

## A New Look at the Role of Urinalysis in the History of Diagnostic Medicine

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Before this century, urine was the predominant body fluid used by the physician for diagnosis and prognosis. Uroscopy, or urinalysis by the senses, has usually been treated disparagingly in historical accounts of diagnostic medicine. Although uroscopy was at times used fraudulently, the thoughtful use of urinalysis was probably an important part of diagnosis for the physician, even before the chemical analysis of urine.

The laboratory of today is ready to offer the physician an extraordinary array of analytical services in many different body fluids; yet until the technological advances of the 20th century, urine was the only practical body fluid for most diagnostic purposes. Furthermore, before the 18th century the physician had no laboratory to call upon; his only method for examining this crucial body fluid was the use of his own senses: sight, smell, and (at times) taste. Thus, urinalysis by the senses, often referred to as uroscopy, is an important component in the history of diagnostic medicine.

Although publications have dealt, in part, with the role of uroscopy in the history of clinical chemistry (1-8), bizarre and fanciful aspects have generally been emphasized, rather than its positive role in diagnosis and prognosis.

Just over a century ago, the English physician William Roberts, who later published the first paper on the observation of bacteria in fresh urine (9), wrote

... the amount of information concerning a urine which may be obtained through the unaided senses of smell and sight far exceeds, both in precision and extent, what is usually supposed (10).

Writing at a time when the chemical approach to urinalysis was gathering momentum, Roberts noted that physicians were already beginning to ignore information available through simple inspection of urine.

Challenged by Roberts's comments to reassess uroscopy, I have looked closely at the positive as well as the more commonly cited negative aspects of urinalysis by the senses. I conclude from the evidence that, in many cases, uroscopy was of genuine value to both the patient and the physician in the 17th century and earlier.

### Problems in Assessing the Value of Uroscopy

The modern reader has many problems in accurately assessing the role of uroscopy in ancient and medieval

medicine. The accuracy of ancient texts that have survived through translation and transcription is questionable, even for texts that seem straightforward. The physician of ancient or medieval times usually had a rather poor concept of anatomy, and no clear concept of disease-causing agents such as bacteria or viruses. As a result, texts from this era usually display a substantial confusion between what is a symptom and what is a disease. Many physicians relied on the humoral theory that attempted to explain a person's nature by the balance of the four humors: blood, yellow bile (choler), phlegm, and black bile (melancholy). A recent article on this subject gives a good idea of the difficulties involved in trying to make sense out of writings from this period (11).

Another source of confusion for the 20th century student of diagnostic medicine is that many formerly prevalent diseases have been eliminated in the past century. However, textbooks on urinalysis from the late 19th century can greatly reduce this confusion (12). By that time, basic understanding of the chemistry of urinalysis was reasonably well developed, yet most of the diseases prevalent 1000 years earlier still existed. Thus, these texts cover the details of urinalysis that accompany these diseases and their symptoms. In addition, one must remember that most major authors of these ancient manuscripts were practicing medicine in a tropical or semitropical climate. The possibility of various tropical parasites must always be kept in mind to explain their observations.

In trying to assess fairly the role of urinalysis in the practice of diagnostic medicine by ancient or medieval physicians, I have tried wherever possible to locate a source for information contemporary to the physicians. In some cases, this was possible, but in others, a more circumstantial approach was necessary.

### Uroscopy and Quackery

Ample evidence from the late Middle Ages and the Renaissance indicates that many physicians were prepared to carry uroscopy beyond the bounds of reason. Figure 1 shows a physician looking at urine, apparently a mixture from the patients, in which he sees problems of foot, arm, and head. The appearance of such an illustration with a medical text suggests that at least some physicians of the day were prepared to make such absurd claims.

This sort of quackery has been well described in a number of recent publications (4, 5, 7, 13), as well as by some physicians of that time. James Hart, an English

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Fig. 1. Physician studying urine, with four patients  
From MS 22, 534, f 47, 15th century, a translation into French by Jehan Corbichon of Bartholomaeus Anglicus, *De proprietatibus rerum*. Reproduced by permission of the Bibliotheque Nationale, Paris

physician in the early 17th century, commented:

Hence it comes to pass than any idle old trot cobbler or costard-monger, will seem to pronounce some Delphian oracle by the urine (14).

Another English physician of that time, Thomas Brian, presented himself as a conscientious physician driven to somewhat unethical practices to survive. He admitted to having participated in a particularly egregious abuse that had developed at that time—the practice of prognosticating over the patient merely by examining the urine, without even seeing the patient. Brian complained of the people who sent him their urine with no other information and expected him to solve their problems. He called urine alone a dumb messenger and wrote

She is indeed the dumbe messenger betweene the Doctour and his patient: who (instead of passing the relation of his disease in writing, or by some discreet messenger) pisseth his minde in his water, and expecteth an answer; but if I should write an answer in a letter written in the same language, I doubt he would scarce read it (15).

In some cases, an effort to go beyond mere uroscopy made the situation even more absurd. In the 16th

century, a small group of medically oriented scientists wanted to get something more out of the urine and were prepared to use new methods. Many were the followers of Theophrastus Bombastus von Hohenheim, known as Paracelsus (1493–1541), who insisted on not just looking at the urine, but on doing things to it to see what would happen. Sometimes this could lead to potentially useful information, as when he added vinegar to some urine and precipitated what must have been protein (16).

Other approaches were not so salutary. One of his followers, Leonhardt Thurneiser (1530–1595), liked to compare urine to a stream rushing down a mountain. Just as the stream picks up particles and carries them along the whole journey, urine carries information from all parts of the body. To get from urine information about all parts of the body, he used a method of analysis based on boiling urine in a special device called an “anatomical furnace” (Figure 2). The fumes and spattering would travel to different parts of the body and show where the patient’s ailment was located (17). This was an extreme version of sophisticated nonsense. With this level of silliness, it is no wonder that some physicians of this era have been held up to ridicule by their contemporaries and by modern authors.

#### Routine Urinalysis by the Senses: What Was Possible?

Despite these absurd activities by some “physicians,” genuine information could be obtained from the urine specimen by the discerning and experienced observer. By reviewing the literature of the time, we can get a

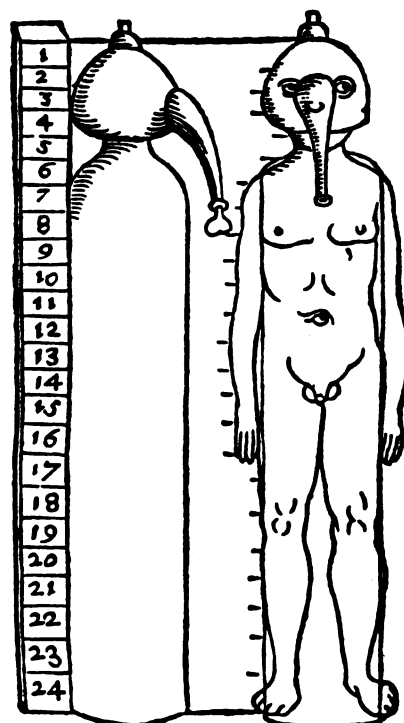


Fig. 2. The “anatomical furnace” for the distillation of urine and diagnosis of the locus morbi

Originally from *Aurora Theaurusque Philosophorum Paracelsi* with “Anatomia Viva Paracelsi,” Basel, 1577. Here taken from ref. 16, reproduced by permission of S. Karger AG, Basel, Switzerland

feeling for the quality of diagnostic information available.

### Protein

The first really extensive description of the use of urine for diagnostic purposes comes from the writings attributed to Hippocrates of Cos, the famous Greek physician who lived from 460 to 377 B.C. In the *Aphorisms* he states that bubbles on the surface of the urine indicate kidney disease and a long illness (18). Presumably, these bubbles, or foaming, would be caused by a high concentration of protein.

Except for this reference to bubbles, the earliest physicians did not generally notice anything that we can say, in retrospect, was protein. Theophilus, a physician of the seventh century, left a reference suggesting that he applied heat to get a substance, again presumably protein, to precipitate from solution (19). Generally, however, the best that we have from this period are descriptions of symptoms. William of Saliceto, who lived in the 13th century in Italy, left an excellent description of the symptoms of chronic nephritis:

The signs of hardness in the kidneys are that the quantity of the urine is diminished, that there is heaviness of the kidneys, and of the spine with some pain: and the belly begins to swell up after a time and dropy is produced the second day . . . (20)

There is not a word of any feature in the urine that we can say in retrospect was due to proteinuria. Nevertheless, he did note the reduction in urine quantity.

As mentioned earlier, there is clear indication that in the 16th century, the Swiss physician Paracelsus precipitated protein from urine by using vinegar, although he had no idea what to do with the information (16). At the end of the 17th century, Frederick Dekkers established clearly that heat would accomplish this feat (21). From that point we can say the real chemistry of protein detection began, yet more than a century passed before the correct associations with disease states were made.

### Glucose

We think of diabetes in terms of glucose concentrations in blood or urine, but the ancient physicians detected only Type I diabetes. They diagnosed it entirely by observing the huge quantity of urine put out by the patient. Galen (130–201 A.D.) described the disease as diarrhea of urine (22) and commented on its rarity; at the time of his writing, he had seen only two cases.

The first good clinical description of diabetes that has come down to us is that of Aretus the Cappadocian (2nd–3rd century A.D.):

Diabetes is a wonderful affection, not very frequent among men, being a melting down of the flesh and limbs into urine (23).

He is given credit for the name of the disease, which comes from the Greek word for "siphon." Aretus does not mention the taste of urine, the distastefulness of such a test being so great that it was only rarely reported. There are isolated mentions of the taste in the literature over hundreds of years, but this fact remained essentially unrecognized among physicians of Europe

and the Middle East until Thomas Willis commented on it in 1679 (24).

### Blood

Blood in the urine (frank, not occult) was a symptom well known throughout these millennia. A rather wide-ranging symptom, it reflected either something rather serious and life-threatening, or something rather insignificant in the scheme of things in those days.

Hippocrates commented that blood or pus in the urine indicated ulceration of the kidneys or of the bladder (25). Rufus of Ephesus, a physician who lived in Alexandria during the first century A.D., described hematuria as coming from the body's being unable to hold back the blood as it normally would:

The kidneys can no longer secrete urine; the canals have become too wide, they allow part of the blood from the vein and other thick substances to escape (26).

Given that Rufus was in Egypt, many cases of hematuria that he saw were probably due to schistosomiasis, a parasitic disease still prevalent in many parts of the tropics. Calcified schistosomiasis eggs have been found in the straight tubules of kidneys of 20th dynasty mummies (4000 years old) (27). On the other hand, a more benign cause of hematuria could have been the intermittent hematuria associated with malaria (28).

Abu Ali al-Husain ibn Abdallah ibn Sina (980–1037 A.D.), whom we know as Avicenna, was a Persian physician who worked at the time of the flowering of Islamic science and medicine and wrote extensively in both Persian and Arabic. His major work, the *Canon*, was widely copied and quoted. He said that red urine (hematuria) was very bad in the case of renal disease because it indicated a "hot" inflammatory process (29).

### Infection

The modern physician has two rapid diagnostic tests for detecting infection in urine—leukocytes and nitrite. The ancient physician also had two approaches—sight and smell. Needless to say, their limit of detection was not as good. Avicenna commented that a dreadful odor of the urine indicated an illness in the bladder (30).

Rhazes (Abu Bakr Muhammad ibn Zakariya al-Razi), another major figure in Islamic medicine, who lived from about 850 to 923 A.D., has provided us with a good description of pyelonephritis, with a correct diagnosis and reasonable therapy. He was concerned in general with the question of infection. He chose a hospital location by hanging pieces of raw meat in various parts of Baghdad, and then building where the putrefaction was the slowest (31).

### Liver Function

The functioning of the liver is indicated on a urine reagent strip by the areas that detect bilirubin and urobilinogen. The tests available to the ancients for liver function were again color and smell. Avicenna said, "Urine is often white at the onset of a disease and offensive in odor later. So it is in jaundice (29)." The odor



referred to by Avicenna has been identified within the past 30 years as being attributable to certain mercaptans (32, 33). Avicenna also noted that in cases of jaundice urine stained linen (34). Perhaps this can be regarded as the earliest use of a "reagent strip" for medical diagnostic purposes.

### Concentration

Concentration is another relevant characteristic of urine, assessed currently as specific gravity or osmolality. Galen commented on the relationship between ingested and excreted fluid:

Now, the amount of urine passed every day shows clearly that it is the whole of the fluid drunk which becomes urine, except for that which comes away with the dejections or passes off as sweat or insensible perspiration (35).

Because this relationship would naturally be known to any observant physician, any deviation from this would be noted as unusual, as in cases of fluid retention.

Color was one natural consequence of the different concentrations of urine. Many physicians probably recognized this, although Bellini in the 17th century gave the first recorded observations of changes in color, odor, and taste of urine during evaporation (36). Some physicians of 500 years ago tried, at times, to get an idea of more than just concentration from urine color. They tried to match the urine color to a chart of 20 or more colors, each of which was intended to represent a different condition of health or disease. Physicians of the late Middle Ages often carried a folded calendar that contained, in addition to the "necessary" astrological information, various medical references, including a color chart for urines (37).

Avicenna gave some hint of the possible value of looking at the density of urine (38), as did a few others (39). The first person to experiment seriously in this area was Jan Baptista van Helmont in the early 17th century (39). He related the weight of urine to the weight of the same amount of rainwater. Although he was an extremely creative and influential physician, he knew of nothing to do with the information in terms of diagnosis.

### Sediment

In the *Aphorisms*, Hippocrates stated

When the urine of a man with fever is thick, full of clots and of small quantity, an increase in quantity and clarity is advantageous. Such a change is especially likely to occur if, from the beginning or very shortly afterwards, the urine has a sediment (25).

In essence, he is saying that the sediment in the urine can be used to follow the course of a disease for which a fever is a major symptom. This may seem far-fetched; yet, a comment in a textbook on urinalysis by C. W. Purdy in 1896 is remarkably similar.

It may be stated, as a general rule, that the amount of tissue-metamorphosis, as indicated by the excretory waste in the urine in fevers, constitutes a good indication of the severity of the disease,—often, indeed, better than the thermometer or pulse (40).

This suggests that we may have unlearned some aspects of urinalysis over the years.

### Urinalysis and the Physician

Thus we see there were some ways to gain useful information from the urine, even if the physician was restricted to using only his senses. What was the attitude of responsible physicians of the time toward the use of urinalysis?

### Medical Texts

Clearly, uroscopy was widely associated with the practice of medicine by the time of the late Middle Ages. Manuscripts on uroscopy, many of which were illustrated, were invariably included with other medical texts in libraries used for medical purposes throughout the Middle Ages (41, 42). Because of the individuality of each manuscript's illustrations, these pictures display a wide range of artistry. Some are quite crude; others are strikingly beautiful. Figure 3, an illumination from the 15th century, shows an outpatient clinic in which one of the physicians is examining urine in a flask brought by one of the patients. By the 16th century, printing was used for most medical texts, and woodcuts were important for medical illustrations. Figure 4 is typical in its portrayal of a doctor of the time.

In all these illustrations, the urine flask, called a *matula*, was the special identification of the physician used by artists of that period. Illuminations showing a *matula* can be found in manuscripts from as early as the 12th century (8). The *matula* was made in the shape of the bladder, with a round bottom, and thus had to be carried around in a special basket, so that the contents would not spill. The patient is shown carrying this basket in Figure 4.

Parenthetically, worth noting in connection with these figures is the use of a clear glass flask (the *matula*), which provided the best possible technology for uroscopy. In the paper cited earlier, Roberts commented:

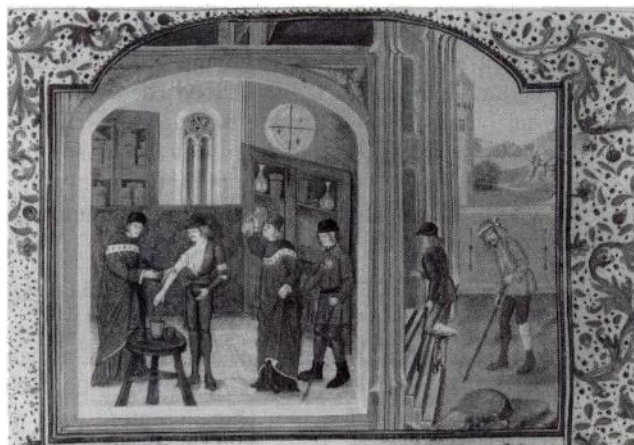


Fig. 3. An outpatient clinic

From MS Royal 15.E.II, f 165, 15th century, also a French translation of Bartholomeus Anglicus, *De proprietatibus rerum*, reproduced by permission of the British Library, London



Fig. 4. Physician examining the urine in sunlight  
Originally from a calendar printed by Steffen Arndes, Luebeck, 1519. Here taken from ref. 8, reproduced by permission of GIT Verlag GmbH, Darmstadt, F.R.G.

Most [precipitates] are not deposited until after emission, and the manner of their deposition is often so distinctive that it suffices for their identification. It is consequently necessary to collect the urine in a glass vessel immediately after emission, in order that their mode of deposition may be correctly observed (10).

Secondly, in virtually all illustrations of this sort, the physician is shown as well-dressed, which suggests financial success and accordingly some measure of medical success.

#### Sensible Urinalysis

The writings of physicians practicing during this time indicate that they well understood the limitations of urinalysis as well as its uses. Isaac Israeli (840?–950?), a Jewish physician practicing in what is now Egypt and Tunisia, wrote a number of guidelines for the use of urine as a diagnostic, but he also recognized clearly its limitations:

The urine informs only on matters in the liver and the urinary pathways, and this when it is considered in all its circumstances, ... (43).

Similarly, Andrew Boorde (1490–1549), a physician to Henry VIII of England, said that he “trusted not the single witness of the water if better testimony be had. For reasons drawn from the urine alone are as brittle as the urinall (44).” He emphasized the need to look at more than the urine alone for a diagnosis. These views correspond well with a modern view of urinalysis, that it should be regarded as just one portion of the total

diagnostic information available.

The ancient authorities also clearly recognized some of the same factors we now regard as important for proper urinalysis. Avicenna’s *Canon* had some observations (29) that can be compared with those from a recent publication on urinalysis (45). Both advise analysis within an hour of voiding; warn of substances that can mask the true color of the urine; suggest the use of the first morning urine, if possible; and emphasize the need for clean vessels to hold the urine.

#### The Physician Viewed by His Contemporaries

Both quacks and responsible physicians made use of urinalysis by the senses. What were the attitudes of contemporaries to these physicians’ use of urinalysis? We can learn something about this from art, literature, and other comments of the time.

#### Art

The physician as uroscopist was not limited to medical texts (8, 46). Paintings by many Dutch and Flemish artists of the 17th century provide us with the average person’s view of a physician. Figure 5 is typical, with its study of a village doctor using urine to help him with his diagnosis. The artist, David Teniers, treats the subject with seriousness and sympathy, suggesting a general atmosphere of acceptance of the whole concept by both physician and patient. The number of pictures of this genre suggests that the simple ritual of uroscopy itself was probably a positive factor in giving the patient faith in the physician’s ability to diagnose and prescribe.

Urinalysis is also depicted to a more limited extent in other forms of art. Bas relief sculptures showing uroscopy can be found in Italy on the wall of a hospital in Tuscany, on the bell tower of Santa Maria del Fiore in Florence, and in France on the cathedral of Notre Dame in Rouen. In Germany, the twin physician saints, Cosmas and Damian, are displayed in the stained glass of a church window in Pipping, near Munich. Cosmas holds



Fig. 5. The village doctor  
Painting by David Teniers the younger, 17th century, from the Staatliche Kunsthalle, Karlsruhe; reproduced by permission





Fig. 6. The doctor  
 Originally a colored print by Jeremias Wolf, Augsburg, ca. 1700; taken here from ref. 47

a matula, representing the diagnostic side of medicine, and Damian holds a mortar and pestle, representing the therapeutic side.

On the other hand, not all art portraying uroscopy was flattering to the physician. Many illuminations from medieval manuscripts portray various animals acting as physicians, examining flasks of urine. Figure 6 gives a different unflattering view of the 17th century physician. The accompanying German verse translates

For healthy people I am a doctor. God help the sick.  
 My large hat is to hold my many thoughts.  
 My clothing shows the art that I possess,  
 And what the urine is hiding, my long nose will discover (47).

#### Literature

Literary references also cite the study of urine, or "water" as it was often called. Shakespeare's works contain such references as a passage from *Macbeth* (Act V, scene 3) in which "water casting" is spoken of by Macbeth in a metaphorical sense. He is asking the physician to diagnose the problems of Scotland and then prescribe a cure.

If thou couldst, doctor, cast  
 The water of my land, find her disease,

And purge it to a sound and pristine health,  
 I would applaud thee to the very echo,  
 That should applaud again. . . .

As in the art of the period, not all literary portrayals of physicians performing urinalysis were kind to the physician. *Piers Plowman*, an allegorical poem by William Langland, is one of the earliest literary works in English. In these lines, a group of physicians speaking to the allegorical figure Liar are urging this "Liar" to come and make a home with them.

Thanne loured leches and lettres thei sent  
 That he shold wonye with hem wateres to loke.

In modern English this translates "Then the doctors were annoyed, and sent him an urgent letter asking him to join them, and help them analyse urine (48)."

In contrast to Langland's opinion, a careful examination of various literary sources led I. B. Jones to conclude that physicians were generally, although not universally, highly regarded in the 14th century (49). Although there seems to be no comparable studies for other centuries during this era, various sources offer some relevant comments. An official Ostragothic document from the early sixth century touches in part on urinalysis.

The physician helps us when all other helpers fail. By his art he finds out things about a man of which he himself is ignorant; and his prognosis of a case, though founded on reason, seems to the ignorant like a prophecy. . . . The patient's pulse, the patient's urine, tell a skilled physician the whole story of his disease (50).

There are examples of persons of known high moral character who used urinalysis or approved of it. Although a strong believer in faith healing, Pope Gregory the Great (died 604 A.D.) clearly also had faith in the diagnoses and prescriptions of physicians (51, 52). Abbott Walafrid Strabo, tutor in the court of the son of Charlemagne, had a respect for the physicians of his time (53). The famous Jewish philosopher, rabbi, and physician Moses Maimonides (1135–1208) wrote about the proper use of urinalysis (54, 55). Dante (1265–1321) was proud to be a member of the Florentine guild of physicians and apothecaries. Although he did consign medical quacks to the Inferno, the only contemporary pope he placed in Paradise was the only physician pope, John XXI (56). That pope even wrote a book about medical practice, including urinalysis, under his given name, Petrus Hispanus (57). Thus, it seems fair to conclude that responsible physicians were respected by their contemporaries.

From this look at uroscopy from Hippocrates to the 17th century, one can conclude that clearly some quacks used uroscopy, and their abuses eventually led to ridicule from many quarters about the whole concept. On the other hand, genuinely useful information was also gained from examination of the urine. Responsible physicians understood the limitations of this information, and used it in combination with other tools available, such as case history, symptoms, and pulse. Consequently, the responsible physician was highly respected,

and his ability to use urine for diagnosis contributed to his positive image. The advice of 16th century preacher Geyler von Keisersberg to patients gives us an insight into what could be expected from a proper patient-physician interaction:

If you wish to act wisely, sick man, tell the physician exactly and faithfully all about your infirmity and with this produce your urine and answer correctly all his questions. If when all this is done he has given the right verdict, give thanks to God (58).

In the end, even the good physician was limited in what he could accomplish, given the general level of medical knowledge. The physician of this time was hampered greatly by a limited knowledge of anatomy and inadequate concepts of disease causality. He probably did the best he could in the situation, and used the urine in a limited way to help him understand what was wrong with his patient.

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