



Pediatric vesicolithotomy from ancient India to Greece, Arabia and the western world

John G. Raffensperger^{1,2} · V. Raveenthiran³

Accepted: 1 April 2019 / Published online: 9 April 2019
© Springer-Verlag GmbH Germany, part of Springer Nature 2019

Abstract

Surgeons removed bladder stones by perineal lithotomy in ancient times. The first surgeon who dared to invade a body cavity knew human anatomy and was skilled in the use of surgical instruments. The operation probably originated in India since the Sushruta Samhita, a surgical text, antedates Hippocrates by several hundred years. Sushruta's knowledge of bladder of stones, surgical complications and instrumentation identifies him as originator of vesicolithotomy. Why did Hippocrates advise his students to leave operations for bladder stones to practitioners who were skilled in the art? Who were these practitioners and how did knowledge of vesicolithotomy reach Greece from India? Our research suggests that the operation came to Greece from India over ancient trade routes and with surgeons who accompanied Alexander the Great's army. The Sushruta Samhita was translated in Arabic and may have reached Europe during the dark ages by way of Arabian surgeons such as Albucasis. Chelseldon, an eighteenth century English surgeon, brought Sushruta's vesicolithotomy to a peak of perfection.

Keywords Sushruta (900-600 BC) · Hippocrates (460-370 BC) · Alexander the Great (357-323 BC) · Ammonius Lithotomus (circa 200 BC) · Celsus (25 BC-50 AD) · Albucasis (936-1013 AD) · William Cheseldon · (1688-1752 AD) · Vesicolithotomy · History of Medicine

Perineal lithotomy for the removal of urinary bladder stones may be the oldest elective operation in children and certainly, and was the first operation in a body cavity [1, 2]. The word lithotomy, coined from Greek 'lithos' (stone) and 'tomos' (cut), suggests that the operation originated in Greece. However, the Sushruta Samhita, an Indian medical text, described vesicolithotomy several centuries prior to Hippocrates.

Hippocrates (460–370 BC) made the diagnosis:

“Calculous children rub their privy parts and tear at them, as supposing the obstruction of urine is situated there” [3].

He suggested that the etiology was mineral laden water and recommended treatment with diluted wine. In the oath administered to his students, Hippocrates wrote

“I will not use the knife, not even, verily, on sufferers from stone, but will give place to such as are craftsman wherein” [4, 5].

Hippocrates recommended speed and cleanliness in surgery. His operations for rectal prolapse, empyema, fractures, dislocations, and head injuries indicate great surgical skill. His reluctance to operate on bladder stones may have due to his lack of knowledge of internal anatomy. The Greeks forbade dissection of the dead. Hippocrates left lithotomy to 'craftsmen', but did not identify those specialists. Were they Greek surgeons who had been to India or surgeons from India who were not his students? His immediate followers paid more attention to medical ethics and philosophy than to surgery [6]. Celsus, the next Greek to mention lithotomy, referred to Ammonius Lithotomus, a surgeon who practiced in Alexandria during the second century BC [7].

Soon after Alexander the Great founded Alexandria in 322 BC, it became the cultural and scientific center of Greece, where Euclid and Archimedes worked. After the

✉ John G. Raffensperger
j-raffensperger@northwestern.edu

V. Raveenthiran
vrthiran@gmail.com

¹ Children's Memorial Hospital, Chicago, USA

² Northwestern University, Evanston, USA

³ SRM Medical College, Chennai, India

death of Alexander, Ptolemy, his general, founded a research institute and a medical school [8]. Ammonius Lithotomus coined the term lithotomy in 276 BC [9]. His writings were most probably destroyed when Julius Caesar burned the Alexandrian library in 48 BC. Cornelius Celsus (25 BC–50 AD) cited Ammonius in his encyclopedia, ‘De Medicina’ [10]. Ammonius invented an instrument to break large stones for easier removal and was a skilled lithotomist. Celsus probably borrowed the description of lithotomy from Ammonius and it was later named after him as *Sectio Celsi*. Celsus advised operating during spring on boys 9–14 years of age, as follows:

“The surgeon after carefully paring his fingernails pressed the stone down to the perineum with a finger in the rectum and a hand on the epigastrium. He cut down on the neck of the bladder and removed the stone with a scoop; afterward, the wound was dressed with bandages soaked in strong vinegar and salt. When the bleeding stopped, he was placed in a tub of warm water” [11].

Celsus gave detailed instructions on how to position and hold the patient, the instruments, the incision, removal of the stone and the post-operative care. He warned that the removal of a large or spiculated stone through a small incision would cause more damage to the bladder neck than a larger incision. He made liberal use of antiseptics and also described the treatment of complications.

Celsus’s description of perineal lithotomy is almost identical to that found in the Sushruta Samhita. The Samhita (meaning ‘treatise’ in Sanskrit) was written by Sushruta who practiced Ayurvedic surgery in northern India, prior to 600 BC. If Hippocrates is the ‘Father of Western Medicine’, then Sushruta is rightfully the ‘Father of Surgery’ [12].

Unlike his Greek counterparts, Sushruta knew internal anatomy. According to Hindu tradition, dead bodies were incinerated rather than buried; the only exception was the first born male child, whose bodies were available for dissection. Sushruta learned anatomy from dead newborn babies [13]. He emphasized the need to treat children differently from adults and described many pediatric operations including the repair of cleft lips, hernias, and even colostomy for intestinal obstruction [14]. Here, his classic description of perineal lithotomy in children:

“A person of strong physique and un-agitated mind [the attendant] should be made first to sit on a level board or table as high as the knee-joint. The patient should then be made to lie on his back on the table placing the upper part of his body on the attendant’s lap, with his waist resting on an elevated cloth cushion. Then the elbows and knee-joints of the patient should be contracted and bound up with fastenings

(Sataka) or with linen (Figure 1). After that the umbilical region of the abdomen of the patient should be well rubbed with oil or clarified butter and the left side of the umbilical region should be pressed down with the closed fist so that the stone comes within reach of the operator. The surgeon should then introduce into the rectum, the second and third fingers of his left hand, duly anointed and with the nails well pared. Then the fingers should be carried upward towards the rope of the perineum (i.e., in the middle line) so as to bring the stone between the rectum and the penis, when it should be so firmly and strongly pressed as to look like an elevated Granthi (tumor), taking care that the bladder remains strongly contracted but at the same time even. An operation should not be proceeded with nor an attempt made to extract the stone in a case, where, the stone on being handled, the patient would be found to drop down motionless with his head bent down and his eyes fixed in a vacant stare like that of a dead man, as an extraction in such a case is sure to be followed by death. The operation should only be continued in the absence of such an occurrence.

An incision should then be made on the left side of the raphe of the perineum at the distance of a barleycorn and of sufficient width to allow the free egress of the stone. Several authorities recommend the opening to be on the right side of the raphe of

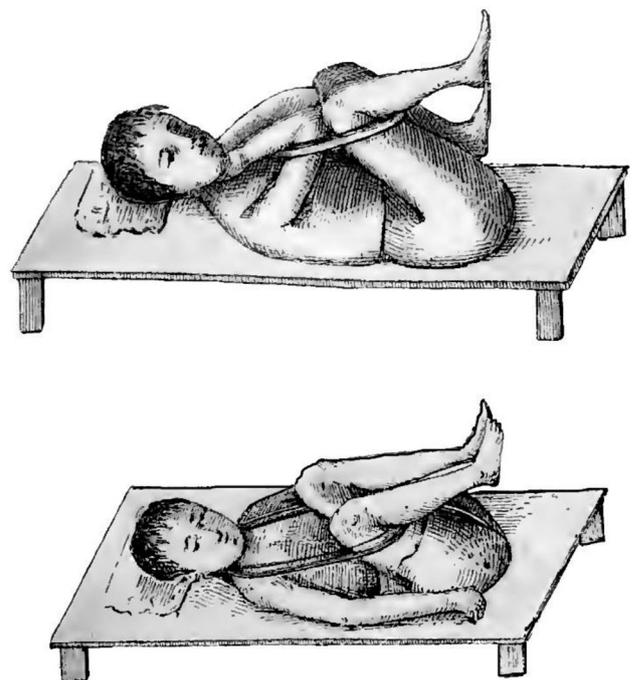


Fig. 1 Two methods of lithotomic position recommended by Sushruta (Adopted from Mukhopadhyaya 1912; public domain)

the perineum for the convenience of extracting the stone from its cavity so that it may not break into pieces nor leave any broken particles behind, however small, as they would in such a case be sure to grow larger again. Hence, the entire stone should be extracted with the help of forceps, the points of which are not too sharp.

After extraction of the stone, the patient should be made to sit in a Droni (cauldron) full of warm water and fomented, thereby. In doing so, the possibility of an accumulation of blood in the bladder will be prevented; however, if blood be accumulated therein, a decoction of ksheera trees should be injected into the bladder with the help of a Pushpa-netra (urethral catheter)” [15].

Sushruta used a scoop called *Agravaktra yantra* or *Sarpafana Sala* that resembles a snake hood (*sarpa* in Sanskrit means snake) and removed left over stone pieces by irrigation with a bulb syringe with a decoction of Ksheera tree (Figs. 2 and 3) [16].

Sushruta classified stones as *Vatasmari*, *Pittasmari*, and *Kaphasmari* (*Sleshmari*) [17]. *Asmari* is coined from two Sanskrit words ‘*azman*’ meaning ‘rock’ and ‘*bemari*’ meaning ‘disease’. The *Vata*, *Pitta*, and *Kapha* of Ayurveda can be equated with the neuromuscular, metabolic, and secretory nature of diseases. The *Kapha* stones were “white, smooth, glossy, large sized as big as a hen’s egg, and look like *Madhuka* flower (*Madhuca longifolia*)”. This description matches with the modern description of a triple phosphate stone. Sushruta further says that these stones are common with incomplete emptying as in neurogenic bladders. *Vata* types stones are “hard, dusky, rough, uneven, faceted, and spiculated like a *Kadamba* flower

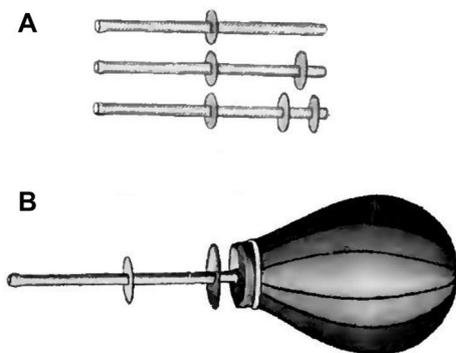


Fig. 2 Bladder irrigation devices used by Sushruta. A. *Pushpanetra* (*Pushpa* means flower; *netra* means eye or stalk). It appears that the urethral tubes are made either from or to resemble a flower stalk in their flexibility and slenderness; B. *Vasti Yantra* (Bladder syringe) mounted onto *pushpanetra* (Adopted from Mukhopadhyaya 1912; public domain)

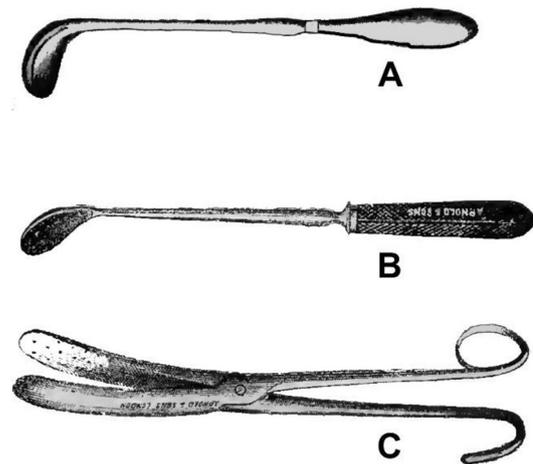


Fig. 3 Instruments used by Sushruta and others for stone removal. A. *Sarpafana Sala* (snake hooded spoon) used by Sushruta (also known as *Agravaktra Yantra*); B. Eribosea’s Lithotomy Scoop; C. Modern lithotomy forceps (Adopted from Mukhopadhyaya 1912; public domain)

(*Neolamarckia cadamba*)”, a description that matches oxalate stones. *Pittasmari* stones are reddish or yellowish black resembling *Bhallataka* fruit (*Semecarpus anacardium*), a description matching either oxalate stones covered with blood clots or xanthine stones (Fig. 4).

Knowledge of the operation could have reached Greece by trade routes that connected India with the west from pre-historic times [18]. Another avenue could have been the Greek mercenaries who accompanied Darius, a Persian Monarch, who in 538 BC, invaded the Indus valley [19]. Greek surgeons successfully treated Alexander the Great for life threatening wounds, including a one caused by a steel tipped arrow that penetrated the general’s chest causing hemorrhage and bubbling of the air from the wound [20]. They had to be skilled to successfully treat a hemothorax, and like surgeons of today, they would have sought out Indian surgeons and learned of Sushruta’s vesicolithotomy. Alexander’s invasion of India in 326 BC was just prior to the time of Ammonius [21].

During the first centuries of the Christian era, Greek science and medicine were transferred from Constantinople to Persia and Arabia [22]. Abillasiabil translated Sushruta Samhita into Arabic in the eighth century AD [23, 24]. His book, *Kitab-e-Susrud* (‘Book of Sushruta’) became a standard reference in Arabian Medicine. Rhazes (865–925 AD) and Avicenna (980–1037) repeatedly quoted Sushruta [25, 26]. Albucasis (936–1013 AD), an Islamic surgeon who practiced in Cordoba Spain, authored a chapter on bladder stones in children that appears to have been taken from the Sushruta Samhita [27]. He added a method of removing small stones that slipped into the urethra during surgical manipulations.

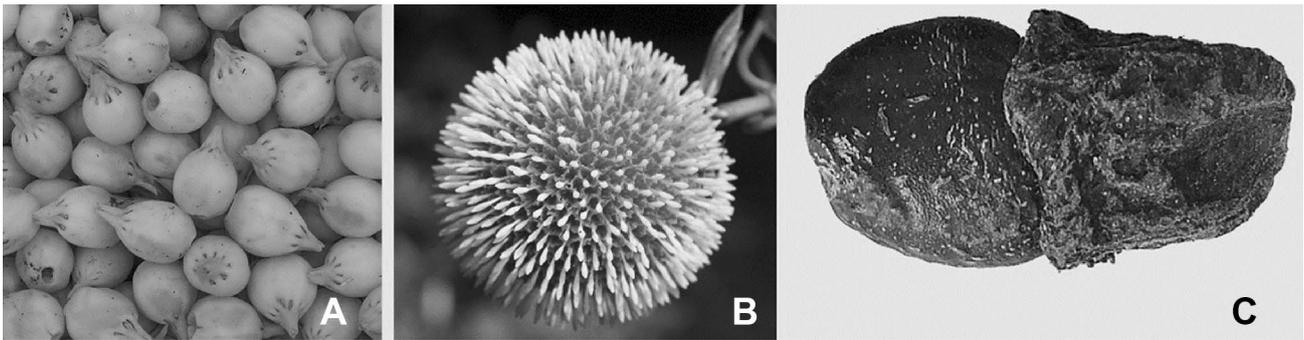


Fig. 4 Similes used by Sushruta to describe the appearance of different bladder stones. A. *Madhuka* flower (*Madhuca longifolia*) is likened with *Kaphasmari* that resemble smooth triple phosphate stones; B. *Kadamba* flower (*Neolamarckia cadamba*) is likened with *Vatasmari* that resemble spiked oxalate stones; C. *Bhallataka* fruit

(*Semecarpus anacardium*) is likened with *Pittasmari* that resemble xanthine stones (Photo credits to Gypsykpd, Aravindreddy, and Zell, respectively; modified and reproduced from Wikipedia under creative common license)

Itinerant, poorly trained lithotomists operated on patients with bladder stones during the dark ages, because the Church forbade skilled physicians, who were often clerics, from performing surgery. John Baptiste Morgagni (1682–1771) at Padua, one of the first physicians to dissect the human body to detect the cause of disease described bladder inflammation found at the autopsy of a 14-year-old boy who had died, in great pain, 21 h after an unskilled lithotomist had removed two small bladder stones [28]. He quoted both Hippocrates and Celsus and was skeptical of lithotomy. Morgagni suggested treatment with medicated water, prepared from the shells of oysters and experimented with injections of an effervescent mixture of alkali and acid into the bladders of dogs. He also observed teenage girls who had inserted needles or bodkins into their bladder through the urethra. Stones formed on these objects and eventually led urosepsis and death.

William Cheseldon (1688–1752), the leading English surgeon in the first half of the eighteenth century, brought perineal lithotomy in children to the peak of perfection [Fig. 5]. He apprenticed to a surgeon when he was 15 years of age and passed the examinations to become a barber surgeon after his 7-year apprenticeship. He taught anatomy at St. Thomas Hospital and based on human dissections, published “*Anatomy of the Human Body*” in 1713 [29]. Unlike earlier surgeons, Cheseldon used a urethral sound as a guide. He routinely did the operation in a little over 1 min and once in 53 s. Only 3 of 125 children under 10 years of age died [30]. This extraordinary survival rate, prior to anesthesia and antisepsis, attests to his dexterity. Cheseldon’s success is attributed to his perineal incision lateral to midline that avoided the urethra as described by Sushruta.

John Cooper Forster who published “*The Surgical Diseases of Children*” in 1860 used a sound in the urethra to guide a lateral perineal incision into the neck of the bladder



Fig. 5 William Cheseldon

and a forceps to remove the stone. The wound healed in 8–10 days [31]. His illustration of a child held in the lithotomy position is essentially the same as that used by Sushruta, except, that with anesthesia, a nurse, rather than two strong men held the patient [Fig. 6].

With the advent of antisepsis, a supra-pubic cystostomy became the operation of choice for the removal of stones. Bladder stones are now rare, but are seen in arid countries



Fig. 6 Lithotomy position from “The Surgical Diseases of Children” by John Cooper Forster

and in children with neurogenic bladders and after reconstruction for congenital deformities [32].

Author contributions JGR conceived the project and wrote the first draft. VR critically revised the manuscript and added references. Both authors approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors have no conflicts or commercial interest

References

1. Tefekli A, Cezayirli F (2013) The history of urinary stones: in parallel with civilization. *Sci World J* 2013:423964. <https://doi.org/10.1155/2013/423964>
2. Ellis H (2011) The early days of surgery for stones in the bladder. *J Perioper Pract* 21:179–180
3. Hippocrates on Airs Waters and Places; in Adams, F. [Tr] The Genuine works of Hippocrates [Vol 1] London Sydenham Society, 1829, 201
4. Nittis S (1939) Hippocratic Oath in reference to lithotomy. New interpretation with historical notes on castration. *Bull Hist Med* 7:719–728
5. Herr HW (2008) ‘I will not cut...’: the oath that defined urology. *Br J Urol Int* 102:769–771
6. Jouanna J, Allie N (2012) Greek medicine from Hippocrates to Galen: selected papers (Ed by Eijk P). Leiden; Boston
7. Serageldin I (2013) Ancient Alexandria and the dawn of medical science. *Glob Cardiol Sci Pract* 47:395–404
8. Fraser PM (2001) Ptolemaic Alexandria, vol 3. Clarendon Press, Oxford
9. Tsoucalas G, Sgantzios M (2017) Ammonius Lithotomos (3rd Century BC), the Alexandrian innovative surgeon who introduced lithoclastic cystotomy. *Surg Innov* 24:183–185
10. Celsus CA (1938) *De Medicina*, vol 7, translated by Spencer WG. Harvard University Press, Cambridge, MA, pp 26–28
11. *Ibid*, 28
12. Singh V (2017) Sushruta: the father of surgery. *Natl J Maxillofac Surg* 8:1–3
13. Bhishagratna KK (1907) Introduction. In: Bhisagratna KK (ed) An English translation of the Sushruta Samhita based on original Sanskrit text, vol 1. Self Publications, Calcutta, pp 1–67
14. Raffensperger JG (2012) Children’s surgery, a world wide history. McFarland & Company, London, pp 48–55
15. Sushruta S (1911) Chikista Sthana chapter 7—The medical treatment of Asmari (urinary calculus). In: Bhisagratna KK (ed) An English translation of the Sushruta Samhita based on original Sanskrit text, vol 2. Self publications, Calcutta, pp 329–337
16. Mukhopadhyaya G (1914) The surgical instruments of the Hindus, vol 2. Calcutta University Press, Calcutta, pp 79–80
17. Sushruta S, Nidana S (1911) Chapter 3—Urinary calculus. In: Bhisagratna KK (ed) An English translation of the Sushruta Samhita based on original Sanskrit text, vol 2. Self publishing, Calcutta, pp 25–30
18. Rawlinson HG (1916) Intercourse between ancient India and the western world, from the earliest time to the fall of Rome. Cambridge University Press, Cambridge, p 24
19. Adamson PB (1982) The military surgeon: his place in history. *J R Army Med Corps* 128:43–50
20. Machowiak Phillip A (2007) Postmortem solving histories great medical mysteries. College of Physicians, Philadelphia, p 60
21. *Ibid*, 60
22. *op.cit.* Raffensperger, pp 48–56
23. Raju VK (2003) Sushruta of ancient India. *Indian J Ophthalmol* 51(2):119–122
24. Hoernle AFR (1897) The Bower manuscript, (English Tr.). Archeological Survey of India, Calcutta
25. Changizi Ashtiyani S, Cyrus A (2010) Rhazes, a genius physician in diagnosis and treatment of kidney calculi in medical history. *Iran J Kidney Dis* 4:106–110
26. Madineh SM (2009) Avicenna’s Canon of medicine and modern urology: part-2: bladder calculi. *Urol J* 6:63–68
27. Abdel-Halim RE, Altwajiri AS, Elfaqih SR, Mitwalli AH (2003) Extraction of urinary bladder stone as described by Abul-Qasim Khalaf Ibn Abbas Alzahrawi (Albucasis) (325–404 H, 930–1013 AD), A translation of original text and a commentary. *Saudi Med J* 24:1283–1291
28. Morgagni JB (1960) The seats and causes of disease (book-3). (Translated by Alexander B), New York Academy of Medicine, New York, NY, pp 476, 496–497
29. Cope Z (1953) William Cheseldon. E. and S. Livingston, London
30. Cheseldon W (1943) A Treatise on the high operation for a stone. In: Leonardo RA (ed) History of surgery. Froben, New York, pp 207–208
31. Raffensperger JG (1969) A review of the first textbook of pediatric surgery in the English language. *J Pediatric Surg* 4(4):403–405
32. Lebowitz RL, Vargas B (1987) Stones in the urinary bladder in children and young adults. *Am J Radiol* 148:491–495

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.