be made to extract the stone. And again those single medicines (used) for the extraction of stone are that I mention: Jews' stone (Lapis Judaicus) grinded in clean water and three Deram-Sang (37.5 gram) of it consumed, root of cumin (Cuminum cyminum* L.*), scholopendriun* (*Asplenium scolopendrium* L.*), seeds of caper (Capparis spinosa* L.*), capillaire* (*Adimantum capillus-veneris* L.*), round cypress (Cyperus rotundus), root of star-thistle (Centaurea calcitrapa* L.*), caraway (Cuminum carvi* L.*), seeds of melon (Cucumis melo* L.*), seeds of cucumber (Cucumis sativus* L.*), seeds of pentaphyllum (Gynostemma pentaphyllum* (Thunb.) Makino.), *and beetroot (Beta vulgaris* L.*) concentrate; these drugs are the first line (medications). And ground pine (Teucrium chamaepitys* L.*), dittany (Marrubium pseudodictamnus* L.*), herb ivy (Ajuga iva* (L.) Schreb.*), decoction of black pea (Lathyrus niger* (L.) Bernh.*), asparagus root (Asparagus officinalis* L.*), Indian Djatrah (?), crown of the root of agrimony (Agrimonia eupatoria* L.*), seeds of radish (Raphanus sativus* L.*), and …… these drugs are stronger, and the strongest of them is beetle (Cantharidae), but care should be taken as it could lead to bladder ulceration. Now that I gave the guidelines (for treatment), I proceed to pay attention to stone prevention. As it is known that the etiologies of stone are concentrated materials, natural heat, and obstruction in the ducts, I have to mention, briefly highly concentrated foods like... fresh fruit, and cow and camel meats,…… and everything that is concentrated should be avoided, particularly fresh cheese..……..And also the use of those drugs that dilate the urinary duct like the seed of melon (Cucumis melo* L.*), cucumber (Cucumis sativus* L.*), white cucumber (Cucumis anguria* L.*), seeds of marsh-mallow (Althaea officinalis* L.*), seeds of sweet squash (Cucurbita maxima* Duchesne.*), and…… is recommended* [12, 13]".

Al-Zahrawi

He shared a number of specially designed practically applied surgical equipments (Table-4) for urolithiasis management, which provided the basis to develop modern surgical equipments later on.

Ibn Sina

In Al Qanoon Fit Tibb, he shared very important data about anatomy and physiology of renal system, pathophysiology of urolithiasis, surgical treatment and natural medicines for the management and treatment of urolithiasis. He pointed the epidemiology of bladder calculi 10 centuries ago at the time, there were no radiological or ultrasonographic facilities. It was so accurately as compare to modern urology findings. In chapter 5 of part 19 book III he stated, "*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……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" [7]. Ibn Sina shared a number of simple and compound herbal formulations, animal and mineral drugs as well as surgical techniques for the management and treatment of urolithiasis (Tables 1- 4)**.** Some important points about symptoms, diagnosis and treatment of renal calculi, in part 19 of book III are as follows [2, 14]:

I. The diagnosis of kidney diseases is based on a detailed examination of the urine.
II. Thirst, leg edema, oliguria, polyuria, dysuria, enuresis, retention, and hematuria as signs of kidney disease.
III. Renal calculi are usually associated with impaired function of the kidneys, obstruction, inflammation of the urethra or bladder, and excessive heat within the urinary tract.
IV. Renal calculi are caused by coalescence of phlegmatic material, sticky mucus, pus, and rarely, bloody material around a dense core particle.
V. Heavy foodstuff, dairy products, sour fruit, unclear water, and dark juices could increase the risk of renal calculi. Constipation could be a risk factor for kidney calculi.
VI. Bladder calculi are less in common women than men as the bladder outlet is less tortuous, shorter and wider.
VII. Dysuria is more common with small calculi, because the calculi may obstruct the opening of the bladder and the patient may urinate unconsciously, rub the tip of the penis, and urinate again because the bladder is irritated.
VIII. Pain is worse when calculi are formed or during the passage of the calculi to the bladder, otherwise patients feel heaviness in the flanks.
IX. Overeating makes pain worse, and after defecation, the pain will be reduced.
X. The treatment strategy for kidney calculi is the elimination of materials with the potential to form calculi, breaking the calculi and removing the gravel by urine.
XI. After lithotripsy, the remaining calculus fragments in the bladder even if very small, could act as a nidus and grows and forms large calculi again.

He further shared that pharmacotherapeutic regimen must contain 6 actions to obtain optimal results for urolithiasis management [14].

I. Calculus dissolving and destructing drugs: These are categorized into four groups. First: drugs acting on small and soft gravel; Second: affect kidney calculi, but do not have suitable effects on bladder calculi for example Hajrul Yahud (Jew's stone). Third: drugs mainly affect kidney calculi and have some benefits on bladder calculi. Fourth: drugs with dissolving effect on both kidney and bladder calculi, like *scorpion ash.*
II. Drug targeting agents for kidney calculi for example, black pepper fruit (*Piper nigrum* L.), pennyroyal leaves (*Mentha pulegium* L.), and cinnamon bark (*Cinnamomum verum* J. Presl.).
III. Drugs needed to maintain antiurolithiatic medicines at the site of action and concentrate in the kidney. These drugs usually are highly viscose and sticky. Examples are the gums of polypody of the Oak *(Polypodium vulgare* L.) and Persian walnut (*Juglans regia* L.).
IV. Strong diuretics are needed to pass gravel, which remain from calculus destruction.
V. Drugs behave as kidney tonics are needed as calculi usually cause some harm to the kidneys. Spikenard (*Nardostachys jatamansi* (D.Don) DC.), ginger (*Zingiber officinale* Roscoe), iris (*Iris* × *germanica* L.), centaurea (*Centaurea cyanus* L.), fruit of vitex (*Vitex agnus-castus* L.), burra gokhru (*Calotropis gigantea* (L.) Dryand.), pomegranate (*Punica granatum* L.), camel grass (*Cymbopogon schoenanthus* (L.) Spreng.), damask rose (*Rosa* × *damascena* Herrm.), sandalwood (*Santalum album* L.), and cassia (*Cinnamomum cassia* (L.) J.Presl.), used in formulations.
VI. Drugs to control pain or sedatives during colic attacks, helped to move the calculi once the pain had subsided. These drugs included *opium* (*Papaver somniferum* L.), flax (*Linum usitatissimum* L.), turkish pine (*Pinus brutia* Ten.), hazel (*Corylus avellana* L.), and marshmallow (*Althaea officinalis* L.).

Ibn Zuhr

In *Kitab al Tasir* he described, how to detect a tendency of kidney stone formation in normal person? and surgical procedure for litholysis. However he stressed the importance of diet for urolithiasis management. About urolithiasis diagnosis and surgical treatment he stated: *"Whenever you see, in a healthy individual, that his urine turns thin, looking like water you must fear the possibility of him forming stones…….. And if a fine probe is introduced, in the urethra, till it reaches the stone and the probe is of the finest caliber, with a tiny piece of diamond-stone fitted to its end; that diamond upon touching into the stone will lead to its crushing* [15]".

Muhadhdhab Al-Deen Al-Baghdadi

In his book *Al Mukhtar Fi Al Tibb* wrote about kidney stone disease. He stated, "*Stones in the kidney arise, more commonly, in aged men, while those in the bladder occur more in boys……. It may even form in children who are still breast fed; that is because of excessive curdling effect of their mother's milk; and the stone reaches large size in their bladder. We have seen some of those stones which are comparable to a medium sized truffle……. Most of those with kidney stones are obese and most of those with bladder stones are slim. And it is infrequent for stones, particularly those in the bladder to occur in women or girls……The pain from a kidney stone may be suspected by unskilled physicians as being of colonic origin (Qawalang) and we shall mention how to differentiate in between……..Use the medicaments that crumble and disintegrate the stone together with those that help extruding it out. And here are some simple drugs that can be used to achieve stone passage. Some of them act by: crumbling (disintegration); some by lubricating; some by enhancing the effect of the used medicaments; some by conveying the medicament to the organ; some by strengthening the organ and some by nullifying the pain…….. (list of 70 simple and 13 compound drugs)……. Take light meat such as of birds (poultry) and avoid different types of milk and soft cheese* [9]." His point of view about surgical management of renal stones is noted in table-4.

Al-Baitar

In *Al Advia Wal Aghdia*, he mentioned number of medicinal plants for urolithiasis management (Table-1).

Al-Antaki

In *Tadhkirat Uli l-al-Bab-wa l-Jami li-L-'Ajab Al-'Ujab*, he shared different mineral and animal drugs used against urolithiasis (Table-3).

Conclusion

The presented historical vistas of Greco-Arabic contribution are not complete. There is plenty to be done. Much more efforts are still needed to fill this wide literature gap and to restore the missing continuity in the management of urolithiasis either in the form of natural medicines and surgical management. Sincere group efforts are required to encourage and publish the missing link of Greco-Arabic contribution.

Table-1: List of medicinal plants used by Dioscorides, Pliny the Elder, Ibn Sina and Al-Baitar against renal stones.

Plants	Dioscorides (*De Materia Medica*) [4, 16, 17]	Pliny the Elder (*Naturalis Historis*) [16]	Al Razi / Rhazes (*Al-Hawi fi al-Tibb*) [12]	Ibn Sina (*Al Qanoon Fit Tibb*) [14]	Al-Baitar (*Al Advia Wal Aghdia*) [18]
	Part used (mode of preparation) and effect(s) mentioned in books				
Acanthus mollis L.	Wp(NDF)DI	-----	-----	-----	-----
Achillea ageratum L.					
Acinos alpinus Moench.					
Acorus calamus L.	-----			Ro(NDF)DI	
Adiantum capillus-veneris L.	Wp(NDF)LL, DY			Wp(NDF)LL,ES	
Ajuga chamaepitys (L.) Schreb.	-----				
Alcea officinalis L.*				Fr / Ro(Dec)LL, ES	
Alisma plantago-aquatica L.				Wp(Dec)useful in kidney stones	
Allium cepa L.	Bl(NDF)DI			-----	
Allium porrum L.	DI				
Allium sativum L.	Bl(NDF)DI	-----			
Althaea officinalis L.	Le / Ro (NDF)DI, DY			Fr / Ro(Dec)LL, ES	Ro(NDF)LL
Amomum subulatum Roxb.	-----			-----	FrRn(NDF)LL
Amygdalus communis L.	Se(NDF)DI				-----
Anethum graveolens L.					
Anthemis chia L.	Ro(NDF)DI, LL				
Apium graveolens subsp. *rapaceum* (Mill.) P.D.Sell.	Ro / Se(NDF)DI				
Artemisia absinthium L.	Le(NDF)DI		Le(NDF)ES	Wp(NDF)LL, ES	
Artemisia abrotanum L.	-----		-----	Fr(NDF)LL	
Artemisia arborescens (Vaill.) L.	Ap(NDF)LL			-----	
Artemisia campestris L.	Le(NDF)LL				
Artemisia herba-alba Asso.	Wo(NDF)DI				
Artemisia vulgaris L.	-----	-----		Wp(NDF) LL	
Asarum europaeum L.	Fr(NDF)DI			-----	
Asparagus racemosus Willd.	-----			Ro(NDF) LL, ES	
Asphodelus spp.	Ro(NDF)DI			-----	
Aster tripolium L.	-----			Fr(NDF)LL	
Astragalus boeticus L.	DI			-----	
Astragalus gummifera Labill.	Re(NDF)DI				
Aristolochia clementis Alain.	-----		Wp(NDF) ES		
Athamanta cretensis L.	Se(NDF)DI	-----	-----		
Athamanta macedonica (L.) Spreng.					
Berula erecta (Huds.) Coville.	Ap(NDF)DI, LL				
Brassica cretica Lam.	Se(NDF)DI				
Brassica oleracea L.				Fr(Ash)LL	
Bryonia alba L. / *Bryonia dioica* Jacq.	Wp(NDF)DI			St(NDF)LL, ES	
Bunium ferulaceum Sm.	DI			-----	
Cachrys ferulacea (L.) Calest.	Wp(NDF)LL, STN				
Calamintha officinalis Moench.	Wp(NDF)DI				
Cannabis sativa L.	-----			Fr(NDF) LL, ES	
Capparis spinosa L.	Wp(NDF)DI		Wp(NDF)LL	-----	
Carum carvi L.	Fr(NDF)DI				

Carum copticum (L.) Benth. & Hook. f.	-----			Fr(NDF) LL, ES	
Caucalis grandiflora L.	Wp(NDF)DI				
Cedrus deodara (Roxb. ex D.Don) G.Don.		-----			Lx(NDF)LL
Ceratonia siliqua L.	-----	Wp(NDF)DI			
Ceterach officinarum Willd.	Wp(NDF)LL, STN	-----			
Cicer arietinum L.	Fr(NDF)DI	DI	Fr(Infu)LL	-----	
Cinnamomum aromaticum Nees. / *Cinnamomum cassia* (L.) J.Presl.	Ba / Le(NDF)DI	-----		Ba(NDF) LL, ES	
Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	Le (NDF)DI				
Cistus creticus L.	Wp(NDF)DI				
Citrullus lanatus (Thunb.) Matsum. & Nakai.	Se(NDF)DI			-----	
Cnicus benedictus L.		-----	-----		
Commiphora gileadensis (L.) C.Chr.	Wp(NDF)DI, DY				
Commiphora mukul (Hook. ex Stocks) Engl.				Gum(NDF) LL, ES	
Costus arabicus L.	-----			Oil of roots(NDF) LL, ES	-----
Crataegus azarolus L.				Fr / OlGmRe (NDF)LL, ES	
Crocus sativus L.	Stg(NDF)DI			-----	
Cucumis melo L.	Se(NDF)DI			Se(NDF)DI, ES	
Cucumis sativus L.			Fr(NDF)DI		
Cuminum cyminum L.	-----	Fr(NDF)DI			Fr(NDF)LL
Cupressus sempervirens L.	Cn / Le (NDF)DI			-----	
Cydonia oblonga Mill.	Fl / Fr (NDF)DI				
Cymbopogon schoenanthus (L.) Spreng.	Wp(NDF)DI			Inf(NDF) LL, ES	
Cynodon dactylon (L.) Pers.	Wg(NDF)LL, Dy			Wg(NDF)LL, ES	
Cynara scolymus L.	-----			Ro(NDF) LL, ES	
Cyperus rotundus L.	Ro / Ri (NDF)DI, LL			Fr / Ro(NDF) LL, ES	
Daucus carota subsp. *sativus* (Hoffm.) Arcang.		-----	-----	-----	
Diospyros ebenum J.Koenig ex Retz.	DI			Wo(NDF)LL	
Dolichos biflorus L.				Se(NDF)LL	
Dracunculus vulgaris Schott.					
Elettaria cardamomum (L.) Maton.	Se(NDF)LL, DY			-----	
Equisetum sylvaticum L.	Wp(NDF)DI				
Eruca sativa Mill.	Se(NDF)DI				
Eryngium planum L.	Wp(NDF)DI				
Ferula persica Willd.	-----	-----		OlGmRe(NDF)LL	
Ficus carica L.	Fr(NDF)DI			-----	
Foeniculum vulgare Mill.				Fr(NDF)LL	
Gypsophila struthium Loefl.	-----			Ro(NDF)LL	
Hordeum vulgare L.	Sh(NDF)DI				
Hypericum coris L.	Se(NDF)DI				
Hypericum olympicum L.	DI, DY				
Hypericum triquetrifolium Turra.	DI	-----		-----	
Inula helenium L.	Wp(NDF)DI				
Iris pseudacorus L.	Ri(NDF)DI, STN				
Juniperus communis L.	Fr(NDF)DI		-----		
Laburnum anagyroides Medik.	Wp(NDF)DI				
Lagoecia cuminoides L.	LL, STN				-----
Laurus nobilis L.	Ba / Ro (NDF)LL			Ba / Ro(NDF)LL	
Lawsonia inermis L.	-----			Ro(NDF) LL, ES	
Lepidium latifolium L.	Wp(NDF)DI			-----	
Levisticum officinale W.D.J.Koch.	-----			Fr(NDF)DI	
Lithospermum officinale L.	Wp (NDF)DI, LL				

Lonicera etrusca Santi.	Fl / Le (NDF)DI	-----		-----	
Malva sylvestris L.	Le(NDF)DI				
Matricaria chamomilla L.	-----			Fl(NDF) DI, ES	
Medicago sativa L.				Ro(NDF) LL, ES	
Mentha longifolia (L.) L.	Le(NDF)DI			-----	
Mentha pulegium L.	-----	-----		Wp(NDF) LL, ES	
Myrtus communis L.	Le(NDF)DI				
Nardostachys grandiflora DC.	Ro(NDF)DI				
Nardostachys jatamansi (D.Don) DC.					
Nasturtium officinale R.Br.	Wp(NDF)DI	-----		-----	
Nigella sativa L.	Se(NDF)DI			Se(NDF)useful in renal stone	
Ocimum basilicum L.	Wp(NDF)DI	-----		Wp(NDF)ES	
Olea europaea L.	-----	Le(NDF) DI			
Ononis antiquorum L.	Wp(NDF)DI, LL				
Origanum heracleoticum L.	DI				
Orlaya grandiflora (L.) Hoffm.	Wp(NDF)DI			-----	
Paeonia officinalis L.	-----			Fr(NDF) useful in children renal stones	
Paliurus spina-christi Mill.	Ap(NDF)DI, LL				
Panicum miliaceum L.	Se(NDF)DI				
Parnassia palustris L.	Wp(NDF)DI				
Pastinaca sativa L.	Ro(NDF)DI			-----	
Peganum harmala L.	-----			Fr(NDF) LL, ES	
Petroselinum crispum (Mill.) Fuss.	Fr(NDF)DI			Wp(NDF) LL, ES	
Peucedanum grande C.B.Clarke.	-----			Fr(NDF)DI	
Physalis alkekengi L.	Fr(NDF)DI				
Phoenix dactylifera L.					
Pimpinella anisum L.	Wp(NDF)DI			-----	
Pinus eldarica Medw.	-----			Fr(NDF)stops the formation of stones in bladder	
Pinus halepensis Mill.	Le(NDF)DI			-----	
Piper cubeba L.*	-----			Fr(NDF)ES	
Piper nigrum L.	Fr (NDF)DI		Fr (NDF)ES	Fr(NDF) LL, ES	
Pistacia lentiscus L.	Ap(NDF)DI			-----	
Pistacia palaestina Boiss.	Le(NDF)LL				
Pistacia terebinthus L.	Ap(NDF)DI				
Polygonum aviculare L.	Wp(NDF)DI			Wp(NDF)LL, ES	
Populus alba L.	Ba / Le (NDF)DI			-----	
Potentilla reptans L.	-----	-----		Ro(NDF)LL, ES	
Prunus amygdalus var. amara	-----		Se(NDF)LL, DY	-----	
Prunus amygdalus var. *dulcis* (Borkh. ex DC.) Koehne.	Se(NDF)LL, DY				
Prunus cerasus L.	-----			Fr(NDF) LL, ES	
Prunus virginiana L.				Fr(NDF)useful in urinary stone	
Prunus avium (L.) L.	Fr(NDF)LL			-----	
Prunus mahaleb L.	-----	-----	LL		
Raphanus raphanistrum L.	Se(NDF)DI		-----		
Raphanus sativus L.	Le(NDF)DI		Le(Ju)LL	Fr(NDF)LL, ES	
Rubia tinctorum L.	Ro(NDF)DI			-----	
Rubus fruticosus L. ex Dierb.	-----			Fr / Fl / Ro(NDF) LL, ES	
Rumex acetosella L.	Ro(NDF)LL			Ro(NDF)LL	
Ruscus aculeatus L.	Fr / Le(NDF)DI, LL, STN				
Ruscus racemosus L.	Ro / Ri (NDF)DI				
Ruta chalepensis L.	-----	Le(NDF)DI			
Ruta graveolens L.	Le(NDF)DI				
Salvia divinorum Epling & Játiva.	Wp(NDF)DI				
Saponaria officinalis L.	Ro(NDF)DI, LL				
Satureja thymbra L.	Ap(NDF)DI				

Saussurea costus (Falc.) Lipsch.	Ro(NDF)DI				
Scandix pecten-veneris L.	DI			-----	
Scolopendrium vulgare Sm.	-----			Le(NDF)LL	
Scilla bifolia L.	DI				
Serapias lingua L.					
Smyrnium olusatrum L.	Wp(NDF)DI				
Stachys officinalis (L.) Trevis.					
Tanacetum parthenium (L.) Sch.Bip.	Ro(GmRe) (NDF)LL			-----	
Teucrium polium L.	-----			Wp (NDF)LL, ES	
Teucrium scordium L.	Ap(NDF)DI				
Thymus serpyllum L.				-----	
Tribulus terrestris L.	Fr / Le (NDF)LL			Fr / Ro (NDF) LL, ES	
Trigonella foenum-graecum L.	-----			Fr(NDF) LL, ES	
Tripolium pannonicum (Jacq.) Dobrocz.	DI	-----			
Triticum repens L.	Ro(Dec)LL			-----	
Umbilicus rupestris (Salisb.) Dandy.	LL				
Urginea maritima (L.) Baker.	DI				
Urtica dioica L.					
Valeriana celtica L.					
Valeriana wallichii DC.	-----			Ro(NDF)DI	
Vicia ervilia (L.) Willd.	DI, DY			-----	
Vigna unguiculata (L.) Walp.	Se (NDF)DI			Fr(NDF)DI	
Vitex agnus-castus L.	-----			-----	
Vitis silvestrii Pamp.	DI				
Vitis vinifera L.	Fr(NDF)LL		Fr(NDF)DI		

Keys: Ap= aerial part; Ba=bark; Bl= bulb; Cn=cones; Dec=decoction; DI=diuretic; DY=dysuria; ES= expel stones; Fl= flower; Fr= fruit; FrRn=fruit rind; GmRe=gum resin; Inf=inflorescence; Infu= infusion; Ju= juice; Le= leaf; LL= litholytic; Lx=latex; NDF= no data found; OlGmRe=oleo gum resin; Re=resin; Ri= rhizome; Ro= root; Se= seed; Sh=shoot; St=stem; Stg=stigma; STN= strangury; Urinary stones= kidney and bladder stones; Wg= whole grass; Wo=wood; Wp= whole plant; *= plants not found in the electronic database. The Plant List - a working list of all plant species created by Royal Botanical Gardens, Kew and Missouri Botanical Garden.

Table 2: Compound formulations used by Ibn Sina for urolithiasis management.

Antiurolithiatic formulations shared in Al Qanoon Fit Tibb [14, 19]	**Effects mentioned in the book**
Amygdalus communis var amara L. (fruit oil) + *Iris germanica* L. (roots)	Litholytic
Arnebia euchroma L. (root decoction)+ Hydromel	Useful in kidney stones
Carum carvi L. (fruit) + *Olea europaea* L. (olive oil)	Litholytic and expel renal stones
Cicer arietinum L. (fruit decoction of black chickpea variety) + *Prunus dulcis* (Mill.) D.A.Webb. (almond oil)+ *Raphanus sativus* L. (root) + *Apium graveolens* L. (seeds)	
Scilla indica Roxb. (bulb)+ Oxymel	
Tanacetum parthenium (L) Sch Bip. (flower) + Oxymel	Litholytic for bladder stones
Acorus calamus L. (rhizome)+*Apium graveolens* L. (seeds) + *Carum carvi* L. (fruit) + *Cinnamomum cassia* (L.) J.Presl. (bark) + *Commiphora myrrha* (Nees) Engl. (secretions through natural fissures of stem)+ *Commiphora opobalsamum* (L.) Engl. (wood) + *Crocus sativus* L. (stigma)+ *Cuminum cyminum* L. (fruit) + *Cymbopogon jwarancusa* (Jones) Schult. (whole plant)+ *Laurus nobilis* L.+ *Piper longum* L. (fruits) + *Piper nigrum* L. (fruit) + *Portulaca tuberosa* Roxb. (seeds) + *Saussurea hypoleuca* Spreng. ex DC.+ Honey	Diuretic, lithotriptic

Keys: Hydromel= drink made with water mixed with yeast and honey; Oxymel =mixture of honey and vinegar; Litholytic= agent which dissolves or break stones; Lithotriptic= agent which causes binding inhibition among particles to form stones and stop further stone growth.

Table 3: Animal and mineral drugs used by Ibn Sina and Al-Antaki for urolithiasis management.

Animal drugs	**Effects mentioned in books**
Ibn Sina (*Al Qanoon Fil Tibb*) [14]	
Columbidae (smoke of pigeon feces to urinary tract)	Litholytic and expels renal stones.
Erinaceinae (spines of hedgehog)+ Frankincense	Expels renal stones.
Equus hemionus Pallas. (urine of Asian Wild Ass)	Litholytic for bladder stones.
Gallus gallus domesticus L. (ash of hen egg shell)	Litholytic and expels renal stones.
Lumbricus terrestris (whole common earth worm) + Frankincense	Diuretic and expel stones
Oryctolagus cuniculus (ash of whole rabbit)	Litholytic and expel renal stones.
Mus L. (ash of mouse stool)	
Scorpion (ash of whole scorpion)	
Al-Antaki (*Tadhkirat Uli l-al-Bab-wa l-Jami li-L-'Ajab Al-'Ujab*) [18]	
Echinoidea (petrified spines of sea urchin)	Litholytic
Otis tarda L. (Bustard's stomach and ashes from its feathers and claws)	
Mineral drugs	**Effects mentioned in books**
Ibn Sina (*Al Qanoon Fit Tibb*) [14]	
Glass (powdered and burnt)	Litholytic and expel renal stones.
Hajrul Yahud (Jew's stone)	
Natron (naturally occurring mixture of sodium carbonate decahydrate, sodium bicarbonate along with small quantities of sodium chloride and sodium sulfate)	
Al-Antaki (*Tadhkirat Uli l-al-Bab-wa l-Jami li-L-'Ajab Al-'Ujab*) [18]	
Hajrul Yahud (Jew's stone)	Litholytic and expels renal stones.
Frankincense = an aromatic resin obtained from trees of *Boswellia sacra*	

Table 4: Historical glimpses of surgical management for renal stones.

Year	**Contributors**	**Contribution(s)**
5000-3500 BC	Ancient Mesopotamia	No evidence of surgical treatment for urinary stones [3].
3100-1650 BC	Ancient Egypt	No evidence of surgical treatment for urinary stones [20].
460–377 BC	Hippocrates	Described symptoms of bladder stones in *Oath of Medical Ethics* for physicians. A bronze S-shaped catheter with 1 terminal eye and size proportionate to age and sex was common in Hippocratic period [21, 22].
276 BC	Ammonius of Alexandria	First person to use the word "*lithotomus*" to refer to cutting or crushing the stone to facilitate its removal; He fixed the calculus with a hook and then crashed the calculus using a thin blunt-ended instrument [2, 21].
Around 600 BC	Sushruta (surgeon of ancient India)	In *Sushruta Samhita* he described over 300 surgical procedures, including *perineal lithotomy* for those who suffered from severe and ongoing colicky pain for a long time; reported infection, anuria, and uremia as complications of urolithiasis [2, 21].
25 BC–40 AD	Cornelius Celsus (Rome)	Described perineal lithotomy *Operation Minor* or *Petit Appareil* in his book *De Medicina* [21].
23–79 AD	Calus Plinus Secundus (Greek physician)	Practiced lithotomy, basically as described by Celsus [21].
131–200 AD	Galen (Greek physician)	
625–690 AD	Paul of Aegine (Greek physician)	
864–930 AD	Al Razi / Rhazes (Greco-Arabic physician)	Rhazes used *Almajarrah* (the dragger) an instrument like a small spoon called, and calculus would be scooped out; he also used *Alkalbatain* which was similar to the arrows extractor forceps [12]. In *Al-Hawi Fi-Tibb* he described perineal lithotomy almost in the same manner as that carried out by Paul of Aegine [21]; condemned the operation of cutting on kidney stones but approved it in bladder stones [23]. He for the first time introduced preoperative preparation of the patient by an enema and meatotomy for impacted urethral calculus. Rhazes devised various urological instruments, namely pliable lead urethral catheters, and replaced the traditional openings at the catheter tip with eyelets on the sides. Prior to Rhazes, it was believed that breaking the calculus inside the bladder to facilitate its removal could be dangerous; therefore, it was customary to extract these calculi through large incisions. Rhazes questioned this approach, and prior to Al-Zahrawi, he realized the hazards of resorting to large incisions. He invented a modified technique in which the sides of the calculus were pinched off through a small incision, and after they became small enough, they were removed with al-kalbatain forceps [12].
930–1013 AD	Alzahrawi / Albucasis (Greco-Arabic physician)	Al-Zahrawi was the first one to utilize forceps to remove bladder calculi. Before him, the calculus would be extracted by an instrument like a small spoon called *Almajarrah* (the dragger), and it would be scooped out [12]. Invented a novel lithotomy scalpel, called *Nechil*, with 2 sharp cutting edges ; first to use a tool to confirm the presence of the stone before proceeding with the perineal cystolithotomy operation ; introduced the 2-stage bladder stone operation in complicated cases [21].
980–1037AD	Ibn Sina /Avicenna (Greco-Arabic physician)	Condemned the operation of cutting on kidney stones but approved it in bladder stones by following Al Razi recommendations [23]. Ibn-Sina advised that lithotomy should be reserved for patients in whom the calculus cannot be dislodged by other means; he emphasized perineal urethrostomy. He also described surgery via the transperineal route and warned the surgeon of the proximity of the vasa deferentia, prostate gland, and neurovascular bundle and exposure in this position. He was the first to recommend the use of soft malleable catheters made of leather and silver, should have many

		holes, so that if one becomes plugged, medicine can be injected or urine drained out through the other holes, avoiding withdrawing and reinserting the catheter; used grasping forceps for removal of the bladder calculus and emphasized on removing all calculus fragment; explained a technique similar to the use of a Babcock forceps for prevention of calculus migration; discussed complications of calculus surgery and cystotomy [14].
1117-1213 AD	Muhadhdhab al-Deen Al-Baghdadi (Greco-Arabic physician)	Although he documented lumbotomy and subcostal approach in his book *Al-Mukhtar* but he himself condemned this line of management because of great risk and only approved it in bladder stones [23].
1300–1367 AD	Chauliac(French surgeon)	Combined surgical influences of the Arabs, the Greeks, and his experiences in his book *Chirugia Magma* [21].
15th century	Sabuncuo˘glu Serafettin and Ahi Ahmed Celebi (Turkish physicians)	Described a new technique of transurethral stone fragmentation and bladder irrigation [21].
1510–1590 AD	Par´e (French surgeon)	Invented a bullet forceps (*tire de balles*) [24].
1515-1595 AD	Alphonso Ferri (Surgeon at Naples and Rome)	Invented and used *Alfonsinum*, a 3-pronged pincer with internal toothing for the extraction of bullets from fire-arm wounds [24].
1520 AD	Farncisco de Romanis (French surgeon)	Introduced a sound to identify the bladder neck, and the perineal incision was made onto the sound using a broad knife called *Novacula* [21].
1561 AD	Pierre Franco (French surgeon)	First time removed a calculus by suprapubic lithotomy; modified and transformed *Alfonsinum* into a lithotrite with 4 jaws (*Quadrupulus vesicae*), to remove stones transurethrally [21, 24].
1561-1636 AD	Santorio Santorio (French surgeon)	Designed a lithotripter consisting of a hollow tube and a central rod ending in 3 prongs and a cup [24].
16th century AD	Marianus Sanctus (Italian surgeon)	Used *Marian operation* or *Grand Appareil* technique [21].
17th century AD	Jack De Beaulieu (French surgeon)	Inventor of the lateral lithotomy. Use scalpel, very close in shape to Albucasis / al-Zahrawi scalpel [21, 24].
1651–1714 AD	Jacques de Beaulieu	Introduced *lateral lithotomy* [21].
1719 AD	John Douglas	Realized the possibility of extraperitoneal approach [21].
1722 AD	William Cheselden	
1668–1738 AD	Hermann Boerhaave	Gave the opinion of lithotomy as a last resort when other approaches failed due to the risks of the surgical procedures [21].
1783-1843 AD	Franc¸ois Fournier de Lempdes of Montpellier (French surgeon)	Constructed the *litholept* [24].
1813 AD	Franz von Gruithuisen (French surgeon)	Introduced *Steinbohrer* (stone drill) for *litholept* [24].
1817 AD	Jean Zulema Amussat (French surgeon)	Constructed an instrument consisting of 2 jaws and a ratchet [24].
1822 AD	Leroy d'Etiolles (French surgeon)	Introduced his *lithoprione* (wire-loop basket with rotating cutter) and his *litholabe* by using the principle of *Alfonsinum* [24].
1824 AD	Jean Civiale (French surgeon)	First to carry out a successful transurethral lithotripsy; designed *trilabe* to drill and crush the stone [24].
1803-1876 AD	Joseph Frederic Benoît Charrière (Swiss origin instrument maker)	Inserted a standard gauge system *French sizing* by the help of Jean Civiale for use in medical equipment such as catheters and probes [24].
1869 AD	Gustav Simon	First planned nephrectomy for a fistula [21].
1873 AD	Ingalls	Carried out the first nephrotomy [21].
1874-1876 AD	Henry J. Bigelow of Boston	Developed strong and hard lithotrite introduced into the bladder with balloons aspiration by using anaesthesia, crushed the stones, and evacuated the fragments known as *litholopaxy* [21].
1870-1945 AD	Hugh Hampton Young (French surgeon)	Invented a cystoscopic lithotrite, to viewed stone by inaugurating lithotriptoscope, using Bigelow's lithotrite as a model [24].
1879 AD	Heinecke	First pyelotomy was performed [21].
1881 AD	Le Dentu	First nephrolithotomy was carried out [21].
1887 AD	Czerny	First to suture a nephrotomy incision [21].
1889 AD	Kummel and Bardenheuer	First partial nephrectomies for stone disease [21].
1889-1984 AD	Abraham Ravich	Invented a visual lithotrite with a scissor handle for crushing the stone [24].
1901-1913 AD	Max Brodel	Described the avascular area as safer and easier for removing renal stones than nephrolithotomy [21].
1941 AD	Rupel and Brown	Removed a stone through a nephrostomy [21].
1870–1945 AD	Young and Mckay	Developed the cystoscopic lithotrite; the first person to perform and report ureteroscopy [21].
1924 AD	Crowell	Methodically filled a young cystine stone former's renal pelvis with an alkaline antiseptic lavage of mercurochrome by using a primitive retrograde catheter along with oral sodium bicarbonate for urinary alkalinization for stone lavage. Every alternate day weekly lavages were performed for a total of 10 months until the roentgenogram was clear of stones [25].
1948 AD	Trattner	Used a cystoscope to examine the renal collecting system at open renal surgery [21].
1955 AD	Goodwin *et al.*	The first to place a nephrostomy tube to a grossly hydronephrotic kidney to provide drainage [21].
1965 AD	Gil-Vernet	Introduced intrasinusally *extended pyelolithotomy* [21].

1967 AD	Smith and Boyce	Introduced and popularized anatrophic nephrolithotomy for the treatment of staghorn stones [21].
1974 AD	Fitzpatrick *et al*.	Suggested the combination of extended pyelolithotomy with multiple radial nephrotomies for the treatment of large, complex staghorn stones [21].
1976 AD	Fernstrom and Johannson	Established percutaneous access with specific intention of removing a renal stone [21].
1953 AD	Mulvaney	First investigation of *ultrasound* for the destruction of urinary stones was undertaken [21].
1954 AD	Yutkin	Invented the first modern intracorporeal lithotriptor *Electrohydraulic lithotripsy* [21].
1964 AD	Marshall	First to perform flexible ureteroscopy using a 3mm fiberscope [21].
1977 AD	Kurth	Applied *ultrasound* to renal stones for the destruction [21].
1980 AD	-----	Introduction of the first ESWL machine, Dornier HM-3,which later on used after USDA approval in 1984 [21].
1986 AD	-----	Development of *laser* for the fragmentation of ureteral calculi was initiated [21].
1992 AD	Swiss company	*Pneumatic lithotripsy* approved for the fragmentation of renal, ureteral, and bladder calculi by designed pneumatic device the Lithoclast [21].

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