

The functional anatomy of the uretero-vesical junction

A historical review

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ABSTRACT

This paper evaluates the progress of anatomy and dissection during the Middle Ages both in Europe and in the Muslim World. For that purpose, the functional anatomy of the ureterovesical junction and the mechanism of micturition were studied both in the works of Galen (130-200 AD) and in the works of 6 Islamic medical scholars who lived in the period from the ninth to the thirteenth centuries AD (Alrazi, Alzahrawi, Ibn Sina, Al-Baghdadi, Ibn El Nefis and Ibn El Quff). The study relied, only, on original sources in the form of authentic editions and manuscripts. In general, the ideas and findings of those 6 Islamic physicians, as regard the anti-reflux and the micturition mechanisms, differed and contradicted with those of Galen but conformed well with our present day concepts.

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In agreement with Hamarneh,¹ the sixth and seventh centuries AD witnessed a remarkable outburst in economic, religious, cultural and political: creativity, vitality and outreach in Arabia and fertile crescent. Meanwhile, as confirmed by Cumston² and Hamarneh,¹ the Muslim leaders encouraged the preserving of the ancient legacies and endeavored to adopt and make use of the most worthy accomplishments from earlier civilizations leaving aside what is superfluous. Therefore according to Dickinson,³ Cumston,² Hamarneh,¹ Castiglioni,⁴ Campbell⁵ and Kirkup,⁶ by the ninth century AD, Arabic civilization developed into a mature and promising position in all fields of human knowledge including the healing art.

Anatomy and dissection in the Middle Ages. In the muslim world. In agreement with Brown,⁷ Cumston,² Radbill,⁸ Hamarneh⁹ and Behbehani,¹⁰ the Islamic physician Alrazi (Rhazes; 825-925 AD) was a towering figure in the history of medicine and allied science as

adding substantially to the theory and clinical applications of the healing art. Furthermore, as stated by Hamarneh,⁹ he emphasized on the value of dissection and the knowledge of anatomy in diagnosing diseases, relationships of affected organs to one another and applying adequate medical treatment.

Also a similar view was held by the Islamic physician Ibn El-Nefis (the discoverer of the pulmonary circulation) in the period between 1261 and 1288 AD in his book *Sharh Tashrih Al-Qanun*.¹¹ Furthermore, in this book, he wrote a special chapter on the best mode for dissecting the following parts: bones, peripheral vessels and internal organs of the chest (heart, lung, big vessels and the diaphragm). Meanwhile, both of Ibn El-Nefis in his previously mentioned book and Alrazi (Rhazes) in his treatise on anatomy, in his book *Al Mansouri*, frequently mentioned the word *المشريحون* "Al-Musharrihon" which, according to the Arabic language etymology, is derived from the Arabic verb *يشرح* Yusharrih".

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According to Lisan Al Arab¹³ lexicon, this verb means dissecting the flesh and dissecting the flesh out of bones.

Thus the word "Musharrihon" subsequently means the dissectors. Therefore, in contradiction with Long,¹⁴ the practice of dissection for medical teaching, then, was not prohibited in either the religion of Islam or the Islamic world. Furthermore, in agreement with Hamarneh,⁹ all the eminent Islamic physicians; Alrazi (Rhazes; 825-925AD),¹⁵ Alzahrawi (Albucasis; 930-1013 AD),^{16,25} Ibn Sina (Avicenna; 980-1037),¹⁷ Al-Baghdadi (Muhazzabuldin; died 1232 AD),¹⁸ Ibn el Nefis (1261-1288 AD)¹¹ and Ibn El Quff (1232-1286 AD)¹⁹ stated that knowledge of anatomy leads to a deeper appreciation of God's wisdom and omniscience.

In Europe. According to Singer,²⁰ Kerr²¹ and Bennion,²² the ban upon dissection of human bodies continued after the renaissance. It was due to the theological concept of the sanctity of the human body and its resurrection (Garrison, 1967).²³ According to Singer (1925),²⁰ the practice of dissection for teaching purpose was first approved by the Pope Clement VII (1523-24 AD). Therefore, while in the renaissance, their physicians relied only on the anatomy of the Arabs especially Ibn Sina (Avicenna)¹⁷ whom no body doubted (Singer, 1925),²⁰ in the Middle Ages, they relied only on the writings of Galen (Garrison).²³

The contra galen criticism by Islamic scholars. Galen (130-200 AD) was the eminent Roman physician who summed up all medical knowledge before him and revived the Hippocratic teaching beside recording his own observations (Desnos).²⁴ However, in agreement with Hamarneh (1977),⁹ Galen was criticized by the eminent Islamic physicians: Alrazi (Rhazes),¹⁵ Alzahrawi (Albucasis),²⁵ Ibn Sina (Avicenna),¹⁷ Al-Baghdadi,¹⁸ Ibn El Nefis¹¹ and Ibn El-Quff¹⁹ for errors in some of his works including anatomical texts. This is confirmed by the statement of Ibn El Nefis¹¹ that as regards the function of organs, we only rely on what is dictated by investigations, observations and accurate research not caring whether it conformed with or differed from the opinion of those who came before us.

In this study, we will present the dispute between Galen and the above mentioned Islamic physicians as regard the vesico-ureteric anti-reflux mechanism and the mechanism of micturition.

The vesico-ureteric anti-reflux mechanism. All the above mentioned Islamic physicians agreed with Galen²⁶ that the ureters run obliquely for some distance in the bladder wall before opening into its cavity. Only Alzahrawi (Albucasis)²⁵ denoted that their course within the bladder wall is sinuous rather than straight. However, contrary to Galen²⁶⁻²⁷ (Figure 1), all of them identified the differentiation of the bladder wall into 2 layers with the ureters acquiring their course in between them, first by penetrating the outer layer then, near the bladder neck, penetrate the second layer to open into the lumen of the bladder (Figures 2, 3 & 4). Therefore, as mentioned by Ibn El Quff,¹⁹ the 2 penetration sites will not be opposite

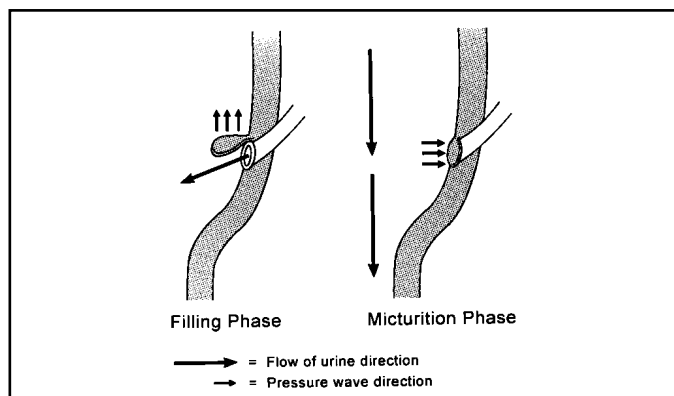


Figure 1 - Diagrammatic representation of the functional anatomy of the ureterovesical junction according to Galen.

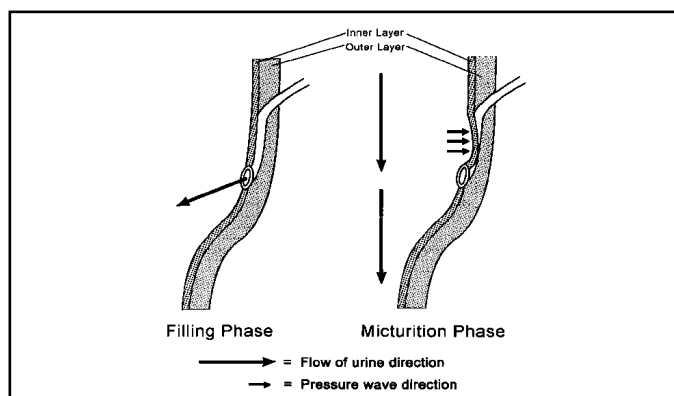


Figure 2 - Diagrammatic representation of the functional anatomy of the ureterovesical junction according to Rhazes, Abulcasis, Avicenna, Al Baghdadi, Ibn El-Quff and Ibn El Nefis.

each other and, according to Ibn El Nefis, the first penetration is situated at a level superior to the second one (Figure 2). Alrazi (Rhazes),^{12,15} Alzahrawi (Albucasis),²⁵ Ibn Sina (Avicenna),¹⁷ Al-Baghdadi,¹⁸ Ibn El Nefis¹¹ and Ibn El Quff¹⁹ considered this anatomical arrangement of the ureterovesical junction as an amazing urinary anti reflux mechanism as the accumulation of urine within the bladder will lead to the approximation of the inner layer towards the outer layer until the 2 layers appear as if they were one layer leading to the tight closure of the portion of the ureter inbetween thus preventing the backward return of urine to the kidneys (Figures 2, 5 & 6). However, contrary to the previously mentioned Islamic physicians, for the explanation of the urinary anti reflux mechanism, Galen^{26,27} relied on the oblique course of the ureters within the bladder wall and the presence of a covering in the inside part of the ureteric opening into the bladder "comparable to the lid (skyphon) of a dove/cote [ureteric valve] which is not something different from the substance of the bladder but part of it so clearly fitted to its form". This valve thrusts inwards and opens up to

يتميز بالاعضاء العليا واسفل العروة في هيئة الكلى
 ككليت موضوعتان عن جيب خزان السلب بالقرب من الكبد والكليتين
 تقع موضعها ولكل واحد منهما عتبات ينزل أحدهما بعرق تضيق الكلى
 من حلبة الكبد والآخر من حلبة المثانة ويستقلحني تضيق المثانة
 انشاجياً وهما مجرى البول وليس الخالبين
في هيئة المثانة
 المثانة وعروة البول ومعضنها وموضعها بين الدير والمخاض وهي
 لطيفة وعلى قعرها عضلاتها ويسمى من خروج البول منه حتى تضيقه
 والبول منه من الكلى في عتقها الذي هو حينئذ هما الحالبين
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 والبول من الكلى في عتقها الذي هو حينئذ هما الحالبين
جمل وجوامع من مناقع الإرت الغلاء
 أن الغشاء ختم مع حن العن المشرك بحسن التدوير وذلك ليعتد به
 لإتساق اللدونة من ألتية البقرة لان اللدونة في العانة والموافقة في الإرت
 وأسان عن عتقها مع عظم رفعه في الكبد يقابلها الصغار في العن عند الصغ

Figure 3 - The page from manuscript No. 3997 of Al Mansouri Book of Alrazi^{31,32} showing his description of the anatomy of the urinary bladder and ureterovesical junction.

بما فيها مما ينفذها ثم تدفع لبس في فريجين اللذين في صكونهم في المثانة
 وجعلت المثانة فوسحة ليلا يحتاج الألتان ومزارة الغيب ببوله في جمل
 على قعرها عضلاتها وبينهما ولا يخرج منه شيء حتى يمل وتنادى بكثرة
 البول في مثله وعندها في مختلف حبيباتها لزيادة حتى يخرج البول فانه يخرج
 الكلى في المثانة ضيقه في حكمة بالغة وذلك لانه قد يثقل ثقله ويثقل
 منه التي على قعرها في المثانة يدخل فيهما البول ومنها تضيق المثانة
 والبول من الكلى في عتقها وذلك لانه يثقل ثقله ويثقل ثقله
 المثانة ويستلزم فيهما بين طينتها حتى يثقل ثقله في عتقها
 المثانة فيصير من البول ذلك كذا دخل في تخريف المثانة مفرق للطيفة
 بالتفريجة وهي امثالات كان أشد لراقة طينتها وضيق ذلك المجرى فلا يمكن
 ان يخرج شيء من البول في تلك المثانة في المذمة وفيه تضيقها فالتول
 يضيق البول في المثانة حتى يثقلها فاذا استتظفت من انماها ما يصلح للتحرك
 عن اسلاك في المثانة فاطمست المثانة على قعرها يخرج البول وانما تضيق
 الخليفة فانه اذا استتظفت من انماها ما يصلح للتحرك فالتول
 المثانة المستقيمة ولهذا المثانة من حيث يخرج في خروج البول
 الامثان في التثنية والحقبة كحلها في ذلك فانه ما يجمع فيه والذم
 بذلك في ذلك في حكمة الحيوان وانما تدنه عن العتق في ذلك في
 والحقبة في حكمة الحيوان وانما تدنه عن العتق في ذلك في
في هيئة مرقا الطر
 ان من قتل في المثانة المجرى في البطن والعضلات التي في قعرها وفي ذلك
 العضلات مدمج يسمى المصفاة وذلك لانه المصفاة في القرب ووراء ذلك

Figure 5 - The page from manuscript No. 3997 of Al Mansouri book of Alrazi^{31,32} showing his description of the functional anatomy of the urinary bladder explaining the anti reflux and micturition mechanisms.

فصل في مرقا المثانة وهو يستلزم
 يستلزم المثانة في المجرى في البطن والعضلات التي في قعرها وفي ذلك
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فصل في مرقا المثانة وهو يستلزم
 يستلزم المثانة في المجرى في البطن والعضلات التي في قعرها وفي ذلك
 العضلات مدمج يسمى المصفاة وذلك لانه المصفاة في القرب ووراء ذلك
 العضلات مدمج يسمى المصفاة وذلك لانه المصفاة في القرب ووراء ذلك
 العضلات مدمج يسمى المصفاة وذلك لانه المصفاة في القرب ووراء ذلك

Figure 4 - The page from manuscript No. 4932 of Al-Tasreef book of Alzahrawi^{25,32} showing his description of the anatomy of the urinary bladder and ureterovesical junction.

العضلات مدمج يسمى المصفاة وذلك لانه المصفاة في القرب ووراء ذلك
 العضلات مدمج يسمى المصفاة وذلك لانه المصفاة في القرب ووراء ذلك
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 العضلات مدمج يسمى المصفاة وذلك لانه المصفاة في القرب ووراء ذلك

Figure 6 - The page from manuscript No. 3997 of Al Tasreef book of Alzahrawi^{25,32} showing his description of the functional anatomy of the urinary bladder explaining the anti reflux and micturition mechanisms.

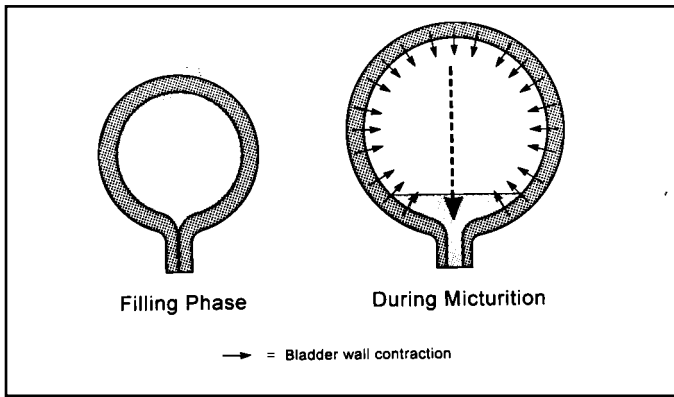


Figure 7 - Diagrammatic representation of the mechanism of micturition according to Rhazes, Abulcasis, Avicenna, Al Baghdadi, Ibn El-Quff and Ibn El Nefis.

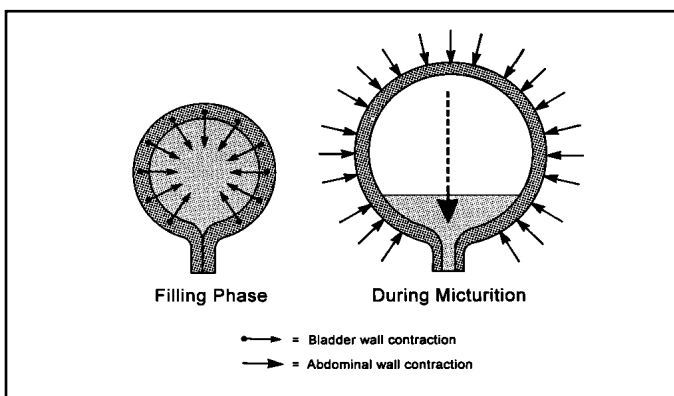


Figure 8 - Diagrammatic representation of the mechanism of micturition according to Galen.

allow urine in and outward to prevent it from refluxing back (Figure 1).

The mechanism of micturition. As regard the mechanism of voluntary emptying of the bladder, Alrazi (Rhazes),¹²⁻¹⁵ Alzahrawi (Albucasis),²⁵ Ibn Sina (Avicenna),¹⁷ Al-Baghdadi,¹⁸ Ibn El Nefis¹¹ and Ibn El Quff¹⁹ agreed with Galen²⁶ on the presence of transverse muscle fibres around the neck of the bladder acting as a sphincter to prevent the involuntary coming out of urine. However, they disputed with him as regard its role in the voluntary act of emptying the bladder. All of them stated that: fullness of the bladder, while the sphincter around its neck is contracted, leads to its distress and the subsequent inhibition of the sphincter to let the urine out. Therefore, according to Ibn Sina (Avicenna),¹⁷ the sphincter muscle is rich in nerves so as to increase its sensitivity. Meanwhile, the inhibition of the sphincter is associated with simultaneous contraction of the bladder wall to help the squeezing of urine out (Figures 5, 6 & 7). However, Galen's concept of the mechanism of voluntary emptying of the bladder was the exact opposite to that described by the Islamic physicians. He²⁶

believed that the process starts by the relaxation of the already tensed bladder wall and the contraction of the abdominal muscles to help the squeezing of urine out. Meanwhile, the sphincter muscle simultaneously remains tensed so as to help the expulsion of urine through the bladder neck and the oblique urethra (Figure 8). Contrary to Galen, none of the previously mentioned Islamic physicians stated that contraction of the abdominal wall muscles is needed as part of the normal mechanism of voluntary voiding of urine. Furthermore, Alrazi (Rhazes)¹⁵ pointed out that this contraction of the abdominal wall muscles is called into action only if the urine is very little in amount or the bladder is weak.

In general, the ideas and findings of those six Islamic physicians (9th-13th centuries AD) as regard the anti-reflux and micturition mechanisms conformed well with our present-day concepts²⁸⁻³⁰ which are based on vast modern technological achievements; thus confirming the statement of Cumston² that one is tempted to believe that the great Arab thinkers of this period (Middle Ages) foresaw many truths that modern discoveries have revealed.

In conclusion, it is true that the more exact the science is, the more accurately can it influence and its transmission from one culture to another can be traced.

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