History of Urinalysis by Razi and Avicenna in Iran and Their Clinical Judgment from Urinalysis

Behrooz Broumand,M.D.,F.A.C.P.
Professor of Medicine IUMS
Permanent member Iranian Academy of Medical Sciences
Past President Iranian Society of Nephrology

Abstract:

Urinalysis (Uroscopy) has been performed by physicians from 500 BC. Evidence of this diagnostic procedure can be found in the works of Hippocrates, Aristotle, Galen and a few others. Liquid Gold described as " one's water used to be considered a divine fluid, a window into the body and soul." [1]
Meanwhile, uroscopy had become a tool in the hands of uneducated people for fortune telling, to the point that Thomas Brian published the book titled "The Piss Prophet", a book against abuses of uroscopy. [2]

Abu Baker Muhammad ibn Zakariyā Rāzī (Rhazes or Rasis, 865 AD-925 AD) and **Abū Alī al-Ḥusayn ibn Abd Allāh ibn Sīnā** (Avicenna 980 to 1037 AD) were amongst a few scientists who pioneered in performing urinalysis in scientific methods very similar to what is customary in the 21st century, except they did not have access to microscopes to examine for the presence of different cells or crystals.
These scientists were not only examining the urine for the detection and diagnosis of renal diseases, but in their interpretation they would also judge the function of other organs and their relation to the quality of urine.

Key words: Iran, History of medicine, Medieval, Ancient, Urinalysis

Preface:

Medical notes, from several thousands years ago, have revealed that examination and observation of urine was the first tool for diagnosis of illness and management of patients. Uroscopy was the term first used for observation and examination of urine. According to available ancient literature Hippocrates (460-377 BC) described uroscopy for the first time. Hippocrates' hypothesis was that urine was filtered from blood through the kidneys [2] After the 6th century Galen (AD 129-200) hypothesized that "urine was manifesting the health of liver, the organ where blood was supposedly produced." [1]
Gradually the importance of urinalysis as an important procedure of laboratory medicine was accepted all over the globe. One problem that started as a result of this was an exaggeration of the importance of uroscopy by unqualified practitioners who were not educated and were practicing uroscopy to make more money not considering the well being of their patients. These uneducated uroscopist were considering urine as more than a water and their claim was that, urine is a divine fluid and indeed a window into the body and the soul. So urine was used by them for divination in ancient Rome. These amateurs who were not educated and had no formal medical training were called "Leches".

History of urinalysis in In Iran:

In the ancient scientific book of Vendidad from the Zoroastrian era in Iran there is evidence cited in different publications that observation of urine was a tool in medicine, and urine was being used by Iranian physicians in ancient time, evidenced by this phrase, "Bull's urine due to high acidity has antibacterial effect". [3] The influence of Uroscopy in ancient Iran is also evident in the Iranian non- medical Literature such as in the Shahnameh of the famous Persian poet Ferdowsi. Dr. Cyril Elgood (1893-1970AD) in his famous book , A medical history of Persia; translated this poem from Ferdowsi :

"Firdausi relates something of medical history of Alexander whilst he was in Persia. He states that an Indian rajah presented him with four gifts: a girl, a philosopher, a magic cup and a physician,

"A youthful leech who diagnose. The disease by making uroscopy. So long he is at the court .The Shah will never ail". [4]

It should be noted that the invasion of Alexander the great dates back to the end of the Achamenide dynasty, which is almost contemporary between the era of Hyppocrates and Galen.

It is interesting that in the quoted poem and several other poems Ferdowsi uses the exact Persian/Farsi term "Sereshk" which means tear, and was translated as Urine?

The exact Farsi version of the poem is included in addendum number 1.

In Middle Ages, urine, as the first bodily fluid to be examined, has been explained in detail by two Iranian scholars **Abu Baker Muhammad ibn Zakariyā Rāzī** (Rhzes or Rasis, 865-925AD) and**Abū Alī al-Ḥusayn ibn Abd Allāh ibn Sīnā** (Avicenna 980 to1037AD), that provided medicine with a large body of information about the functions of kidneys and other organs. The purpose of this presentation is to acknowledge ancient Iranian pioneers in medicine and to compare their approach to diseases and clinical judgment with the modern medicine today.

Abu Baker Muhammad ibn Zakariyā Rāzī :

He was born in Rey city (865AD) (*Razi* in Farsi means from the city of Rey), an ancient city located near Tehran, Iran, and pursued a great amount of his research in the City of Rey.

Razi was the head of the Hospital at Rey (895AD). During the reign of Calif Al-Moktafi(901-907AD), Razi moved to Baghdad and became the manager of Mo'Tazdi hospital. Razi was educated in music, mathematics, philosophy, and metaphysics, eventhough he chose medicine as his profession. Razi did most of his seminal work in the city of Rey, and died in Rey after his return from Baghdad.[5] Razi is the author of many text books, treatise and pamphlets that according to different sources the number of his publications is up to 248.[6]Three of his available books are related to our discussion about history of Urinalysis:

1- The book 'Trait Sur Le Calculi dans Les Teins et dans la Vessie' published in French by P. Koning1896AD available in National Library of Medicine in Paris ,France this was translated in Persian in Tehran, Iran, 2009AD. [7]

2- KITABU'L HAWI FI'T-TIBB (Rhazes Liber Continens)

3- ***LES OBSERVATIONS CLINIQUES***

In his encyclopedia of medicine Kitab Al-Hawi in part 19,there are 64 pages devoted to examination of urine and different varieties of urinary sediment, color and concentration (Consistency). In the first section called "Emergencies in Medicine" (Kitab'ul Buhran=Crisis) Razi explains that "A Urine similar to urine of healthy people indicates that the producer of that urine has competent vessels and circulation", Razi continues to say that if urine is not ripened (less mature and not concentrated)that is indicative of vessels weakness.

Based on his judgment on urine examination one can understand that this medieval scientist was not just an observer of urine, but Razi's contribution was adding medical judgment about physiology and anatomy of the whole body including kidneys while performing urinalysis.

In the book, The kidney and bladder stone, Razi explains that if blood comes out before urine it mean there is an ulcer in urethra. While when urine is red and suddenly patient develops difficulties passing urine it means that there is a clot inside the bladder and in order to help the patient that clot has to be dissolved. [7]

Razi himself acknowledged the contribution of Galen in medical sciences and Uroscopy, but he believed that he had achieved more advancement in examining the urine comparing to Galen's instructions. On this respect in the introduction of Razi's book "Doubts on Galen". Razi first apologizes from Galen by explaining that everyone is aware of Galen's contributions, but as obedience and blind imitation is not permissible in philosophy science and wisdom. If Galen was alive, would have admired my criticism and would have encouraged me to publish my suggestions and criticism to his instructions. For instance I would bring the following statement made by Razi concerning his difference with Galen about urinary sediment: "Galen says in winter time the volume and sediment of urine increases, as the metabolism and ripening of urine is more. In my view the volume is more because there is less sweating in winter but about the sediment I agree with Galen."[8]

Razi suggests, in examination of urine apart from clarity, color, sediment and consistency, it is important to touch and taste the urine. Razi believed that examining the urine should be done following physical examination of the patients, as shown in figure #1. Razi was a clinical practitioner with good knowledge about theoretical science and by observing the color of urine when it was red and if the supernatant was getting clear or not? by checking for the symptom of bladder irritation would diagnose that where the blood is coming from?, upper part or lower part of urinary tract.

By odor of urine and presence or absence of pain and its location the diagnosis of urinary tract infection would have been proposed. Presence of a dark string- like sediment (thin branch of a tree) would indicate that the pathology is outside the kidney (systemic) such as melting and necrosis of muscles, which resembles burning heat, inside the blood and vessels.

Razi was able to predict life style and behavior by examining the urine. For instance, gluttony there result in increase waste product inside the blood, that will be excreted, so urine of gluttonous patient contain plenty of tartar (dregs) sediment. Razi continued with this statement that with exhaustion and starvation, the richly yellow colored urine is bitter. When urine turns black, it carries very poor prognosis .I have not seen anyone with black urine and black urinary sediment who has survived. According to Razi if urine of a patient is clean during urination but turn dark later, patient imminently will develop encephalopathy. [8]

Razi has written case histories of his interesting patients which in several of them the diagnosis was made by examination of the Urine. In case history number six, Razi described a middle aged man who had urinary incontinence and white mucous like threadbare in urine causing difficulties in passing urine. After a complete history, Razi diagnosed that with previous catheterization the bladder was traumatized.[9]

Abū Alī al-Ḥusayn ibn Abd Allāh ibn Sīnā (Avicenna or poore Sina):

'Abu 'Ali al-Husayn ibn 'Abdullah ibn Sina was born in August 980 A.D. in the village of Afshana near Bukhara (980-1037AD). Avicenna had an exciting life involved in Medicine and politics. He never stepped out of Iran and is known as the prince of physicians and a Giant in Pharmacology.

Ibn Sīnā wrote almost 450 treatises on different subjects, of which around 240 are available. Almost 150 of his surviving treatises concentrate on philosophy and 40 of them concentrate on medicine. [5] His most famous works are *The Book of Healing*, a vast philosophical and scientific encyclopedia, and *The Canon of Medicine*,[10] which was a standard medical text at many Islamic and European universities up until the early 19th century. The *Canon of Medicine* was used as a text-book in the universities of Montpellier and Louvain as late as 1650.

In volume 1 pages 312-342 Poore Sina has a chapter describing urinalysis in scientific manner from the very beginning, step by step. He suggested, the urine for examination must be the first voided urine in the morning. The patient should not eat or drink from the night prior to examination .Not to take any food or drug that can change the color of urine such as beetroot or saffron etc. Even external use some coloring material like henna can change the color of urine. Urine should be used for examination if the patients has diarrhea or vomiting. Exhaustion, insomnia and fasting are other conditions that must be avoided.

Urine should be examined as soon as possible after voiding and after six hours it is not useful for examination. Avicenna insisted that urine should be examined in the first hour post voiding. If urine used for examination later the color would change and the foam if present will disappear.

The proper method of examination of urine:

Urine should be voided in a spacious urinal with a wide opening. The examiner should wait enough time for the urine tranquility. The urinal should be kept in a place away from wind, sunshine and not to be too cold or hot. The urinal should be washed clean.

It is known that the first urine gives information about the condition of urinary tract, liver and vessels, and can be used to diagnose systemic diseases.

Ibn Sina considered seven aspects of urine:

1-Color
2-Texture and consistency (Concentration and Dilution)
3-Clarity (Brightness and turbidity)
4-Sediment (Dregs, Tartar or Deposit)
5-Volume
6-Odor (Smell)
7-Foam or froth

1. Color:
Usually the color of normal urine is light yellow. Different shades of yellow to be considered when examining urine: Light yellow (Straw), Citron, golden yellow, orange yellow, fiery yellow (the same color as Saffron or tincture), which is dense yellow also called bright red. Besides the first two shades of yellow that are considered normal, the rest are revealing a warm temperament as a result of hard exercise, painful stimuli, starvation and dehydration. If the red urine has the color of saffron it is mostly due to disease of the gall bladder. If the color of urine is dark red without any cause in the urinary tract, it can be the result of a blood disorder, most likely a manifestation of hemolysis.
After describing other colors, such as green and black and their significance, Abu Ali Sina explains that changes in urine color can indicate the pathology in different parts of the body. There are occasions that change of urine's color is seen in a patient with headache, insomnia, deafness and abnormal mentality. These descriptions can be due to uremic encephalopathy as a result of alport's syndrome.

Predicting the outcome of disease based on the findings in urinalysis, reveals that Avicenna was a great observer and described what he then did not know the exact underlying pathology but later on from his descriptions, others were able to the diagnosis.

2. Texture and consistency (Concentration and dilution):
Urine can be A-Dilute, B-Concentrated, or C-Moderated.

A-Diluted Urine: If urine is too dilute or not concentrated, we should consider one of these four:

1- Immature (not ripened)
2- Occlusion of the vessels (narrow renal blood vessels)
3- Renal failure in febrile children; if urine continues to be very dilute, renal insufficiency is indicated
4- Drinking too much fluid

B-Concentrated urine: if urine is too concentrated, it might be not ripened adequately or thick mucous is being ripened, that will be followed by high grade fever. A concentrated urine in severe illnesses, indicates poor prognosis. If the urine of someone who appears to be healthy became concentrated, it means that soon a fever will develop. In healthy people, a concentrated urine can be due to dehydration.

C-Moderation of urinary concentration means urine is mature and ripened.

3. Clarity (Brightness and turbidity):
A cloudy urine is usually due to renal failure. It is said that if there is a foggy smoky appearance in bottom of urine, the prognosis is poor and usually death will occur after long standing illness.

4. Sediment (Dregs, Tartar or Deposit):
The nature, quality, and quantity of urine are important.

When the nature of a normal dregs is good and desirable, indicates maturity and ripening of urine, it is homogenous, white in color and soft. Occasional in the presence of puss the sediment is white in color, but not homogenous and pulpy (soft).Different bad kind of sediment are lentil form, it is better that this type of sediment be dispersed and not to have plane level. The urine of thin people has less dregs. The discussion about urinary sediment is very long and this was just a small sample of what Avicenna had described in detail.

5-Volume (Quantity of urine):
Low urine output is due to failure of the forces. Any time that the volume of urine is much less than the amount of drinking, it indicates that either there is high fever or diarrhea and vomiting. This statement reveals that Avicenna was aware that dehydration decreases the volume of urine. Avicenna continued to say that "in renal failure, patients develop oliguria and if accompanied by headache, they maybe hypertensive and later on develop encephalopathy."

6-Odor (smell):
In Canon of Medicine, we read "If urine is black but has no odor, this is a sign of cold temperate, when the nature is depressed the urine has no odor." Indeed Avicenna explained that in chronic renal failure urine is like pure foam or froth.

7- Foam or Froth:
Froth in urine is due to a strange indigent large bubble, that depending on the nature of the deposit along with froth indicate different diseases. Today we are aware that if foam n urine persists for a long time, it is indicative of proteinuria.

The rest of the 30 pages of Avicenna's urinalysis devotes to ripening of urine, the urine of elderly and the differences of male and female urine. At the end, Poore Sina describes the urine of animals that is similar to heated oil, and how to distinguish that from the urine of humans.

Of interest is that both Razi and Poore Sina were experts in all branches of medicine. This quotation is proof: "Two reputable Persian medical scholars of the Middle Ages are Razi (Rhazes) and Ibn-Sina (Avicenna). Their most important otorhinolaryngologic contributions based on the relevant data from two major medical books i.e., al-Hawi (Liber Continens) and Qanun fi-Tebb (Canon of Medicine)." [11] Apart from being a great teacher and clinician, Ibn Sina is known for his clinical research. In a recent article in the Annals of Internal Medicine, it was noted: "Ibn Sina proposed applying logic to the testing of drugs, and in doing so, he wrote the earliest known treatise related to clinical trials". [12]

Concluding remarks:

While both Razi and Poore Sina acknowledged the pioneering roles of Hyppocrates and Galen in the field of Uroscopy, by constructive criticism, they were able to improve the technique of urinalysis with their wise innovations. Razi's and Avicenna's major contribution was that by observing the urine they were able to relate it's various characteristics of color, texture, clarity, sediment, volume, odor, and foam to clinical manifestations reached to the conclusion about the significant of the same finding in urinalysis of other patients. Hence, they shared a major role in setting the foundation for modern urinalysis by the examination of urine and their remarkable interpretations.

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Addendum #1:

در شاهنامه ,بزرگ مرد ادب پارسي , فردوسيدر سروده "پادشاهی اسکندر" چندين بار از واژه سرشك
ياد شده است كه بنابر نوشته هاي لغت نامه دهخدا جلد هشتم صفحه 11991 كه در زير آورده مي
شود سرشك ، جايگزين پيشاب مي باشد .
زرشك و آن نباتی است معروف كه بعربی انبرباريس گويندو قاتق آشها كنند و درخت و بوته زرشك
را سرشك گويند .(برهان) . زرشك (انجمن آرا)
(آنندراج) . ادرار . پيشاب . آب بيمار :

سوم آنكه دارم يكی نوپزشك كه علت بگويد چو بيند *سرشك (پيشاب)*

همه بود ینهـــــا بگوید بشاه زگردنده خورشیدو رخشنده ماه
اگر باشد او سالیان پیش گاه ز دردی نه پیچد جهاندار شاه

سردردمندان بدو گفت چیست که بر درد آنکس بباید گریست
بیاموزم اکنون ترا داروئی گیاها فراز آرم از هر سوئی
زدانا ئی او را فزون بود بهر همی زهر بشناخت از پاد زهر
فغستان بباریدخونین *سرشك(اشك)* همیرفت با فیلسوف وپزشك

بدو گفت آنکس که افزون خورد چو بر خوان نشیند خورش نشمرد
که همواره باشي توزاو تندرست نباید بدارد ترا روده سست
ورا خلعت و نیکوئیها بساخت ز دانا پزشکان سرش برفراخت
گیاهاي کوهی فراوان درود بیفکند از او هر چه بیکار بود
چنان بد که روزی بیامد پزشك ز کاهش نشان یافت اند *رسرشك(پیشاب)*

Persian Scholar
Medieval era

European depiction of the Persian physician Rhazes, in Gerard of Cremona's "Recueil des traités de médecine" 1250-1260. Gerard de Cremona translated numerous works by Arab scholars.[1]
Fig#1

Urinalysis consists of whole host of chemical and microscopic tests, and it is a useful screening tool for diseases such as urinary tract infections, renal disease, and other diseases of the body which result in the formation of compounds that can be detected in the urine at abnormal levels. The urinalysis has proven itself as a procedure that can be performed relatively quickly and easily while providing the doctor with lots of useful information.Â Urinalysis is a term used to describe a process used to examine urine using chemical and/or physical means. Clinical urine tests (also known as urinalysis, UA) is an examination of urine for certain physical properties, solutes, cells, casts, crystals, organisms, or particulate matter, and mainly serves for medical diagnosis. The word is a blend of the words urine and analysis. Urine culture (a microbiological culture of urine) and urine electrolyte levels are part of urinalysis. There are three basic components to urinalysis: gross examination, chemical evaluation, and microscopic examination. â€¢ Reveals how Avicennaâ€™s understanding of the â€œhumorsâ€ corresponds directly with the biomedical classes known today as proteins, lipids, and organic acids. A millennium after his life, Avicenna remains one of the most highly regarded physicians of all time. His Canon of Medicine, also known as the Qanun, is one of the most famous and influential books in the history of medicine, forming the basis for our modern understanding of human health and disease. It focused not simply on the treatment of symptoms, but on finding the cause of illness through humoral diagnosisâ€”a method still used in tradi A urinalysis is a group of manual and/or automated qualitative and semi-quantitative tests performed on a urine sample. A routine urinalysis usually includes the following tests: color, transparency, specific gravity, pH, protein, glucose, ketones, blood, bilirubin, nitrite, urobilinogen, and leukocyte esterase. Some laboratories include a microscopic examination of urinary sediment with all routine urinalysis tests.Â The specific gravity of urine is a measure of the concentration of dissolved solutes (substances in a solution), and it reflects the ability of the kidneys to concentrate the urine (conserve water). Specific gravity is usually measured by determining the refractive index of a urine sample (refractometry) or by chemical analysis. Specific gravity varies with fluid and solute intake. The Razi Vaccine and Serum Research Institute is an Iranian pharmaceutical company. It is located in the Hessarak district in Karaj, Iran. The Institute was built as a national center with the purpose of countering epidemics in domestic animals during Reza Shah era. Further departments were installed, including those dedicated to human medicines. In modern years, the Institute has focused primarily on nanomedicine and biotechnology.