Documenta Ophthalmologica **93:** 159–167, 1997.

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Sushruta: The father of Indian surgery and ophthalmology*

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Key words: cataract, trichiasis, pterygium, Hippocratic Oath, uveitis

Abstract. Sushruta is the most celebrated physician and surgeon in India. Though he practiced during the 5th century B.C., many of his contributions to medicine and surgery preceded similar discoveries in the Western world. Sushruta devotes a complete volume of his experiences to ophthalmologic diseases. In the *Uttar Tantrum*, Sushruta enumerates a sophisticated classification of eye diseases complete with signs, symptoms, prognosis, and medical/surgical interventions. In particular, Sushruta describes what may have been the first extracapsular cataract surgery using a sharply pointed instrument with a handle fashioned into a trough. His ability to manage many common eye conditions of the time with limited diagnostic aids is a testament to his virtuosity.

Introduction

The era before Sushruta is known as Vedic India when Indo-Aryans entered the region now known as the Punjab in 1500-2000 BC [1]. Medical knowledge during this time was transmitted orally through poetic hymns (Vedas), which consisted of songs or prayers. The four *Vedas* (Knowledge) were divided into *Rig* -"Praise", *Sama* -'Songs', *Yajur* -'Prayers', and *Atharva* -'Spells' and they reflected the religious backbone of these people [1]. Interspersed among the *Vedas* are verses on medicine, hygiene, and surgery. Treatment consisted of propitiatory rites, offerings, auspicious ablations, penances, purificatory rites, fasting, and incantations to gods and evil spirits. These were complemented by amulets, witchcraft, and magic [2]. The most recent Vedic manuscript, known as *Atharva-veda* (700-800 BC), is the chief source of Vedic medical knowledge; the precepts described form the foundation of Ayur-vedic medicine still in vogue in some parts of India [1].

Vedic physicians were divided into three types: *Shalya Vaidyas* (Surgeons), *Bhisaks* (Physicians), and *Bhisagatharvans* (Magic Doctors) [3]. Magicoreligious beliefs became increasingly prevalent as evidenced by the addition of two new subdivisions among physicians during the time of Sushruta around

* Read at the annual meeting of the Cogan Ophthalmic History Society, The National Library of Medicine, Bethesda, Maryland, March 15 and 16, 1996.

Table 1. Dateline of the Ancient World [4]

1500 BC	Edwin Smith Papyrus
800 BC	Period of Brahminic Medicine-Sushruta, Charaka
550 BC	Buddha, Confucius, Lao Tse lived
525 BC	Asclepius raised to rank of God of Medicine in Greece
460-361 BC	Hippocrates
338-323 BC	Alexander the Great conquers northern India

8th century B.C.: *Rogaharas* (physicians), *Shalyaharas* (surgeons), *Vishaharas* (Poison curers), *Krityaras* (demon-doctors), and *Bishag-Atharvans* (magic doctors) [3].

Discussion

The period between the seventh and first centuries BC saw an immense change in the thought processes all throughout the ancient world including Greece, China, Mesopotamia, and India (Table 1). In India, Sushruta ushered in the Golden Age of Surgery (600-800 BC) and effected the extinction of the long practiced magicoreligious medicine of Vedic India [2]. His ken is said to have been divinely inspired ultimately from Lord Brahma (The Creator) to Lord Indra (The Master of Gods), then to Lord Dhanvantari, and finally bestowed upon Sushruta [5]. He was a professor of Medicine at Benares University on the banks of the Ganges [6]. Though there is much controversy as to the exact dates that he lived, the Bower Manuscript, found in Turkestan and dated to the 5th century BC, mentions his name [7]. The original manuscript has not survived, only recensions are available. Most of the Samhita, meaning compendium, was compiled by Sushruta the Elder and later revised by Sushruta the Younger; this is evident by the style of Sanskrit in which each section is written [2]. The Samhita attempted to systematically arrange medical knowledge of the time; such an exact systemization suggests an extended experience and a high order of skill [2].

As a teacher, Sushruta was able to confer his wisdom, mold future physician/surgeons, and establish the original code of medical ethics. He taught medical students for a six-year period, during which he encouraged them to perform detailed, thorough physical examinations using all senses [2]. He advised them against unintelligent repetition from writings, for if one did he was 'like an ass with a burden of sandalwood, for he knoweth the weight, but not the value thereof'. Contrary to the Code of Manu, the Indian code of law, which considered the deceased body to be sacred, Sushruta stressed the importance of mastering anatomy on human cadavers. These were per-

Table 2. Examining with only his naked eye, he astutely describes several recognizable ocular conditions

Sanskrit	English	Translation
Kumbhika	External Hordeolum	"...a number of pustules (*Pidaka*) the size of a *Kumbhika* seed appearing on the joint of the eyelids and eyelashes that become inflamed after being burst.'
Vatahata-vartma	Ptosis	'...where the eyelid appears to be out of joint'
Nimesha	Dermatochalasia	'...constant wrinkling of the eyelids'
Prastaryarma	Scleritis	'...thin and extended swelling colored reddish blue on the sclera (*Sukla*).'
Lohitarma, Adhi-mansarma, Snayvarma, sirajala, and Armas	Pterygium	Sushruta provides many names for various stages of pterygia as if they were distinct entities rather than a spectrum.
—	Posterior Vitreous Detachment	'...when the second *Patala* is attacked, false images of gnats, flies, hairs, nets, cobwebs, or rings are seen and seem to be enveloped in a mist'
Abhi-shyanda	Conjunctivitis	'...pricking pain, horripilation, irritation in the eyes, roughness and parchedness of the organ, cold lacrimations, and headache'; this may lead to *Adhimantha* if not treated properly
Adhi-mantha	Uveitis	Several types; *Vataja Adhi-mantha* (Shingles)'...eye becomes cloudy and seems as if being torn out attended with an irritating, piercing, and cutting pain, as well as with a swelling of the local flesh, and half of the head on the side of the affected eye is afflicted with a twisting and cracking sensation, local swelling, shivering, and pain'
Gambhirika	Pupillary Block *Drishti* Glaucoma	'...due to the deranged *Vayu*, in which the (pupil) is contracted and deformed and sinks into the socket, attended with an extreme pain'.

formed primarily on corpses of infants less than two years of age; all other corpses were cremated precluding their dissection [3,8]. The cadavers were wrapped in grass and allowed to decompose in river water for seven days; layer by layer of the body was scrubbed away with a brush and structural details were studied [1]. Upon graduation, every student took an oath, which was similar to the Hippocratic Oath writtten four centuries later, allowing them to commence treating patients: 'Thou shalt renounce lust, anger, greed,

ignorance, vanity, egotistic feelings, envy, harshness, falsehood...nay all acts that soil the good name of a man...Live the life of a truthful, self controlled anchorite and be obedient and respectful towards thy preceptor...Thou shalt help with thy professional skill the helpless and those who shall come to thee from afar...'.[2]

In the realm of medicine, Sushruta had incredible insight into and interesting theories on the pathogenesis of disease. He confidently describes 1120 'specific' disease entities [4]. He was the first to attribute malaria to the mosquito and the plague to rats. He was the first to diagnose diabetes by tasting urine of affected individuals and describing it as sweet as honey [6]. He describes three physiological factors: *Vayu* corresponding to 'nerve force' which sets the whole organism into motion; *Pittam* referring to metabolism of tissue and the heat it produces (*Alochaka* is the subtype indicating the metabolic process in the substance of the *Drishti* (retina) which gives rise to visual sensation); and *Kaphah* which is that part of chyle that fills all the intercellular spaces of the body, thus 'holding them together and preventing the dreadful combustion which would otherwise occur by organic heat (metabolism) [9]', When these three forces are out of balance, they are said to have been transformed into *Doshas*. These *Doshas* are then remedied either surgically or medicinally using mixtures of 760 different plants, milk from various sources (i.e. cows, camels, humans, elephants, and goats), and meats of various animals and fishes [9].

It is in surgery that Sushruta excelled beyond his contemporaries in the ancient world. Not only did he devise novel procedures, but he also designed many surgical instruments (*vide infra*). Sushruta describes surgery as '...the 1st and highest division of the healing art...superior in producing instantaneous effects...least liable to fallacy, pure in itself, perpetual in its applicability, the worthy produce of heaven, and the sure source of fame on Earth' [9]. Nonetheless, Sushruta quickly admonishes against forgetting one's knowledge of medicine for 'He who only knows one branch of his art, is like a bird with one wing' [9]. Sushruta described and used 101 blunt instruments and 20 sharp instruments which should have 'an edge so fine as to divide the hairs on the skin' [9]. They were constructed after the shape of beasts and bird [4]. Sutures were fashioned from flax, hemp, bark fiber, or horse/human hair [1]. Magnets were even employed to remove metallic foreign bodies [3]. He describes eight basic types of surgical procedures: extraction of solid bodies (*Ahrya*), excising (*Bhedya*, i.e., pterygium), incising(*Chedya*), probing(*Eshya*), scarifying (*Lekhya*, i.e., chalazia, styes, and recalcitrant pterygia), suturing (*Sivya*), puncturing(*Vedhya*), and evacuation of fluids (*Visravaniya*). His medical students were taught these techniques on household objects: incisions on squash and cucumber; scarifications on stretched skins; punctures on

bladders of dead animals or leather bags full of water; venesection on blood vessels of dead animals or stems of the Lotus plant; suturing on cloth, skin, or hide; and cautery on meats [9].

His contributions to surgery include performing laparotomies to deliver babies in maternal/fetal distress, removing gallstones and urinary calculi, and using the heads and mandibles of large black ants to reconnect transected intestines [2]. Additionally, he was the first to describe the transplantation of sensible skin flaps and grafts. Using a leaf from a tree, a graft was fashioned from the cheek or adjoining part. Skin was also procured from the forehead with its blood supply and rotated to cover the nose. The region for transplantation was then scarified. The graft was then secured with suture and needle. These skin grafts were primarily used for rhinoplasty (noses were cut as punishment for adultery) and repair of disfigured ear lobes (from heavy earrings) [6].

Sushruta reserves discussion of ocular anatomy and pathology in the final sections of the Samhita called the *Uttara Tantra* (Chapters 1-19). He describes seventy-six eye (*Nayana-Budbada*) diseases, fifty-one of which are surgically treated. Reading through the *Uttar Tantram*, one is impressed with Sushruta's keen organizational and observational skills (Table 2). Disease processes are grouped anatomically, pathophysiologically, and by treatment modalities. For each treatment modality, he provides guidelines for when the treatment is satisfactory, deficient, or excessive and methods of dealing with them. Furthermore, each section discusses which diseases are amenable to treatment and those which are incurable (for example: Glaucoma [*Gambhirika*]-incurable; Uveitis [*Adhi-mantha*]- curable; Cataract [*Kacha*] - Palliative/temporary cures; Trichiasis [*Pakshma-kopa*]-palliative) [9].

According to Sushruta, the eye, which 'resembles the teat of a cow', is composed of five basic elements: the solid earth (*Bhu*) form muscles, heat (*Agni*) is in the blood that courses in its veins/arteries, *vayu* forms the black part (Iris/pupil), the fluid element (*Jala*) forms the lucid part (Vitreous), and the void (*Akasa*) forms the lacrimal ducts/sacs for discharge of secretions. Anatomically, he outlines five subdivisions (*Mandalas*) of the eye: Eyelashes (*Pakshma-mandala*); Eyelid (*Vartma-mandala*); Sclera/Cornea (*Sveta[or Sukla]-mandala*); Choroid (*Krishna-mandala*); and Pupil (*Drishti-mandala*), which 'looks like a hole and is the size of a Lentil seed' [9]. *Sandhis* represent the 'joints' where the mandalas bind/connect. An example of a disease involving one of the *Sandhis* is allergic blepharitis (*Krimi-granthi*): 'a swelling (*Granthi*) characterized by itching at the joining of the eyelashes with the eyeli' [9].

Medical treatment for these ocular conditions was formulated according to which component of the *Dosha* was predominantly abnormal. Matured

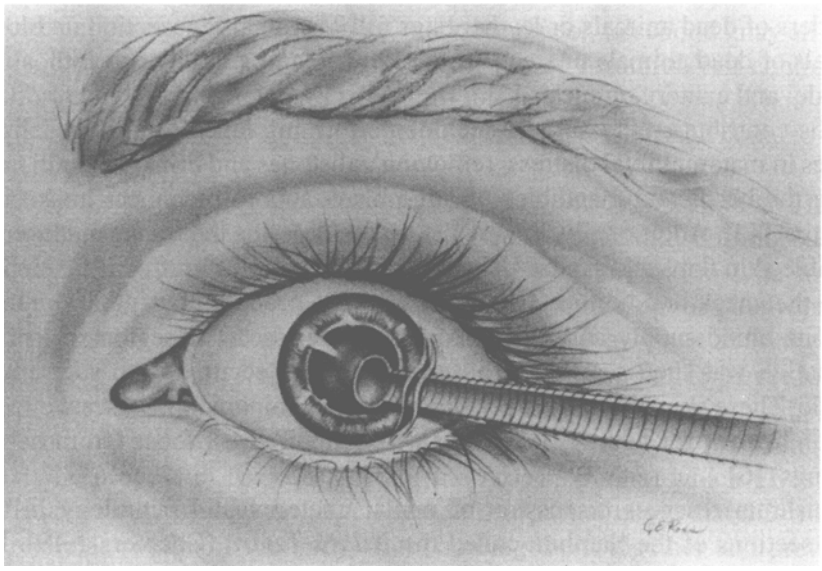

Figure 1. Drawing of Sushruta's technique for cataract surgery. The *Yava Vaktra Salaka* enters through the limbus.

clarified butter (ghee), breast milk, and Saindhava salts were frequently used in addition to plants and meats in the form of eyedrops (*Aschyotana*, made by folding and squeezing materials through a piece of silk), salves (*Anjana*), snuffs(*Nasya*), and fumigation (*Dhuma*). Additionally, linen-soaked bandages, venesections, soothing measures (*Tarpana*), and emetics/purgatives were employed [9].

As one would expect in a region so close to the equator, ocular conditions sensitive to ultraviolet light such as cataract and pterygia were common maladies. In addition to the technique of cataract extraction, Sushruta describes such modern concepts as antisepsis, anesthesia, and postoperative care. The following is a direct translation from the original Sanskrit of what may be the first extracapsular cataract extraction:

> '...This procedure is auspiciously performed primarily in the warm season... [Preoperatively] the skin is rubbed with a pledget of cotton saturated with an oily medicinal followed by a heated bath. The patient is given a light refreshment. The sick room is fumigated with vapours of white mustard, bdellium, Nimva leaves, and the resinous gums of shala trees (in order to rid the area of insects and the diseases they harbor)...Incense of cannabis is used in addition to wine for sedation...

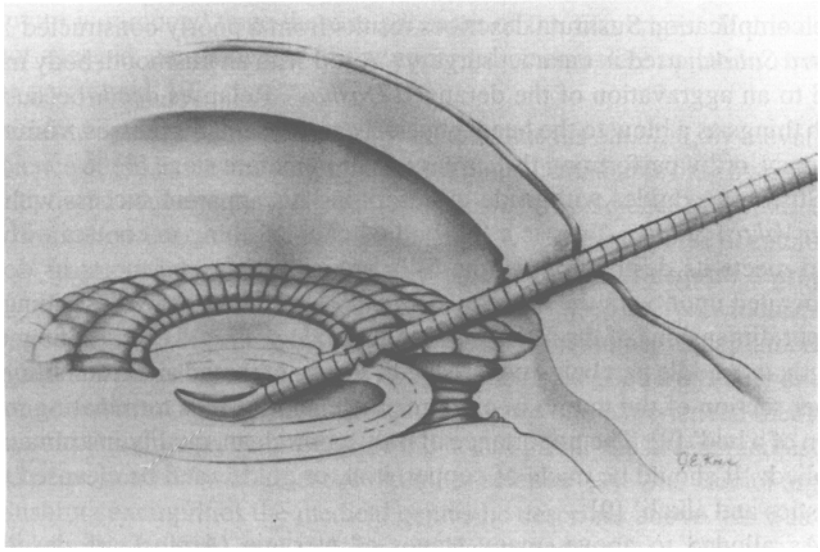

Figure 2. Incising the lens with the *Yava Vaktra Salaka.*

...[Technique] The patient sits on a high stool with surgeon facing him. The hands are secured with proper fastenings. Patient is asked to look at his own nose while the surgeon rests his little finger on the (bony margin of the outer angle of the orbit), holding a *Yava Vaktra Salaka* between his thumb, index, and middle finger. The left eye should be pierced with the right hand, and vice versa. The eye is entered at the junction of the medial and lateral two-thirds of the outer portion of the sclera (i.e., limbus) (Figure 1). If a sound is produced followed by a gushing of watery fluid, the needle is in the correct place, but if the puncture is followed by bleeding, it means that it is misplaced. The eye is then sprinkled with breast milk. Care is taken to avoid blood vessels in the region. The tip is then made to incise the (anterior capsule) of the lens (Figure 2) [10]. With the needle in this position, the patient is asked to blow down the nostril, while closing the opposite nare. After this, lens material (*Kapha*) is seen coming alongside the needle. When the patient is able to perceive objects, the needle is removed...[Postoperatively] indigenous roots, leaves, and ghee are applied with a linen bandage. Patient then lies flat and is asked not to eructate, sneeze, cough or move. The eye is examined every fourth day for ten days. If the whitish material recurs, the same procedure is repeated...' [9].

Complications of cataract surgery including bleeding, excessive pain, and discomfort are recognized and various medicinal treatments are explained.

One complication Sushruta describes results from a poorly constructed *Yava Vaktra Salaka*, used in cataract surgery: 'A rod with an unsmooth body might lead to an aggravation of the deranged *Doshas*'. Relapses occur because of such things as a blow to the head, physical excess, sexual excesses, vomiting, epilepsy, or by performing the surgery at an immature stage [9].

Sushruta exhudes with pride in describing his apparent success with the *Yava Vaktra Salaka*: 'Just as a full-bodied cloud coming in contact with the wind meets its destruction, so the fully aggravated *Dosha* meets its doom, if operated upon with the surgeon's *Salaka*'. He continues by describing the proper dimensions of the *Yava Vaktra Salaka*: '...it should be eight fingers in length, its middle part being covered with strings of thread and resembling the upper section of the thumb in circumference and its ends terminating in the form of a bud' [9]. The importance of only using clean, quality instruments is implied: 'It should be made of copper, iron, or gold.... and be cleansed with caustics and alkali' [9].

As alluded to above, many stages of pterygia (*Armas*) are described as distinct diseases. Once medical treatment with topical drops and salves was exhausted, surgical excision of the inflamed pterygium was considered. Though instrumentation and peri-operative; medicinals have changed, the following exerpt illustrates a technique quite similar to those used today:

> '...[Preoperatively] The eye is irritated with *Saindhava* salt and soaked with a warm compress. [Technique] The patient faces the surgeon while sitting and is asked to look at the interior corner of his affected eye (*Apanga*). The lids are held wide apart and the pterygium is secured with a hook (*Vadisa*) and held with a threaded needle (*Muchundi*), this is then excised at its base with a *Mandalagra* instrument. The root of the pterygium should be pushed asunder from the cornea and then removed. [Postoperatively] The area is then rubbed with a compound made of various salts, fomented, and bandaged for three days...This will recur if not properly excised'

Treatment of trichiasis (*Pakshma-kopa*) was also a common procedure. This may been secondary to widespread trachoma endemic to the subcontinent during this era. The following description has been likened to the Jaesche-Arlte procedure used by oculoplastic surgeons in modern times:

> '...After being treated with *Sneha* (a special diet), the patient sits facing the surgeon. An excision in the shape and size of a barley corn should be made in the eyelid horizontally parallel leaving two parts below the eye-brow and one part above the eyelashes. The surgeon should then suture up the two edges with horse's hair. An application of honey and ghee should be applied. A piece of linen should be tied round the forehead and the horse's hair, sewing up the operated part should be attached thereto. The

suture is removed once there is adhesion of the two edges...If this does not succeed, cauterization of the upper lid or complete epilation should be performed' [9].

Sushruta concludes his *Uttar Tantrum*, and thus his *Samhita*, by elevating the science of medicine and surgery to a new plateau attainable only by persons of exceptional education, experience, and reason: 'The Science of medicine is as incomprehensible as the ocean...Dull people who are incapable of catching the real import of the Science of reasoning would fail to acquire a proper insight into the Science of medicine if dealt with elaborately in thousands of verses. The occult principles of the Science of medicine, as explained in these pages, would, therefore, sprout and grow and bear good fruits only under the congenial heart of a medical genius. A learned and experienced medical man would therefore try to understand the occult principles herein inculcated with due caution and with reference to other science' [9]. One cannot argue that Sushruta exemplifies the medical genius he describes above. He was by any standards a brilliant academician, physician, and surgeon. His legacy to medicine and surgery surpassed not only his contemporaries but also of those who were to enter the medical arena in the centuries to come.

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