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The Historical Evolution of Urinary Catheters: Contributions From the Islamic Golden Age (9th-13th Century CE)

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ABSTRACT

Objective: To explore the historical development of urinary catheters, with a particular emphasis on the contributions of key Persian and Islamic medical scholars during the Islamic Golden Age (9-13th century CE).

Methods: This historical analysis draws on primary medical texts authored by renowned physicians including Rhazes, Haly Abbas, Zahrawi, Avicenna, and Akhawayni. Descriptions of catheter construction, improvements in design, and clinical use were analyzed. In addition, comparisons were made with Greco-Roman sources to highlight original innovations introduced by Islamic physicians.

Results: The findings reveal that Rhazes enhanced catheter functionality by incorporating side perforations and recommending flexible, lead-based materials. Haly Abbas provided practical guidelines on catheter insertion and advocated tailoring catheter length to individual patient needs. Zahrawi developed specialized instruments such as the *Qatatir* to alleviate bladder obstructions. Avicenna emphasized the use of soft, biocompatible materials for increased patient comfort and safety. Akhawayni described a sophisticated metallic catheter device designed for efficient bladder drainage.

Conclusion: Persian physicians of the Islamic Golden Age significantly advanced catheter technology through material innovations, ergonomic designs, and methodical clinical applications. Their legacy not only laid the foundation for modern urology but also shaped the evolution of surgical practice across both the Islamic world and medieval Europe.

The urinary tract system functions to produce, store, and excrete urine. The kidneys filter blood to produce approximately 1 mL of urine per minute, which is transported to the bladder via the ureters. The bladder can hold between 350-500 mL of urine, and urination is controlled by three sets of muscles: the internal sphincter (involuntary smooth muscle), the external sphincter (voluntary striated muscle), and the pelvic floor muscles. In a healthy urinary tract, the flow of urine helps to clear bacteria from the urethra, serving as a defense against infection. However, individuals with impaired bladder function—due to either retention or incontinence—require reliable methods of urine collection. Clean intermittent self-catheterization is considered the gold standard for managing urinary retention.[1]

The urinary catheter is a critical medical device used in both acute and community healthcare settings. Its primary applications include managing urinary retention, enabling accurate urine output measurements, draining neurogenic bladders, performing urodynamic assessments, facilitating bladder irrigation, and aiding in pre- and postoperative care.[2] Urinary catheterization, one of the oldest surgical practices, has evolved over 3500 years. A significant innovation occurred in 1935 with the introduction of the Foley catheter by Frederick Foley—a one-piece catheter with a self-retaining balloon—widely used in contemporary medicine.[3]

Though originally designed for bladder drainage, the Foley catheter now serves multiple functions, including urine monitoring and diagnostic procedures across various medical specialties.[4]

Historical Background: Urinary Catheters in Ancient Civilizations

The term *catheter* originates from the Greek *kathie´nai*, meaning “to thrust into” or “to send down”.[1] Archeological findings and ancient manuscripts reveal the use of catheters in several early civilizations. A

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well-crafted double-curved bronze catheter was discovered in the house of a Pompeian surgeon and is now preserved in the Naples Museum.[5] Primitive catheterization techniques using materials such as bronze, reeds, straws, and hollow onion leaves were also recorded in ancient Egyptian papyri and early Chinese medical texts.[6]

By 400 BCE, Hippocratic literature recognized catheterization as an essential medical skill. Roman authors like Celsus (c. 40 CE) documented the gender-specific application of catheters. Subsequent physicians such as Soranus, Rufus of Ephesus, and Aretaeus of Cappadocia expanded the clinical use of catheters for conditions like urinary retention, bladder stones, and gynecological disorders, though some cautioned against its use in paralysis cases.[7] Galen (129-199 CE) emphasized catheterization in his medical practice, advocating for its diagnostic and therapeutic use in works such as *On the Therapeutic Method*.[7]

Galen's influence persisted into the Islamic Golden Age (8th-13th centuries), where Persian physicians particularly Rhazes built upon his teachings. This article focuses on Rhazes and his successors' contributions to the advancement and application of catheter technology.

The Islamic Golden Age: Transformative Contributions to Urology

The Islamic Golden Age (7th-13th centuries CE) marked a profound transformation in the medical sciences. Fueled by the Islamic ethos of knowledge acquisition, scholars translated pivotal medical texts from Greek, Syriac, Sanskrit, and Persian into Arabic, forming a comprehensive medical corpus.[8] Building on these foundations, Islamic physicians refined and expanded upon earlier concepts, adding their own observations and methods based on clinical practice. Their medical contributions were so influential that many of their works were translated into Latin and used in European medical curricula until the 18th century.[9]

This period witnessed substantial progress in the field of urology, particularly in the development of urinary catheters. Renowned Persian physicians such as Rhazes (Razi), Haly Abbas (Majusi), Al-Zahrawi (Albucasis), Avicenna (Ibn Sina), and Akhawayni advanced catheter design and application by integrating Greco-Roman knowledge with empirical research.[10]

From improvements in materials to innovations in design and application techniques, these physicians used their clinical expertise and experience to enhance the performance of catheters, optimizing their use in treating various urinary conditions.

Rhazes (865-925 CE)

Abu Bakr Muhammad ibn Zakariya Razi, a prominent Persian physician, alchemist, philosopher, and scientist, made remarkable contributions across multiple scientific fields. He authored over 200 works and was a pioneer of experimental medicine. As chief physician at the hospitals of Rayy and Baghdad, his innovative ideas deeply influenced medieval European medicine and shaped Western medical education.[11] Razi, who lived before Avicenna, was praised by him as a respected scholar. Although influenced by Hippocrates and Galen, Razi critically examined many Greek doctrines in his book *Doubts About Galen*, and leaned toward an evidence-based approach in medicine.[12]

In urology, Razi was greatly influenced by Galen's teachings. Galen, particularly in *On the Therapeutic Method*, emphasized the use of catheters in urinary disorders and stressed the importance of anatomical knowledge of the urinary tract. He recommended catheter use for conditions like urinary retention, bladder stones, and even urinary tract wounds and inflammation. Building on this foundation, Razi provided a comprehensive account of catheterization in his encyclopedism work *al-Hawi fi al-Tibb*, integrating Galen's concepts with his own clinical observations and innovations.

His texts describe how to relieve urinary retention caused by stones, clots, or pus, and explain the proper technique for catheter insertion. Galen advised that the patient should sit on a flat surface, sacrum supported, knees slightly raised and apart for access to the bladder. A wool tuft tied with thread was placed in the catheter to prevent blockage from clots or pus. The catheter, lubricated with oil, was gently inserted, angled toward the navel to minimize pain and ensure proper placement.[13]

Razi refined this process by improving catheter design. He described instruments with multiple side holes to prevent obstruction—if one became blocked, urine could still flow through the others. He also introduced catheters made of pliable lead that could be bent to fit individual anatomy. He emphasized the importance of selecting catheter size according to the patient's age and physical condition. Razi also referred to an alternative method for draining urine when catheters could not be used: making a small incision between the anus and scrotum to insert a drainage tube.[13]

Razi's improvements, based on Galen's foundation but enhanced through his own practice, represent a significant advancement in urological history and the evolution of catheter use.

Haly Abbas (930-994 CE)

Ali ibn Abbas Majusi, known in the West as Haly Abbas, was born in the region of Arjan near Ahvaz in southwestern Iran. He later moved to Baghdad, where he served as court physician at the 'Adudi Hospital under the patronage of 'Adud al-Dawlah al-Buyid (r. 949-983 CE).[14]

Haly Abbas was among the most prominent physicians and surgeons of the Islamic Golden Age (9th-12th centuries). He authored the comprehensive textbook *Kamil al-Sina'ah al-Tibbiyyah* (The Complete Book of the Medical Art), also called *al-Kitab al-Maliki* (The Royal Book), written in Arabic and divided into two major parts with ten sections each.[15]

Catheterization is discussed in the second part of the book, specifically in Chapter 45, titled *On Urination with a Catheter*:

> "*A catheter of appropriate length is selected according to the patient's condition. Its tip is first lubricated with an oily substance, then it is inserted through the male urethra and guided toward the bladder. Once in place, the inner rod is removed, allowing the urine to drain*".[16]

Zahrawi (936-1013 CE)

Abu al-Qasim Khalaf ibn al-'Abbas al-Zahrawi, also known in the West as Albucasis, was a distinguished Muslim physician of the 10th century. Born in 936 CE in the city of al-Zahra near Cordoba (modern-day Spain), he spent most of his life serving as personal physician to Caliph al-Hakam II. Zahrawi was renowned for his mastery of medicine, surgery, and anatomy. His magnum opus, *Kitab al-Tasrif*, a comprehensive 30-volume medical encyclopedia, had a profound influence on Islamic and European medicine.[17] His innovations shaped European urology until the 18th century and laid the foundation for modern lithotripsy.[18]

Zahrawi introduced new surgical instruments and techniques, including tools like *Kalaleeb* (for crushing large bladder stones) and *Mishaab* (for drilling and fragmenting urethral stones), which were unknown to Greco-Roman medicine.[18,19]

In treating urinary retention, he described: "*Retention is caused by obstructions such as stones, clots, pus, or overgrown tissue. If treatment fails, the patient should kneel while another person pulls their abdomen backward to dislodge the stone. If this fails, a tool called Qatatir is used—a narrow, polished, hollow silver instrument resembling a kohl stick, about 1.5 hand spans in length, with a funnel-shaped end for urine drainage. A cotton ball tied to a thread is inserted into the tube to help draw out urine.*"[20]

After lubricating the catheter with oil, butter, or egg white, the patient is seated and the instrument is gently inserted into the urethra, adjusted to follow the natural curve toward the bladder. Once the catheter reaches the bladder, the cotton is pulled out, allowing urine to flow. This process is repeated until the bladder is emptied and the patient feels relief.[20]

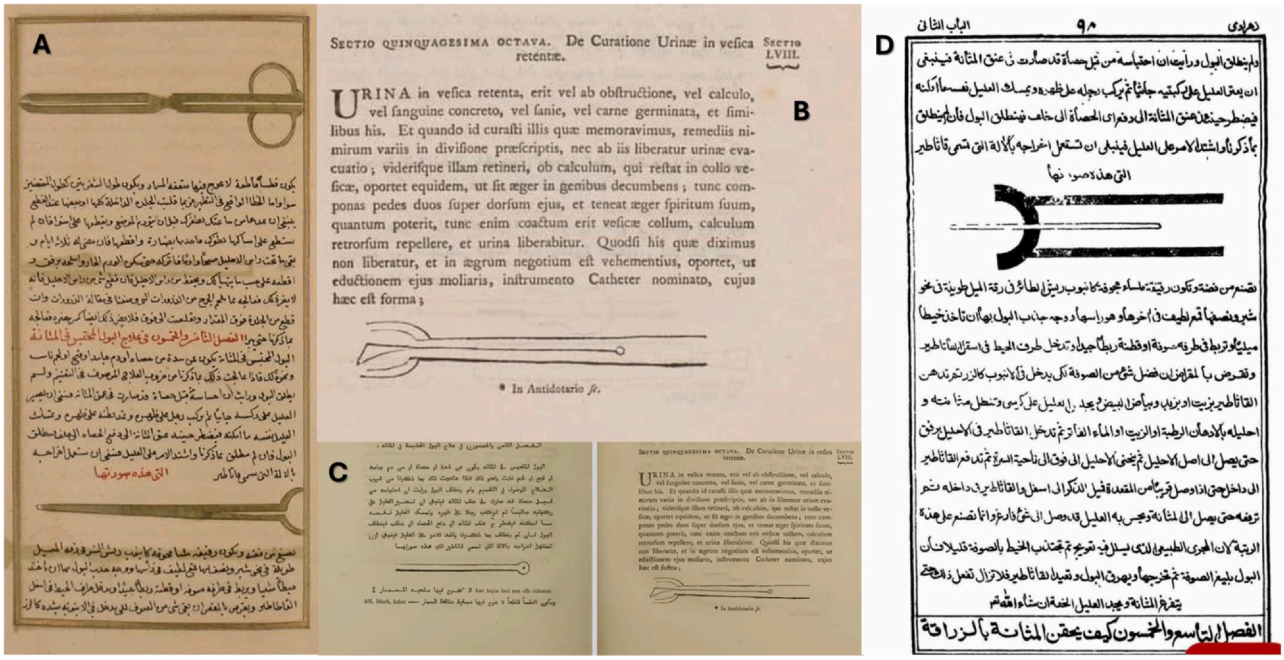


Figure 1. Urinary catheter instruments in various copies of *Kitab al-Tasrif* by Albucasis; **(A)** Presidential Library of Turkey, Manuscript No. A.E. Arabi 2854; **(B)** *De chirurgia. Arabice et Latine. Tomus primus–tertius*, ed. John Channing, Oxonii: E Typographeo Clarendoniano, 1778. Courtesy of Yale University, Cushing/Whitney Medical Library (Public Domain); **(C)** *De chirurgia. Arabice et Latine. Tomus primus et secundus*, Oxonii: E. Typographeo Clarendoniano, 1778. Image from Wellcome Library (Public Domain); **(D)** Lithographed edition, printed in Lucknow in 1830, in Arabic.

This instrument design evolved in Islamic medicine and was later elaborated by Avicenna in his own works (Figs. 1 and 2).

Avicenna (980-1037 CE)

Abu Ali Husayn ibn Abdullah ibn Sina, known in the West as Avicenna, was one of the greatest Persian physicians and philosophers of the Islamic Golden Age. He is recognized for his profound influence on medicine and science, both in the Islamic world and in the West.[21]

His most important medical work, *Al-Qanun fi al-Tibb* (The Canon of Medicine), is considered one of the most significant and comprehensive medical texts ever written.[22] It was widely used in European medical schools during the Middle Ages and remained a standard reference for nearly 500 years. William Osler called it "*the most famous medical textbook ever written.*"[23]

Avicenna made major contributions to the design and materials of catheters. In *The Canon*, he emphasized the importance of using soft, flexible materials—such as the skin of marine animals—for patient comfort and effectiveness.[10] His detailed descriptions of catheter construction and application significantly advanced the field of urology and secured the catheter's role as an essential medical tool.

Akhawayni (d. 983 CE)

Abu Bakr Rabi ibn Ahmad Akhawayni Bukhari, known as "Abu Hakim" (Father of Wisdom), was a distinguished Persian physician during the Islamic Golden Age. Born in Bukhara, a major intellectual center, he studied under Abol Hasan Taher ibn Mohammad Maqanei Razi, a student of Rhazes. Akhawayni became known for his work on neurological and psychiatric diseases and earned the title "Physician of the Insane."[24]

His only surviving work, *Hidayat al-Muta'allemin fi al-Tibb* (A Scholar's Guide to Medicine), was the first medical book written in Persian, intended to teach his son medicine.[25] Its accessible language made it a foundational text for medical education in Iran. Akhawayni's work is known for its clinical precision, honest critique of other physicians, and innovation. He introduced fever charts and a device resembling an orogastric tube.[26]

In the section on urinary retention, he describes a tool similar to Zahrawi's catheter: "*The mubulah is a hollow rod-shaped device made of wire, gold, or brass. At the end is a bell-shaped attachment with many holes. Inside the rod is a piece of iron that can be withdrawn to allow urine to pass through the instrument and drain from the bladder*" (Fig. 3).[27]

DISCUSSION AND CONCLUSION

The history of urinary catheters is a testament to the remarkable evolution of medical technology, spanning thousands of years from rudimentary devices in ancient civilizations to the sophisticated tools used in modern medicine. The journey of urinary catheters is closely linked with advancements in medical knowledge, surgical techniques, and the availability of materials, marking key milestones in the treatment of urinary disorders. Early references to catheters can be traced back to ancient Egyptian and Chinese civilizations, where rudimentary devices crafted from reeds, bronze, and even hollow onion plant leaves

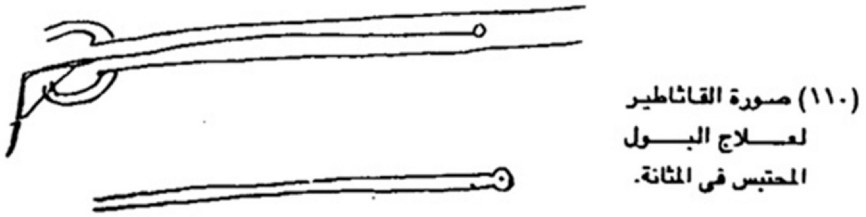


Figure 2. "*Dawr al-Zahrawi fi Ta'sis al-Jiraha*" by Dr Mustafa Labib Abd al-Ghani, p. 102: Discussion of Zahrawi's contributions to the development of surgery.

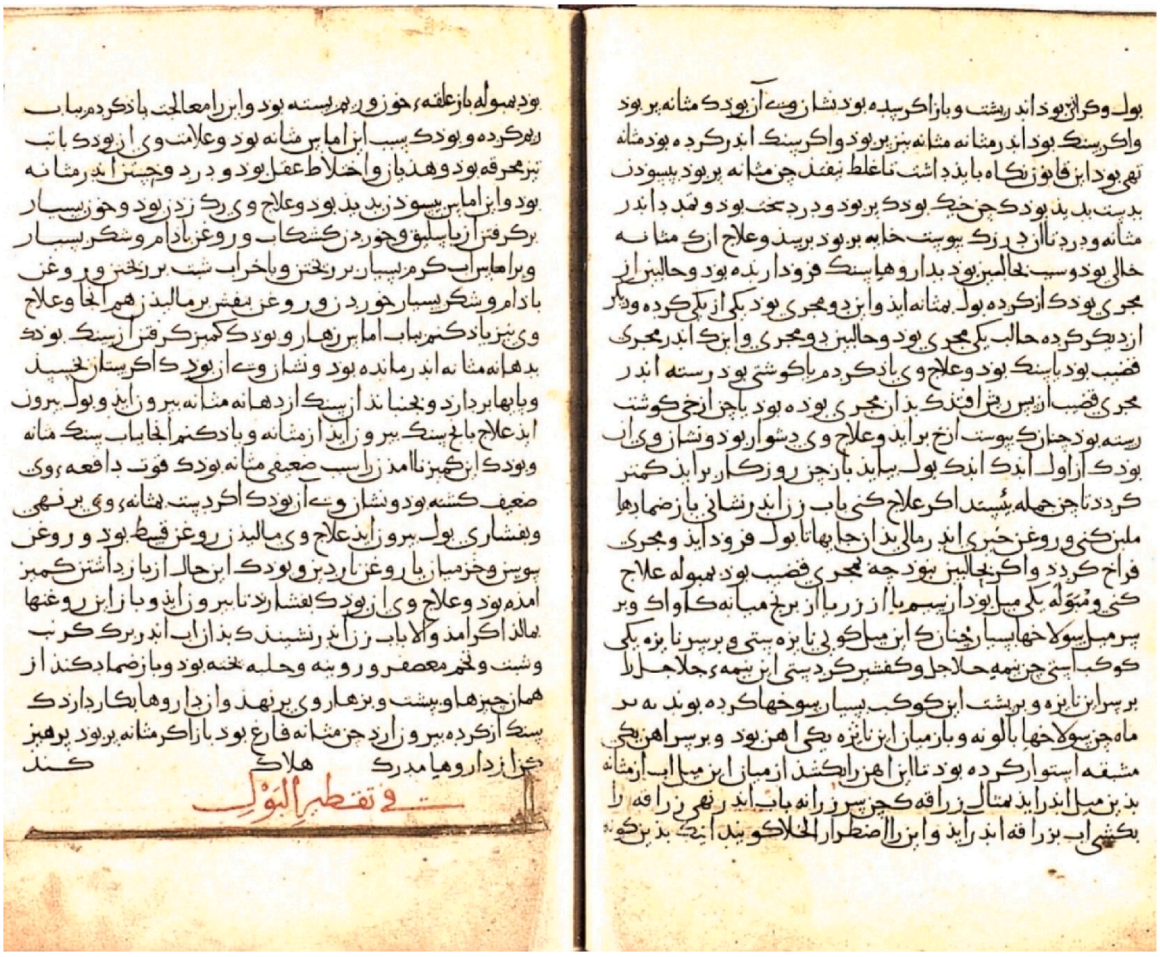


Figure 3. Leaf 123r from *Hidayat al-Muta'allimin fi al-Tibb* by Akhawayni Bukhari, showing medical illustrations. Manuscript No. 3646, Fatih Library, Istanbul. Copied in 510 AH / 1116 CE.

were used to manage conditions like urinary retention. These early forms of catheters laid the foundation for the more advanced designs that emerged during the Greco-Roman period, and later, flourished during the Islamic Golden Age.

During this period, scholars like Hippocrates, Celsus, and Galen contributed significantly to the development of medical theories related to urinary diseases and catheter use. However, it was during the Islamic Golden Age that the design and application of urinary catheters saw significant refinement. Renowned physicians such as Rhazes, Zahrawi, and Avicenna played pivotal roles in advancing catheter design, understanding urinary diseases, and improving surgical techniques. Rhazes, for instance, revolutionized catheter uses by introducing devices made from materials like lead and refining insertion techniques to minimize tissue damage. His work, building on the foundations laid by Galen, greatly enhanced the safety and efficacy of catheterization procedures.

The contributions of Zahrawi and Avicenna were also integral in advancing catheter designs. Zahrawi, known for his innovations in surgical instruments, particularly in the field of urology, introduced groundbreaking designs for bladder stone removal, and his work with catheters influenced both Islamic and Western medical practices for centuries. Avicenna, in turn, emphasized the importance of material quality in catheter construction, contributing to the development of softer, more flexible catheters, which improved patient comfort. The innovations by these scholars marked a significant period of development in the treatment of urinary disorders, laying the groundwork for modern medical instruments used in urology (Table 1).

The contributions of medieval Muslim physicians, particularly Rhazes and Avicenna, were instrumental not only in the advancement of catheter design but also in shaping the principles of modern urology. Rhazes' introduction of multiple fenestrations at the tip of the catheter to prevent blockage—a technique still in use today—highlighted his innovative approach to solving clinical problems. Similarly, Avicenna's emphasis on using soft, flexible materials paved the way for the development of more comfortable and effective catheters.

In conclusion, the innovations introduced by medieval Muslim physicians in the design and application of urinary catheters have had a

Table 1
Comparison of contributions to catheter design and usage by key Persian and Muslim physicians.

Scholar	Catheter Materials	Innovations and Methods	Medical Application
Rhazes	Flexible materials, custom designs	Use of multihole catheters and lead-made catheters	Treatment of urinary retention and bladder stones
Haly Abbas	Basic materials (not specified)	Clear step-by-step insertion method	Treatment of urinary disorders
Zahrawi	Silver, narrow catheters	Creation of new tools for crushing bladder stones	Treatment of urinary obstruction and bladder stones
Avicenna	Marine animal skin, soft materials	Improvement of design for patient comfort	Treatment of urinary diseases
Akhawayni	Metals (gold, brass, copper)	Use of an orogastric tube-like device for urine drainage	Management of urinary obstruction

lasting impact on the field of medicine. Their scientific insights and contributions helped shape the modern tools used in urological treatment and demonstrate the intellectual depth of the Islamic Golden Age, which continues to influence contemporary science and medicine. The legacy of these scholars not only advanced the treatment of urinary disorders but also laid the foundation for the development of the sophisticated medical technologies we rely on today.

Disclosures

None.

Ethical Declaration

Not required.

CRediT Authorship Contribution Statement

Narges Tajik: Writing – original draft, Methodology, Investigation, Conceptualization. **Mohammad Hossein Ayati**: Writing – review & editing, Supervision. **Nafiseh Hosseini Yekta**: Writing – review & editing, Supervision, Methodology. **Fuat Ince**: Writing – review & editing, Methodology, Investigation. **Arman Zargaran**: Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

Declaration of Competing Interest

The authors have no conflict of interest to declare.

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