# Abul-Qāsim Al-Zahrāwi: The Great and Pioneer Muslim Surgeon and Inventor of many Surgical Instruments

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## Abstract

*Abu'l-Qāsim Khalaf b. al-'Abbās al-Zahrāwi (936-1013 AD) can be rightly called the father of modern surgery. He was a physician, surgeon and Chemist who not only used ancient knowledge in his practice but also introduced new surgical methods and surgical instruments. He wrote a 30 volume medical book, al-Taṣrīf li man 'ajaza 'an al-Tālīf (An Aid for those who lack the capacity to Read), in which he wrote on medicine, surgery, ophthalmology, orthopedics, pharmacology and nutrition. He discussed in his work more than 300 diseases and its treatment. Al-Zahrāwi being a Muslim also put great emphasis on medical ethics. He advised his pupils to keep the interest of their patients supreme above every kind of greed.*

**Keywords:** Al-Zahrāwi, Physician, Surgeon, Chemist, Inventor of surgical instruments, al-Taṣrīf

## Introduction:

Islamic Civilization has given lot of magnificent legacies to the humanity, however, after the decline of Muslims' rule those achievements have gone into oblivion. Generally the impression in the modern world is that whatever Scientific or other achievements have been made are accomplished by the Western Civilization, which is not totally correct. There is no doubt that the Western world has given many good things to the welfare of humanity but the Muslims have also played an important role in the advancement of science and other related fields. After the decline of Greeks and Romans till the beginning of Renaissance, a period which is known in the western history as Dark Ages, in the same period the Muslims' knowledge flourished. Their scientists made great achievements which were used by the western world even after many centuries. Among these great scientists one was Abu'l-Qāsim Khalaf Ibn al-'Abbās Al-Zahrāwi, a surgeon, physician, orthopedist, ophthalmologist, pharmacist, anatomist etc. He was so versatile in his work that his impact can be felt in every field of medicines. He was not only a great doctor but was also a dedicated teacher to his students, whom he fondly called "My Sons."

Al-Zahrāwi used his skills for the welfare of humanity instead of accumulation of personal wealth, though he could have done that very easily as the doctor of his caliber was in great demand. Instead he treated half of his patients without any charges. Another important aspect of his and other contemporary doctors was that they did not discriminate the patients on the basis of anything be that religion, race, nationality, culture, gender etc. All patients were treated equally and were given every possible care until they were fully recovered. The Muslim rulers of Spain provided every facility to the patients without any charges making their government and state a welfare one, an idea which the western world imitated later.

Al-Zahrāwi, besides practicing medicines also recorded his experience and knowledge in the form of a 30 volume book titled shortly *al-Tasfir*. The information he provided in this encyclopedic work was incomparable. Volumes 28 and 30 of the book, which deal with preparation of simple drugs and different surgeries, have become world known and have

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been translated in many ancient and contemporary languages. The other volumes too are containing mines of information but have not been fully given attention. *Al-Tasfir* has played an important role in the dissemination of medical knowledge and has remained for centuries a standard reference book in the important medicine teaching institutes of the western world.

## Al-Zahrāwi:

One can notice a great omission in any current article on medicine of a period of almost one thousand years beginning from the Greco-Roman period till Renaissance which gives an impression that nothing worthy of mention was developed during this period. In Europe this period is known as the Dark Ages. But it is not true as during the very same period the Muslim scientists made great progress in botany, pharmacy and chemistry. During the period from 9th to 16th centuries the Muslim scientists made significant developments in the field of medicine and other branches of sciences.[1]

One of the greatest Muslim scientists of this period was al-Zahrāwi, who is also known by more than a dozen other names in European languages, such as Abulcases, Albucasis, Bulcasis, Bulcasim, Bulcari, Alzahawi, Ezzahrwi, Zahravius, Alcarani, Alsarani, Aicaravi, Alcaravius, Alsahrawi etc. He was born in a city called Al-Zahrā six miles northwest of Cordoba (al-Andalus) between 936 and 940 AD.[2] At that time Al-Zahrā was well established center of civilization where there were many institutes of knowledge and wisdom. On the other hand the present day developed Europe was plunged in the dark ages of its history. In the 10th century al Zahrā was the capital of al Andalus and was known for its grandeur and prosperity. The name in itself means "City of Flowers" or "Blooming City". "Referred to as the forgotten Versailles of the Middle Ages, it was renowned for its dazzling complex of palaces full of wondrous treasures. Although not as well-known as the Alhambra in Granada, Spain, descriptions of Al Zahrā's marvels by writers and travelers makes it the most magnificent monument of Islamic Spain. However, the city shined and flourished for only 80 years – it was sacked by Berbers from North Africa, Islamic purists who considered the Muslim culture it represented far too liberal in its interpretation of the Qur'ān. The raid effectively wiped the city off the map for a millennium – it laid forgotten and buried. It was only ninety years ago that the ruins were discovered and only in recent times did the Spanish government painstakingly begin to restore some of the palace-ruins."[3]

Al-Zahrāwi hailed from a family who traced their origins to the anṣār (the local inhabitants of Medina who helped the Holy Prophet and believers after their migration to Medina).[4] He lived, studied and practiced medicine and surgery in his home town until shortly his death in 1013 AD, two years later than the sack of al-Zahrā. Due to the plunder, loot and destruction of al-Zahrā little was known about its illustrious son al-Zahrāwi until Andalusian scholar Abū Muḥammad b. Ḥazm (993-1064 AD) mentioned him as great physician and surgeon of Moorish Spain. The first known biography of this great Muslim surgeon-physician appeared in al-Ḥumaydi's *Jadhwat al-Muqtabis* (On Andalusian Savants), completed six decades later after the death of al-Zahrāwi. Al-Zahrāwi had devoted his entire life to the practice, growth and development of medicine in general and surgery in particular. His professional life spanned over a period of 50 years. Once he became known to the western world, he had tremendous influence on them in the field of surgery. He was called "without doubt the chief of all surgeons" by Pietro Argallata.[5] He developed the field of surgery at a time when in Europe this field of medicine was looked down upon and butchers and

barbers used to carry out the surgery.[6] The Council of Tours declared in 1163 AD, "Surgery is to be abandoned by the schools of medicine and by all decent physicians."[7]

Al-Zahrāwi was an innovative surgeon who invented many new techniques in surgery and many doctors of his time visited him from far flung areas to learn from him. He also worked as personal physician of the Andalusian Caliph Abdul Rahman the Third, also known as Abdul Rahman Al-Nasser, i.e. the victorious.[8] Al-Zahrāwi was not only a good physician/surgeon but also a good human being. He used his skills for the welfare of needy without any greed and expectations. A writer notes about him, "I have been told that al Zahrāwi – God's mercy on him – was extremely ascetic; that half of his work every day he did without fee as charity;.... Historians analyzing his writings say that in his book, he frequently addressed his students as his "sons" – the generation following him in the medical profession."[9] He advised his students, to take all possible care in the treatment of patients. He preferred the use of medicines over surgery as much as possible. If surgery was unavoidable then he advised the maximum precautions for the safety and minimum pain to the patients. He advised his students that maximum instruments should be ready for any kind of surgery during operations; however, he advised them as well to be ready for any consequences during the process of surgery. He also put great emphasis on medical ethics and ensured that when a female patient was examined or treated, a trained midwife was also present.[10]

**Cordoba:**

At the time when al-Zahrāwi lived Cordoba was a blustering and developed city, which could be rightly called one of the wonders of the world. At its peak period it had a population of one million with 200,000 houses. There were 600 Mosques, 900 public baths, 80 schools and 27 High Schools. It was having 300 libraries with a collection of 1 million books. That was the time when the status of a person and his wealth was estimated by his education and the number of books he possessed. The caliph Al Nasser had a personal collection of 30,000 books in his place, many of which he had read and made comments as footnotes. As compared to Cordoba, London and Rome looked small towns at that time as the former had only 18,000 and the latter a total of 50,000 populations. That was the time when the largest library of Europe, The Library of the monastery of St. Gall in Switzerland had a total collection of 35 books only. Thus Cordoba can be rightly called at the time the centre of European knowledge. Lane-Poole the Italian Poet wrote in the 13th Century:

"To Cordoba belong all the beauty and ornament

That delights the eye, or dazzles the sight

The dress is of banners of learning, well knit together

By the men of science and the masters of every art."[11]

The Islamic Civilization of the time also gave great importance to hospitals and can be considered a gift to the humanity. The hospitals at that time were grandiosely constructed or else were established in palaces. The hospitals had separate facilities for male and female patients and patients of different diseases were treated at separate wards having facilities for treatment of fever, infections, mania, eye conditions, diarrhea, and female disorders. Each hospital had:

→ A pharmacy dispensing free drugs to patients,

→ A mosque for Muslim as well as a chapel for Christian patients,

→ A conference room, and

→ A library.

Hospitals were also used as teaching centers for medical students and only qualified doctors were allowed to practice medicine, for which they needed a certificate from the government official known as "*muḥtasib*." For quality control of drugs Pharmacists were appointed whose responsibility was to regularly inspect drugs quality in the market.[12]

The hospitals at that time provided maximum facilities to the patients and were to keep all patients in the hospital until they were cured. The hospitals were required to provide equal kind of treatment facilities to all patients without any charges. The patients were also treated without any discrimination being made between locals or foreigners. There was also no discrimination between 'strong or weak, high or low class, rich or poor, employed or unemployed, blind or not, physically or mentally ill, learned or illiterate.' The service to patients was considered as duty from Almighty Allah. Due to this magnificent free service and treatment, no wonder, sometimes healthy individuals faked to get these royal facilities.[13]

Physicians of the time were having high status in the society, who were earning a hefty amount reaching as much as 4.9 million dirhams per year when cost of living was not more than 1000 dhs per year. At this glorious period al-Zahrāwi had practiced medicines.[14]

### *Al*-Taṣrīf:

The contributions of al-Zahrāwi in the field of science are multi-faceted, which includes surgery, medicines, pharmacy, orthopedics, ophthalmology, nutrition etc. etc. However his 30 volume encyclopedic work known as *al-Taṣrīf,* in full *Kitāb al-Taṣrīf li-man 'ajiza 'an al-tālif* (The disposal of medical knowledge to he who is not able to compile by himself), which was written during his 50 years of training, teaching and practice can be termed his greatest achievement, as it provided treasure of knowledge on medicine-surgery and its related fields.[15] The book was completed in 1000 AD. Al-Zahrāwi wrote about the book in these words:

> "Whatever I know, I owe solely to my assiduous reading of books of the ancients, and to my desire to understand and appropriate this science. To this I have added the observations and experience of my whole life."[16]

*Al-Taṣrīf* was translated for the first time in Latin by Gerard of Cremona at Toledo in the 2nd half of the 12th century under the title of *Liber Alsaharvi de cirurgia* and remained for a long time a major source book on medicine in the educational institutions of Europe from 12th to 17th centuries. Its influence on French and Italian physicians/surgeons was enormous. In 1497 Gerard's version was first printed from Venice followed by many editions in the next century. In 1778 John Channing published the modern version of the book with many explanations in Latin from Oxford. In 1861 the book's first translation into a modern language was published by Lucien Leclerc in French with the title of *La Chirurgie d'Albucassis* from Paris.[17] In the 2nd half of the 20th century the original Arabic text with English translation was made available by the classic work of Lewis and Spink *Albucasis on Surgery and Instruments,* which was published in 1973 by Wellcome Institute of the History of Medicine (London, UK). In 1993 the Arabic text of volume 30 was published in Riyadh, Saudi Arabia as *al-Jirāḥa: Al-Maqāl al-Thalāthūn, Al-Taṣrīf Li-man 'ajaza 'an al-Tālīf,* edited by A. al-Naser and A. al-Twajiri, and published by Al-Farazdaq Press. Sixteen years later from Damascus

another edition was published as *Kitāb al-Zahrāwi fi al-Ṭibb li-'amal al-Jarrāḥīn,* edited by M. Zakoor, which was published by the Syrian Ministry of Culture.[18]

In the modern times many researchers have carried out extensive evaluation of *At-Taṣrīf,* the volume on surgery and techniques along with other related topics. The good example of such work is that of Prof. Rabie E. Abdel Halim of the Urology Department of the King Abdel-Aziz and King Saud Universities, Saudi Arabia. He has published the results of his work between 1985-2003. In spite of many such works there are still many general and special surgical topics, which have not been yet evaluated by the modern researchers. Another important thing to be highlighted is that in spite of the passage of more than 1000 years to the death of al-Zahrāwi extensive studies have been carried out only on his 30th Volume of the book which deals with surgery and related topics. Besides that volume 28, which deals with the preparation of different simple drugs, has also been given some attention by the researchers."…the other 28 *maqālās* [papers] remained totally inaccessible being in the form of unedited manuscript dispersed all over the world. However, in 1963, Sami Khalaf Hamameh and Glen Sannedecker, in their classic work *A Pharmaceutical View of Abulcasis Al-Zahrāwi in Moorish Spain,* translated and commented on excerpts of the 25th *maqala* of *al-Taṣrīf* dealing with the ingredients and manufacturing of ointments (*adhan*) and its uses in medical treatment, thus raising fresh interest in the medical therapy, material medica and pharmacy aspects of *al-Taṣrīf*, almost overlooked by the widespread fame of the surgical aspects of its 30th *maqāla*. Still, until now, there are 25 more pharmaceutical *maqālās* in the *al-Taṣrīf* encyclopedia of al-Zahrāwi not yet fully edited or studied."[19]

The discussion on surgery in *al-Taṣrīf* are spread over th ree books or treatises. "Book 1 deals with cauterization, book II with general surgery, including traumatology, obstetrics, gynecology, and urology, and Book III with bone setting."[20]

Lately it has come to the notice that the Kuwait Foundation for the Advancement of Sciences has published the 2nd Volume of *al-Taṣrīf*, which was edited by Dr. Sobhi Hamami and published in 2004. It is a remarkable step forward towards understanding of many techniques of surgery, diagnosis, cure and other related fields of medicines discussed by al-Zahrāwi in his monumental work. It is also a great contribution for the progress of humanity in the field of medicine. As Will Durant has stated, "civilizations are units in a larger whole, whose name is 'history', they do not disappear. The past always rolls into the present."[21]

Two of its treatises are very important, firstly, the treatise known in Latin as *Liber servitories de preeparatione medicinarum simplicium,* which explains the processes of 'chemical preparations, tablet making, filtering of extracts and related pharmaceutical techniques. This treatise was printed in Venice in 1471 by Nicolaus Jensen.' The 2nd treatise of significance is on surgery which can be rightly called his greatest contribution. It is known to be the first work in Arabic that independently explained surgical processes, which also included pictures of different surgical instruments, many of which al-Zahrāwi invented himself. These pictures are approximately 200, whose method of use was also explained by al-Zahrāwi.[22]

*Al-Taṣrīf* has tremendous impact on the writings of medicines in the west. The French surgeon Guy de Chauliac in his "Great Surgery', completed in about 1363, quoted *al-Taṣrīf* over 200 times. Another French surgeon, Jaques Delechamps (1513-1588) extensively quoted *al-Taṣrīf* in his work. This shows the wide spread influence and prestige that al-Zahrāwi held throughout Middle Ages up to the Renaissance.[23]

Analyzing the impact of *al-Taṣrīf* on Europe, The Encyclopedia Britannica notes that it "stood for nearly 500 years as a leading textbook on surgery in Europe, preferred for its concise lucidity even to the classic Greek authority Gallen."[24]

In *al-Taṣrīf* besides providing information on treatment of diseases he also discussed the importance of medical ethics. Al-Zahrāwi put great stress on the doctor-patient relationship irrespective of the patient's social status as he believed that without the trust of patient doctors cannot perform to the best of his/her abilities. He emphasized great care in the process of diagnosis and treatment of the patient. He emphasized upon ethical norms in practice of medicine and warned against dubious practices to be adopted by medical practitioners for economic gains. He also put great emphasis on the welfare of the patients.[25]

## His Instruments and His Method of Treatment of Diseases:

Al-Zahrāwi takes a holistic approach towards medicines. He suggested prevention besides discussing symptoms, diagnosis and treatment. He also put emphasis on the importance of healthy diet plan; what to eat and what to avoid. He has especially highlighted the negative effects of the use of alcohol. He writes:

> "[Alcohol causes] general weakness of most of the nerves of the body, difficulties in articulation, weakness of voluntary movements, arthralgias, gout, etc., disturbances of the liver which causes tumors and obstructions which is a definite cause of ascites and general ill health."[26]

In *al-Taṣrīf* al-Zahrāwi has elaborated the causes, symptoms and cures of over 300 diseases.[27] In his book he has also discussed "…theories on the upbringing of children and youth and on the care of the aged and convalescent. In the section on pharmacology and therapeutics, he covers areas such as cardiac drugs, emetics, laxatives, cosmetology, dietetics, material medica, weights and measures and drug substitution."[28]

In the 30th volume of *al-Taṣrīf*, al-Zahrāwi has elaborated all the knowledge of contemporary period on surgery. In his book al-Zahrāwi has given complete and rational detail of treatment of diseases. The range of operations al-Zahrāwi has covered is amazing. "In this treatise al-Zahrāwi discussed cauterization, bloodletting, midwifery, and obstetrics and the treatment of wounds. He described the exposure and division of the temporal artery to relieve certain types of headaches, diversion of urine into the rectum, reduction mammoplasty for excessively large breasts and the extraction of cataracts. He wrote extensively about injuries to bones and joints, even mentioning fractures of the nasal bones and the vertebrae. In fact 'Kocher's method' for reducing a dislocated shoulder was described in *al-Taṣrīf* long before Kocher was born! Al Zahrāwi outlined the use of caustics in surgery, fully described tonsillectomy, tracheotomy and craniotomy- operations he had performed on a dead foetus. He explained how to use a hook to extract a polyp tiom (sic.) the nose, how to use a bulb syringe he had invented for giving enemas to children and how to use a metallic bladder syringe and speculum to extract bladder stones."[29]

Al-Zahrāwi was the inventor of many treatments which are even now in use and known with different names. It is believed that he was the first to use "…the so-called "Walcher position" in obstetrics; the first to depict dental arches, tongue depressors and lead catheters and the first to describe clearly the hereditary circumstances surrounding haemophilia. He also described ligaturing of blood vessels long before Ambriose Pare."[30]

Al-Zahrāwi was the first to emphasize the importance of basic sciences, he writes that,

> "Before practicing, one should be familiar with the science of anatomy and the functions of organs so that he will understand them, recognize their shape, understand their connections, and know their borders. Also he should know the bones, nerves, and muscles, their numbers, their origin and insertions, the arteries and the veins, their start and end. These anatomical and physiological bases are important, and as said by Hippocrates: 'there are many physicians by title and a few by practice'. If one does not comprehend the anatomy and physiology, he may commit a mistake that can kill the patient. I have seen someone, who pretend to be a surgeon, incised an aneurysm in the neck of a woman, mistaking it for an abscess. The woman bled to death."[31]

Elaborating the treatment of impacted urethral stone by a special drill called al-Michaab made of a special kind of steel can be considered the foundation of true lithotripsy. He writes in his book:

> "…Now if the calculus be small and be impacted in the opening of the urinary passage, preventing the exit of the urine treat it with the means I am about to describe before you go on to make your incision, for often I have found this treatment sufficient without incision; I have experience of this. You take a drill of the finest steel of this shape. It should be triangular at the point and sharp with a wooden handle. Then take a thread and with it bind the penis beneath the calculus to prevent the stone from returning to the bladder. Then introduce the iron of the drill gently into the meatus until the drill reaches the stone itself and then very, very gently revolve the drill upon the stone with your hand, and try to perforate it, till you pierce it through to the other side. Then the urine will at once be released. Then, with your hand outside the penis, squeeze the remains of the stone and they will crumble and be washed out by the urine and the patient will be cured."[32]

Al-Zahrāwi also elaborated the method how to crush a large vesical stone through a perineal cystotomy. For this treatment he developed a special forceps which he called *Kalālib*. It is believed to be a very old lithotrite. He wrote:

> "…But if the stone be very large, it is foolish to make a great incision down upon it, for the result is that the patient either dies or has a chronic urinary fistula because the place will not heal at all. Try rather to manipulate it so that it protrudes, or else attempt to break up with the forceps so that you can extract it piecemeal".[33]

Al-Zahrāwi describes the extraction of stone from women very difficult. Writing about stones in women body he notes,

> "It is uncommon for stones to form in women. And if it does happen to a woman the treatment is rendered difficult and is hindered for many reasons; first, the woman may be virgin. Secondly, you will not find a woman who will expose herself to a [male] doctor if she is chaste or if she is one of his

close relatives. Thirdly, you will not find a woman competent in this job especially in performing operations. Fourthly, in women, the site for cutting on the stone [the incision] is far away, from where the stone lies, so a very deep incision is required and there is a danger in doing that. So, if necessity compels you to such a situation, you should take with you a competent lady doctor, and she is, indeed scarcely found. So, if you could not find a competent lady doctor, look for an unblemished kind male doctor, or bring a midwife competent in looking after women or a woman who is knowledgeable to some extent about this art. So have her with you and request her to follow all your instructions in, first of all, searching for the stone. Thus, if she finds out that woman is virgin, she should insert the finger in her anus and feel for the stone. If she finds it and manages to trap it under her finger, then instruct her to cut down upon it. But, if she was not a virgin and was previously married then instruct the midwife to introduce her finger in the patient's vagina and feel for the stone after she has placed her left hand on the bladder and applied a good amount of squeezing pressure. If she finds the stone, she should roll it away from the bladder outlet in a downward direction as much as she can until the stone is pushed down furthermost to the area where the thigh originates. And then, she should cut down upon it level with the midpoint of the vulva at the root of the thigh, from whichever side convenient for her and enabling her to feel it; and her finger should never part with the downward push on the stone. And the incision is to be made small at first, then she is to introduce al-mirwed [the sound in the small incision and if she feels the stone then she will extend the incision as much as she knows it would allow the stone to extrude out. You should know that the stones are of many varieties: some are small and some are large; smooth and rough; oblong rounded and branched. You should know about these types so that you may have an indication of what to do. And if you are overcome by a hemorrhage, scatter powdered vitriol in the area and hold [keep] it there for an hour [for a while, for some time] until the hemorrhage has ceased then resume your operating until the stone is out. See also that you have available, with you, those instruments I have informed you about in the extraction of stones in men in order to help you in your procedure. And if you are overcome by hemorrhage and you knew, from its being in pulses, that is coming from an artery that has been severed, then put the powder on the area, band it up with tight bandages and leave it [undisturbed] and do not keep reexamining; leave the stone, do not extract it since this may cause the death of the patient. Then, manage the wound and when, after several days, the zenith of the swelling subsides and the area suppurates return back to your procedure until, Allah willing, you deliver the stone out."[34]

Al-Zahrāwi surgery of varicose veins stripping, even after the passage of one thousand years, look like modern surgery. He writes,

> "…Have the leg shaved if it is much hairy. The patient gets a bath and his leg is kept in hot water until it becomes red and the veins dilate; or he exercises vigorously. Incise the skin opposite the varicose vein longitudinally either at the ankle or at the knee. Keep the skin opened by hooks. Expose, dissect, and separate the vein. Introduce a spatula underneath it. When the vein is elevated above the skin level, hang it with a blunt rounded hook. Repeat the procedure about three fingers from the previous site and hang the vein with another hook as previously done. Repeat the procedure at as many sites along the varicose vein as necessary. At the ankle, ligate and strip it by pulling it from the incision just above. When it reaches there, repeat at the higher incision until all of it is stripped. Legate the vein and then excise it. If difficulty is encountered in pulling it, ligate its terminal part with a string and pass it under the spatula and dissect it further. Pull gently and avoid its tearing because if it does, it becomes difficult to strip all of it and can cuase harm to the patient. When you have stripped it all, put alcohol sponges at the sites fo the skin incisions and take care of the incisions until they heal. If the varicose vein is tortuous, you have to incise the skin more frequently, at each change of direction. Dissect it and hang it with the hooks and strip it as previously described. Do not tear the vein or injure it. If this happens, it becomes difficult to strip it. The hooks used should be blunt, eyeless and rounded; otherwise it can injure the vein."[35]

Another surgery which was performed and developed by al-Zahrāwi was the circumcision. 'He was the first to describe the dissection technique of circumcision performed with scissors, an instrument he was the first to make use of in surgery.' Before him neither Celsus nor Paul of Aegina had described the process. Paul of Aegina has elaborated the surgical procedure only for the removal of blackened foreskin or gangrenous infections.[36]

Al-Zahrāwi made important contribution for the removal of tumour arising from a blood-vessel, called an aneurysm. Explaining this process he writes:

> "When an artery is injured and the overlying skin scars, a tumour very often arises from this; the same thing happens to a vein: a swelling and a tumour. And these are the signs by which you may diagnose whether the swelling and tumour arise from an artery or a vein: if it be from an artery the tumour will be a deep and elongated mass; and when you press upon it with your finger there will be a feeling of pulsation. But if it arises from a vein the swelling will be circular and superficial. It is dangerous to make an incision on tumours of this kind, especially in the axilla, the groin, the neck, and in many other parts of the body; it is indeed highly dangerous, so in these you must avoid treatment by the knife; also in those in the limbs and in the head it must be avoided. But any such that arises from the inflation of the mouth of an artery, you may cut down in the skin over that with a longitudinal incision; then open up your incision with hooks and dissect away the artery, freeing it from the tissues till it is laid bare. Then run a needle beneath the artery to reach the

> other side, and tie the artery in two places with a double thread, as I showed you for the extraction of the temporal arteries. Then with the scalpel prick the part between the two ligatures and let out all the blood and get the tumour down. Then apply dressings to excite suppuration until the ligatures fall away; then dress with suitable ointments until healed. If the swelling be due to a vein that has been penetrated, you should gather up with your hand as much of the tumour as you can, together with the skin; then pass a needle beneath the place which you have grasped in your hand and run it through, threaded with a double thread, until it emerges at the other side; then with it tie a strong ligature round the swelling… if you fear that the threads may come loose, pass a second needle and thread beneath the whole tumour to intersect with the passage of the first needle; and tie your superfluous skin and leave what has been ligatured. Then out on that a pad previously soaked in wine and oil; then apply the treatment with lint and ointments until healed."[37]

He has also elaborated in his book how to carry our surgery for the treatment of Gynecomastia recommending removal of the glandular tissue by a C-shaped incision. For the treatment of excessively large breasts if single incision was not enough, he recommended to "make two incisions so that the edges join each other, then remove the skin and glandular tissue in between and suture the edges of the defect."[38]

Al-Zahrāwi is considered to be the first surgeon elaborating in detail the method of removing tonsils through a special instrument used in tonsillectomy. He describes the operation as following:

> "Sit the patient facing the sun with his head in your lap; open his mouth and let assistant hold [the patient's head] between his hands and depress his tongue with the instrument…Let it be made of silver or bronze and as thin as a small knife blade. Then when you press the tongue down with it the swelling will be apparent and your gaze will fall upon it. Then take a hook and fix it in the tonsil and pull it as far forward as possible but avoid pulling any of its capsule [adjacent mucosa?] with it. Then cut it off with the instrument…which is similar to a forceps except opposite its fellow, and extremely sharp. It is made of Indian iron or *alfuled inbibitum*.

But if you do not have such an instrument cut the tonsil off with a knife of this kind…which is sharp only on one side. When you have removed one tonsil, remove the other using the same type of incision then let the patient gargle with cold water or vinegar and water. If there should be haemorrage make him gargle with water in which pomegranate rind or myrtle-berries have been boiled and continue with styptics until the bleeding ceases then treat him until it is healed."[39]

Al-Zahrāwi was not shy or reluctant of carrying out unknown surgery in emergency. One such emergency operation he performed was on a slave girl whose throat was injured with a knife. Giving the details about this particular incident he writes:

> "My own experience was this: a slave-girl seized a knife and buried it in her throat and cut part of the trachea, and I was called to attend her. I found her bellowing like a sacrifice that has had its throat cut. So I laid the wound bare and found that only a little haemorrhage had come from it. I assured myself that neither an artery nor the jugular vein had been cut, but air passed out through the wounds. So I hurriedly sutured the wound and treated it until it healed. No harm was done the slave-girl except for a hoarseness in the voice which was not extreme, and after some days she was restored to the best of health. Hence [Zahrāwi concludes] we may say that laryngotomy or tracheotomy is not dangerous."[40]

Al-Zahrāwi had special interest in the treatment of eye diseases and particularly the eyelid surgery. "In the treatment of entropion, al-Zahrāwi advised eversion of the eyelid with fingers or with a traction suture. An incision under the eyelashes from medial to lateral is then carried out so that the skin is separated from the lid margin. A leaf-shaped piece of eyelid skin is excised, and lash eversion is achieved as the defect is sutured primarily. He also classified ectropion as congenital and acquired; he advised eversion and resection of a base-down triangular segment from the inner layers for lower lid laxity to treat to cases of eye ectropion."[41]

Al-Zahrāwi is believed to be the first to identify cataract as a distinct part of medical sciences. For his contribution to this particular surgery he is known as the father of cataract surgery. Elaborating the cataract surgery he writes:

> "Patient has to be seated directly in front of the sunshine, while his normal eye is completely covered, if his left eye has to be treated, hold his eyelid up with your left hand. Then put the needle to the border of iris adjacent to the corneoschleral limit. Now push and twist the needle until getting inside the eyeball then you feel that it is gone into an empty space. You will see the needle in the centre of the pupil because of corneal transparency. Now hold the needle where cataractous lens has been formed and push the needle down a few times. if all parts of the lens are discharged, patient can see while the needle is still in his eye. If not, push down the needle once more, then bring back the needle to its original place in the anterior chamber and then turn the needle gently and put it out. Now dissolve Turkish salt in water and wash the eye then put a clean cotton pad coated with white egg, rose water and oil on the eye and cover both eyes with the pad. In some cases when the eyeball is resistant and hard, and the needle is not able to be inserted we should use special surgery needle. Patient has to lay down on his back in a stable bed in a dark room and he should avoid moving or coughing. He should be given soft food not to turn his head to the right or left side. His eye bandage on his eyes has to be kept for 3-7days. Bandage has to be open[ed] in a dark room while examining the eyes by showing the patient some objects. Then put the bandage back again and leave the patient for some days."[42]

Al-Zahrāwi made remarkable contribution in the field of Orthopedics as well. 'He described the reduction of dislocated shoulder [known today as Kocher's Method] long before Kocher was born.' He elaborated patellectomy [kneecap removal] long before Brooke reintroduced it in 1937. He advocated the manipulative reduction with external immobilization in the management of fractures if the bones were separated. He wrote, "reduction was to be effected by traction and counter-traction, using diligent manipulation in order to secure exact reposition of the bones and avoiding violent compression."[43]

He advocated the reimplantation of a fallen tooth and also suggested to use cow bone in dental prosthesis, which was an improvement over the wooden dentures worn by the President of USA, George Washington, even after seven centuries later.[44] Al-Zahrāwi has clearly explained the method for tightening the loose tooth by wiring tightly with the healthy teeth on both sides of the loose tooth with a string of silver or gold wire, preferably the latter as it does not corrode. He explains:

> "And here is the illustration of fixing two loose teeth between two sound ones, as you can see. And if one or two of the teeth should fall out, put them back in place and fix them as we have instructed and they will stay in place; but this is not to be attempted except by a painstaking and skilled surgeon. And sometimes a piece of ox bone may be worked into the shape of a tooth and fitted into the place of a [missing] tooth and fixed there as we have directed; it will remain in place and [the patient] will have the use of it for a long time."[45]

His conclusion that cranial and extremity bones are healed differently is in harmony with the modern day understanding of cartilaginous and membranous bone healing. "After reduction, He cautioned against the presence of pain that signified an increase in the swelling of the extremity, appearance of swelling distal to the bandage as it suggested too tight a splintage, any loosening of the bandage as it indicated the subsidence of the swelling and the relative inefficiency of the immobilization."[46]

He is considered as one of the early leading plastic surgeons who excelled in this particular field. In the 13th Chapter of Volume 30 of his book he delineated upon many principles of the field. He was the one who used ink to mark the incision points before operation. This is now a standard procedure in the modern day surgery. In the same volume he also made difference between primary and secondary wound closure and also the importance of wound Debridement before closure.[47]

He has to his credit to use for the first time catgut for internal stitches. "Catgut is a thread made from the lining of the intestine of animals. It is the only material that can be used for stitches and still be absorbed by the body, preventing the need for a second surgery to remove internal stitches."[48]

Al-Zahrāwi can be given the credit for innovating many new techniques in the field of surgery and medicines. He was the first to:

" → Use cotton (in surgical dressings, in the control of hemorrhage and as padding in the splinting of fractures.

→ Describe in details the unusual disease, hemophilia.

→ Use cautery, wax and alcohol to control bleeding from the skull during cranial surgery and described the ligature of arteries long before Ambrose Pare.

→ Teach the lithotomy position for vaginal operations. He was the first surgeon to describe ectopic pregnancy.

→ Describe the tracheotomy operation and performed it as an emergency on one of his servants.

→ Write on orthodontic and described how to treat misaligned teeth."[49]

Some of al-Zahrāwi accomplishments can be enumerated as under:

1. " Al-Zahrāwi was an expert in dentistry, and his book contains sketches of various instruments used thereof, in addition to a description of various important dental operations.
2. He discussed the problem of non-aligned or deformed teeth and how to rectify these defects.
3. He developed the technique of preparing artificial teeth and of replacement of defective teeth by these.
4. In medicine, he was the first to describe in detail the unusual disease, hemophilia.
5. The first to describe clearly the hereditary circumstances surrounding hemophilia.
6. He also described ligaturing of blood vessels long before Ambroise Pare.
7. Al-Zahrāwi was the first medical author to provide illustrations of instruments used in surgery.
8. Al-Zahrāwi outlined the use of caustics in surgery, fully described tonsillectomy, tracheotomy and craniotomy- operations he had performed on a dead fetus.
9. He explained how to use a hook to extract a polyp tiom (sic.) the nose, how to use a bulb syringe he had invented for giving enemas to children and how to use a metallic bladder syringe and speculum to extract bladder stones.
10. In connection with the preparation of medicines, he has also described in detail the application of such techniques as sublimation and decantation.
11. He was the first to detail the classic operation for cancer of the breast, lithotrities for bladder stones, and techniques for removing thyroid cysts.
12. Also he was considered one of the early leading "plastic surgeon" as he performed many plastic surgery procedures.
13. Al-Zahrāwi has specialized in curing disease by cauterization and applied the technique to as many as 50 different operations."[50]

Al-Zahrāwi had invented many surgical instruments which not only he himself used but continued to be used by later doctors for many centuries. In his book he has also elaborated the methods of using those instruments.

## Conclusion:

The modern world owes a lot to the glorious achievements of Muslim scientists as they have built the modern day magnificent scientific super structure on the foundations the

Muslim scientists built centuries ago. The past plays an important role in the betterment of present and future as the past provides foundation on which the present and future can be made better. As Will Durant, the well-known philosopher has stated: "civilizations are units in a larger whole, whose name is 'history', they do not disappear. The past always rolls into the present."

Al-Zahrāwi's life and practices should be an example to the modern day practitioners of medicines, who are working more like machines than human beings. Al-Zahrāwi, who emphasized on medical ethics, may be emulated by the modern day doctors as amongst many the medical ethics are lacking; particularly they lack a personal contact and sympathy with the patient. This is a very important aspect of al-Zahrāwi practice who had emphasized personal relationship to be developed between the doctor and the patient in order to gain the confidence of the patient, which can play a great role in the speedy recovery of the patient.

Another important aspect of al-Zahrāwi's life and practice was his dedication and sincerity to the practice of medicines. He did not consider his practice as a mean for economic gains only rather he practiced medicine as charity and service for the welfare of humanity. That was the reason that he treated his patients without any greed or expectations and also he treated many of them without charging if they were unable to afford the treatment cost. Unfortunately such doctors in the modern world can be found rarely. It is hoped that some doctors may emulate al-Zahrāwi in this particular aspect in order to serve the ailing and needy humans.

Al-Zahrāwi and his contemporary Muslim scientists made the great achievements in a period which is rightly called the glorious period of Muslim rule in Spain. The Muslim rulers had provided a very congenial atmosphere in their kingdoms, without any prejudice, to all the citizens of the state. For the growth of human's mental and physical capabilities a peaceful, friendly and pleasant environment plays an important role and this is obvious from the study of al-Zahrāwi period. Unfortunately that glorious period came to an end with the attacks of Islamic purists for whom the Muslim rule of Moorish Spain was far too lenient and tolerant. Unfortunately what we saw in the aftermath of the Islamic purists' rise was intolerance and destruction, which also brought to an end the glorious period of the Muslim scientists in Spain.

Regrettably the Muslims lost those glorious characteristics (tolerance and welfare) of their rule in the later centuries as well which have pushed the Muslims into the abyss. The problem is that even now in the 21st century the Muslims have not learnt from history. The Islamic purists are once again on the pillage, which is certainly not good for the revival of the glorious traditions of the great Muslim rules. If the Muslims will not learn from history, once again they will be condemned to oblivion.

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