Featured Article — History of Orthopaedics

Great Names in the History of Orthopaedics XIV: Joseph Lister (1827–1912) Part 1

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ABSTRACT

Although the evolution of surgical practices cannot be the efforts of a single individual, Joseph almost single-handedly revolutionised modern surgery. Undoubtedly one of the greatest surgical benefactors of mankind, Joseph Lister was as great a scientist as he was a surgeon. His earliest research after graduation was on the muscles of the iris and coagulation of blood. He was one of the pioneers in bacteriology and the first to isolate bacteria in pure culture. While Professor of Surgery at Glasgow, he appreciated the significance of the antiseptic properties of certain phenolic compounds and applied them in clinical surgery. Although he was not the first person to apply antisepsis in surgery, he was the one who established the principles of antiseptic and later aseptic surgery and convinced the medical profession of his principles. In the world of science, credit goes to the person who developed and propagated the discovery, it first. Indeed, surgery is divided into its pre- and post-Listerian eras.

中文摘要：約瑟夫．李斯特（第一輯）
李斯特在外科手術消毒法的貢獻，令他被譽為外科手術的象徵。他父親發明了顯微鏡，這對年青時代的李斯特有著極大的影響。憑着強力的顯微鏡，打開了微生物學的世界。當他在倫敦大學就讀時，已研究動物組織學。畢業後便發表了數篇有關方面的文章。其後他因一次偶然機遇，去了愛丁堡大學賽姆教授門下作交流生，因而造就了兩人以後長期的師徒關係，賽姆的女兒更嫁給了李斯特。而賽姆退休後，李斯特便順理成章繼承外科教授一職。

李斯特用石炭酸來進行手術消毒，這種用防腐劑來抑制腐敗的方法已有人在十九世紀廣泛用於污水消毒和處理。在1867年3月16日出版的<<柳葉刀>>雜誌中，李斯特開始發表自己的外科手術消毒法報告。他在蘇格蘭格拉斯哥及愛丁堡的那些年頭，在許多方面都是他一生成長最豐碩的時期。其後他回到倫敦後也得到了不少的榮譽。他更被封為英格蘭上議院議員（他是第一位獲此殊榮的醫生），在此時外科手術消毒法已被稱為“李斯特消毒法”。

Lister
Mankind looks grateful now on thee
For what thou did in Surgery.
And Death must often go amiss,
By smelling antiseptik bliss.
By Volkmann's skill and industry
Famous thou art in Germany!
Who could a better Prophet be,
Than Richard Hotspur was to thee?

Georg Friederich Louis Stromeyer (1804–1876), 1st August 1875, Hanover.

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Introduction

The creative work of some individuals is of such value to humanity that an age has been called after them to mark off one period of time from another. Medical historians speak of pre-Listerian and post-Listerian surgery, and the surgery as Lister entered it and the surgery as he left it is immense.

Joseph Lister was born in a mansion at Upton Park, East London, in the parish of West Ham. He was the second son of Joseph Jackson Lister (1786–1869) (Figures 1 and 2), a prosperous wine merchant and amateur microscopist, who invented achromatic lens in the compound microscope. Joseph Lister’s father’s publication includes On some properties in achromatic object glasses applicable to the improvement of the microscope (1830).1 He worked out the principle of the modern compound microscope. His improvement in achromatic lenses made him one of the important figures in the history of modern microscopy. For his achievements, the senior Lister was elected a Fellow of the Royal Society.

Early Career

As a Quaker (Society of Friends), Lister was barred from entering Oxford or Cambridge Universities. He had to enrol at University College London (the “Godless College” in Gower Street) in 1844, which had recently opened to accept non-conformists. He graduated in BA, and in 1847 he commenced his medical training and obtained his MB and FRCS in 1852. While at the University College Hospital, Lister studied inflammation in the web of frogs, the arrector pili muscles of the skin, and the pupillary muscles of the iris, using the new compound microscope given to him by his father. His publications include Observations on the contractile tissue of the iris (1853),2 which dealt with observations made in 1852 on the smooth muscles of the iris and demonstrated for the first time the existence of two distinct muscles—the dilator and constrictor—for the variation in size of the pupil; and Observations on the muscular tissue of the skin (1853),3 which demonstrated the attachments of the arrector pili muscles to the hair follicles with beautiful illustrations.

After graduation, on the advice of the Professor of Physiology, William Sharpey, whose lectures inspired him with a love of physiology that had never left him, Lister visited Professor James Syme at Edinburgh. An immediate empathy developed between them. Lister first became Syme’s “supernumerary clerk” and then house surgeon and was elected Fellow of the Royal College of Surgeons of Edinburgh in 1854. Their patients, students, and assistants called Lister “The Chief” and Syme “The Master”. At this time, he commenced research on inflammation, nervous control of blood vessels, and coagulation of blood.

In October 1875, it was announced that LISTER

“Mr Lister, FRCS Eng. and Edin., Assistant Surgeon to the Royal Infirmary, will commence his LECTURES on the Principles and Practice of Surgery at No. 4, High School Yards, On Wednesday, November 4th, at Ten O’clock a. m. Attendance on these course will qualify for the Public Boards. FEE for the Course, £3, 5s.; or if it be taken with a view to Graduation at the University, £4, 4s. Edinburgh, October 1857

At first his class consisted of 12 dressers, but soon 23 had joined!

He married Professor Syme’s eldest daughter, Agnes, in 1856 and was appointed assistant surgeon at the Edinburgh Royal Infirmary. When he arrived there, the mortality rate from amputation was 43%.

During this first phase of his career (1852–1860, London and Edinburgh), Lister showed that blood remained fluid in an animal vein as long as the endothelium was intact but coagulated after transfixion of the vein by a needle.4 Arterial embolism of the lower limbs in a child, in which one limb was amputated while the other was saved. He examined the possible causes of coagulation when

Figure 1. Portrait of Lord Lister, now hanging in the Logan Turner (President’s) Room in the Royal College of Surgeons in Edinburgh. Reproduced with kind permission of the President and Council of the Royal College of Surgeons of Edinburgh.

Figure 2. Joseph Jackson Lister with his compound microscope. Portrait courtesy of the Wellcome Library, London.
blood is shed from blood vessels, concluding that contact with
some “ordinary matter” for a brief period induces a reaction
between its solid and fluid components, resulting in the corpuscles
to impart to the liquor a disposition to coagulate.

It has been known that the skin of the frog varied in colour
under different circumstances. In 1838, Lister showed that it was
the pigment granules in the stellate cells that moved and not the
branches of the cellular processes.5

In the same year, Lister published An enquiry regarding the parts
of the nervous system which regulate the contraction of the arteries.6
Although this concerns a pure physiological subject, its clinical
significance became apparent many years later in Lister’s method of
eliciting a limb to render it bloodless before surgery.

One of Lister’s most important papers on basic research was On
the early stages of inflammation (1858).7 Studies are made in frogs’
legs and bats’ wings. Aggregation of blood corpuscles during clot-
ting is shown to depend on their “mutual adhesiveness”. The
structure and function of arteries in regulating capillary blood flow
is due to the contraction and dilatation. The effects of chemical
irritants on tissues and arteries include arterial dilatation and
adhesion of blood corpuscles, resulting in stagnation of blood flow
and eventual obstruction. Applications of these principles in
human pathology were discussed.

In 1859, Lister published Notice of further researches on the
coagulation of the blood.8 This research on basic physiological
science was of significance in the later development of the anti-
septic system. Lister explained the belief that blood coagulation is
carried away by the escape of ammonia (ammonia hypothesis) and
showed that in the blood vessels. He demonstrated that blood does
not clot at 4.45°C but does so when the solid matter is brought into
contact with it. Clotting is caused by injury to the blood vessels. He
further demonstrated that by carrying out the strictest precautions,
he could keep blood free from putrefaction indefinitely, thus sup-
porting the hypothesis that microorganisms were the causes of
wound suppuration.

Lister’s last paper on purely practical aspects of surgery was on
joint excision in place of amputation, which was a recent
development of “conservative surgery”. The complicated technique
was the result of careful anatomical study. It involved the complete
excision of all structures in which caries might recur, while
preserving intact all structures responsible for wrist and finger
motion. The difficulty and the time taken were the only objections
raised against the operation. Lister opined that “to save a human
hand from amputation and restore its usefulness is an object well
worthy of any labour involved”.

The Antiseptic Principle in Surgery

Lister was as great a scientist as he was a surgeon. For his
researches on inflammation, Lister was elected the Fellow of the
Royal Society in 1860. In that year, the post of Regius Professor of
Surgery at Glasgow University fell vacant upon the ill-health of its
incumbent. Encouraged by Professor Syme, Lister applied for and
obtained this desirable post.

Glasgow in 1860 had a population of 390,000, twice the size of
Edinburgh. There had always been a strong intellectual element at
the University. Its medical faculty was very prosperous, attracting
students from all over the British Empire on account of its low fees
and comparatively cheap living costs. Lister was the 3rd occupant of
the Chair of Surgery.

During the 2nd period of his career (1860–1869, University of
Glasgow), he completed his practical experience during the early
years of his tenure in Glasgow. His patients developed serious and
often fatal septic complications. The Glasgow Royal Infirmary
(Figure 3) was built on a former graveyard of a church. The coffins
of patients who died of a cholera epidemic in 1849 reached within
a short distance of the ground. Pit burials of paupers in the
churchyard was contiguous with the infirmary grounds. Lister
considered it as a “house of death, and little short of pest-houses”.
In the words of his house surgeon, Hector Clare Cameron,
“Lockjaw, erysipelas, blood-poisoning of various kinds, and
hospital gangrene were never absent from the hospital wards at
any one time; and repeatedly gangrene and pyaemia became
alarmingly epidemic.”

Figure 3. Restored ward in the Glasgow Royal Infirmary, where Professor Lister treated his first cases of compound fractures. Note the photograph of Lister on the wall. Courtesy of
the Wellcome Library, London.
Lister had a hard time fighting the Infirmary Board of Governors, who wanted to increase the beds in the wards. Lister recalled:

"At this period I was engaged in a perpetual contest with the managing body, who, anxious to provide hospital accommodation for the increasing population of Glasgow. For which the Infirmary was by no means adequate, were disposed to introduce additional beds beyond those contemplated in the original construction. It is I believe, a fairly attributable to the firmness of my resistance in this matter that, though my patients suffered from evils alluded to in a way that was sickening and often heartrending, yet none of my wards ever assumed the frightful conditions which sometimes show itself in other parts of the building, making it necessary to shut them up entirely for a time."

Thus in the middle of the 19th century, the field of surgery was infinitely smaller than it is today. Its progress was restricted by the fear of hospital infections, which although few, had disastrous consequences. As the causes of "hospitalism" were unknown, measures taken against it were inadequate and misdirected.

In 1865, Professor Thomas Anderson of the Department of Chemistry brought to Lister's attention the works of a French chemist named Louis Pasteur (1822–1895), who had shown that fermentation of wine did not take place in the absence of air.

Pasteur was then employed at a distillery in Lille, when in 1864 he was asked by Emperor Napoleon III to investigate why French wine became contaminated during fermentation, which was causing considerable economic loss. He demonstrated that fermentation was linked with a specific microbe — yeast — that could be destroyed by heating to 55°C for several minutes (a process later termed "Pasteurization"). This was the beginning of bacteriology. By delivering a fatal blow to the hypothesis of spontaneous generation, Pasteur developed the germ theory of disease.

As Pasteur said, "In the field of observation, chance only favors the mind that is prepared", so Lister's mind had been prepared for the reception of Pasteur's message. The researches of Pasteur showed that the septic properties of the atmosphere depended not on the air but on the minute organisms suspended in it. It occurred at once to Lister that the decomposition of the injured parts might be prevented without the absence of air, but by applying a dressing capable of destroying the floating particles. A phenol derivative — German creosote — which is an impure form of carabolic acid, had been used to purify and deodorize sewage in the nearby town of Carlisle.

Lister decided to repeat Pasteur's experiments to disprove that life arose out of spontaneous generation. He procured several glass flasks from the Chemistry Department. Into each, he poured his own urine. The neck of each flask was drawn out into a slender tubing at right angle. After boiling each flask, Lister sealed the neck of three flasks but left the fourth flask communicating to the air. Only the urine in the sealed flasks remained free from fresh and undecomposed because all organisms from the atmosphere were excluded. This must have been caused by something in the air. In later years, Lister would travel across the country with his precious flasks for demonstration! According to his former dresser and clerk, John Rudd Leeson of Edinburgh:

"Three flasks of aged urine, the most precious of the Professor's possessions, as sacred to him as the three hairs of Buddha to the faithful Asiatic, he had had them for years, and he told me later, when he was appointed Professor of Surgery at King's College, of the concern and anxiety he had endured in transporting them to London, and how he and Mrs Lister carried them upon their knees all the way in a specially reserved first-class carriage to obviate as far as possible any evil that mightbefall them."

The scene was thus set for clinical application of the hypothesis of Pasteur, with some crude extract of creosote supplied by Professor Anderson. Lister's first patient was Charles Cobb, admitted on 13 March 1865 with a compound fracture of the femur. Lister covered the wound with a piece of cotton soaked in carabolic acid and then splinted the limb as usual. By the middle of June, Cobb left the hospital with a sound leg.

On 12 August 1865, Lister applied his carabolic acid dressing to a compound fracture of the left tibia of 11-year-old James Greenlees, who was knocked down by a cart. The wound, an inch and a half long, was close to but not over the fracture. A probe could be passed beneath the skin to the fracture site. Very little blood had extravasated into the tissues. Lister instructed his house surgeon, MacFee, to thoroughly cleanse the wound with carabolic acid, lay a piece of lint soaked in carabolic acid on the wound, and apply lateral plasterboard splints padded with cotton wool, the leg resting on the external side with the knee bent. It was left undisturbed for 4 days, when the boy complained of some uneasiness; Lister removed the dressing and examined the wound, which showed no signs of suppuration. The boy recovered without complications and left the hospital.

After a further 11 cases treated by similar methods, with one death from secondary haemorrhage and one requiring amputation, Lister first reported his results in 1867. This paper is divided into a main section dealing with compound fractures, followed by a short note on treatment of abscesses. After a preliminary introduction and acknowledgement to the illuminating researches of Pasteur, Lister described his method of treatment in 11 cases of compound fractures in the Glasgow Royal Infirmary. He reported that out of these cases, only two suffered from hospital gangrene, one of whom required amputation. Another patient died of secondary haemorrhage. Thus, 9 successful cases out of 11 consecutive cases was a remarkable achievement.

In the Surgical Section of the Annual Meeting of the British Medical Association in Dublin on 9 August 1867, Lister read the following paper:

"In the course of an extended investigation into the nature of inflammation, and the healthy and morbid condition of the blood in relation to it. I arrived several years ago at the conclusion that the essential cause of suppuration in wounds is decomposition brought about by the influence of the atmosphere upon blood or serum retained within them, and in the case of contused wounds, upon portions of tissue destroyed by the violence of the injury."

"To prevent the occurrence of suppuration, with all its attendant risks, was an objective manifestly desirable; but till lately apparently unattainable, since it seemed hopeless to attempt to exclude the oxygen, which was universally accepted as the agent by which putrefaction was effected. But when it has been shown by the researches of Pasteur that the septic property of the atmosphere depended, not on the oxygen or any gaseous constituent, but on minute organisms suspended in it, which owed their energy to their vitality, it occurred to me that decomposition in the injured part might be avoided without excluding the air by applying as a dressing some material capable of destroying the life of the floating particles."

"Upon this principle I have based a practice of which I will now attempt to give a short account."

"The material which I have employed is carabolic or phenolic acid, a volatile organic compound, which appears to exercise a perfectly destructive influence upon lower forms of life, and hence is the most powerful antiseptic with which we are at present acquainted. The first class of cases to which I applied it was that of compound fractures, in which the effects of decomposition in the injured parts were especially striking and pernicious. The results have been such as to establish conclusively the great principle that local inflammatory mischief and general febrile disturbances, which follow severe injuries, are due to the irritating and poisonous influence of decomposing blood or sloughs. For these evils are entirely avoided by the antiseptic treatment, so that limbs which would otherwise be unhesitatingly condemned to amputation may be retained, with confidence of the best results..."
The next object to be kept in view is to guard effectually against the spreading of decomposition into the wound along the stream of blood and serum which oozes out during the first few days of the after the accident, when the acid originally applied has been washed out or dissipated by absorption and evaporation....

The next class of cases to which I have applied the antiseptic treatment is that of abscesses. Here also the results have been extremely satisfactory, and in beautiful harmony with the pathological principles indicated above...In an ordinary abscess, whether acute or chronic, before it is opened, the stimulus which maintains the suppuration is derived from the presence of the pus pent up in the cavity. When a free opening is made in the ordinary way, this stimulus is got rid of, but the atmosphere gaining access to the contents, the potent stimulus of decomposition, comes into operation, and pus is generated in greater abundance than before...In order to the treatment to be may be satisfactory, the abscess must be seen before it is opened...All that is required is to guard against the introduction of living atmospheric germs from without, at the same time that free opportunity is afforded for the escape of discharge from within.

Further I have found that when the antiseptic treatment is efficiently conducted, ligatures may be safely cut short and left to be disposed of by absorption or otherwise...Since the antiseptic treatment has been brought into full operation, and wounds and abscess no longer poison the atmosphere with putrid exhalations, my wards have been completely changed their character; so that during the last nine months not a single instance of pyaemia, hospital gangrene or erysipelas has occurred in them.

The original idea of the antiseptic system was the exclusion of all microbes from wounds...During the operation, to avoid the introduction into the wound of material capable of inducing septic changes in it, and secondly to dress the wound in such manner as to prevent the subsequent entry of septic mischief...In wounds which already septic attempts are made to with more or less success to restore the aseptic state...In speaking of the antiseptic system of treatment I refer to the systematic employment of some antiseptic substance so as entirely to prevent the occurrence of putrefaction in the part concerned, as distinguished from the mere use of such an agent as a dressing...I always endeavoured to avoid the direct use action of the septic substance upon all tissues.

Lister believed that germs could enter the wound and cause suppuration and putrefaction. It was necessary to kill germs already in the wounds by applying dressings impregnated with bactericidal substance. He eventually used carbolic acid for this purpose. Having realized the significance of Pasteur's work on fermentation, he evolved the idea of antiseptic prevention of wound infection. This paper presented two of the most epoch-making contributions to surgery.

The logic of Lister's argument was quite simple:

1. In practice, compound fractures become septic, simple fractures do not. Therefore, sepsis is due to access of air.
2. It is known that air in the pleural cavity does not cause sepsis. Therefore, sepsis must be due to something carried in the air.
3. Pasteur has proved that fermentation of wine is caused by germs in dust particles.
4. It is probable that putrefaction of wounds may occur in the same way.
5. Putrefaction should be preventable by barring the access of germs.

The simplicity of this reasoning is deceptive; with the hindsight of a century and a half, it appears obvious.

In the context of 1865, it was a stroke of genius, for in those days all wounds suppurated, spreading infections were the rule, and pus was laudable because it indicated that infection had ceased to spread.

Hippocrates of Cos (460–375 BCE) was the first to apply pitch and coal tar (which contains phenol) to compound fractures in his Corpus Hippocraticum: On Fractures. The ancient Egyptians employed tar to preserve cadavers. Claudius Galen (CE 129–216) dressed wounds with wine. In the ensuing centuries, vinegar, rose oil, turpentine, corrosive sublimate (mercuric chloride), alcohol, and limewater (hypochlorite) were used. Ignaz Phillip Semmelweis (1818–1865) of Vienna advocated hypochlorite solution for hand wash before operating which immediately reducing the mortality of his maternity ward inpatients drastically.

A distillate from coal tar, called German creosote, was discovered in 1828 in Germany. It was proposed as a preservative for meat. Its purer derivative, carbolic acid, was employed in medicine in the mid 19th century when Frederick Calvert (1819–1873), a Professor of Chemistry in Manchester, succeeded in obtaining large quantities in a state of purity. At the Manchester Royal Infirmary and London's Middlesex Hospital, several physicians used it in a variety of conditions. These even included chronic diarrhoea, vomiting, and consumption of the lungs, in addition to diptheritic ulcers, lupus sores, carbuncles, fetid ulcers, bone necrosis, and sloughing sores. It was used mainly as an external agent—disinfectant and antiseptic.

A significant observation was that a few drops of the acid added to a pint of fresh urine would preserve it from fermentation or other chemical changes for several weeks. Calvert concluded that it is the most powerful preventive of putrefaction known to him.

Thus, Lister was not the first person to employ carbolic acid in clinical practice. As early as 1864, Dr James Watson of Edinburgh had already reported clinical applications in infected wounds of the limbs in a number of patients in the Royal Infirmary, with satisfactory results. He also devised a series of experiments demonstrating the antiseptic properties of carbolic acid:

Properties of carbolic acid antisepsis:

1. It has a powerful germicidal action.
2. It is a tissue poison and when absorbed causes renal damage over a long period.
3. It acts as a caustic on tissues.
4. It has a pungent odour.
5. It has a mild local anaesthetic effect due to its effect on nerves.
6. It combines with exudes to form a sterile eschar or scab.
7. It has a macerating effect on the hands and produces skin sensitivity.
8. It achieves the prime objective of preventing and curing wound infection.

Lister initially used pure carbolic acid mixed with olive oil applied to the wound on a dressing. Soon he switched to gauze soaked in 1/20 carbolic acid. The dressing consisted of 9 layers and was left for 3–4 days. During operation, Lister washed the patient's skin, his hands, and soaked his instruments in 1/20 carbolic acid solution.

Lister experimented with various forms of carbolic acid dressings, trying plaster, paraffin, gutta-percha tissue, shellac, and antiseptic gauze. To prevent evaporation, a layer of tin foil covered the outer most layer. The final antiseptic dressing consisted of a layer of double cyanide of zinc and mercury gauze wrung out in a weak solution of carbolic acid. Over it were placed a few layers of dry gauze, and over the gauze a mass of wool. The carbolic acid disinfects the wound, the gauze sucks up any discharge which can evaporate, and the outer most wool filters and protects the wound.

At Glasgow, Lister confined himself largely to the surgery of trauma and certain aspects of orthopaedic surgery because such cases provided him with the most suitable conditions of refining his
antiseptic methods. Although this period in Glasgow was a short one, extending from 1865 to 1869, it was impossible to exaggerate the changes Lister achieved in surgery. Wounds healed without suppuration, compound fractures and dislocations no longer required amputations, large arteries were ligatured without fear of secondary haemorrhage, large chronic abscesses were no longer incurable, non-united fractures were treated boldly by freshening the ends, and joints opened by accident or surgically healed without difficulty. One of such pioneering examples was osteotomy for deformity. A patient had a 4-month-old malunited fracture of the ankle with the foot driven outwards and backwards. Lister divided the calluses of the tibia and fibula. The foot was forced into proper position, and the wound was treated antiseptically. The patient recovered with a sound and useful foot.

Lister devised a new thigh amputation through the femoral condyles, a circular amputation with a minute posterior flap so as to secure a neat scar. The skin incision was made over the tuberosity of the tibia. The femur was divided at the level of the upper border of the patella that is immediately above the articular cartilage. It was, in the opinion of those who performed it, superior to any other amputation around the knee. The stump was so sound that the patient could bear weight on it. It interfered very little with the circulation, and for this reason was recommended in cases of senile and diabetic gangrene.

In the pre-antiseptic era, metal wire sutures were very popular, being introduced by James Marion Sims (1813–1882). Lister designed a special curved needle for passing silver wire sutures. The eye of the needle was at some distance from the end, with two grooves in which the twisted wire lay snugly, producing an atraumatic passage through the tissues.

In December 1868, a 45-year-old man was treated for non-union of a femoral neck fracture. Lister exposed and freshened the bone ends, leaving the bone chips in place. Pulleys were used to correct the shortening. The patient recovered and walked out of the hospital in March the next year.

For fractures of the femoral shaft, Lister stripped off the periosteum and sawed the bone across in a way as to make one fragment being locked into the other. The bones were then drilled and bound together with a very stout silver wire, which was secured by twisting and hammering the twisted ends.

Lister’s new operation for excision of the wrist joint was first described in 1865. He was encouraged by the results of a patient with compound fracture of the wrist whom he had treated in 1863. He sawed off the ends of the protruded radius and ulna, carefully preserving the tendons and blood vessels. He attributed the almost-perfect result to early mobilization. The operation was very elaborate. Two long skin incisions were planned so as to avoid important blood vessels and tendons, allowing extrusion of the diseased bones for inspection and complete excision. A gouge, small saw, and bone pliers were the only instruments available.

The accuracy required for excision of the wrist was made possible by Lister’s method of rendering a limb bloodless by elevation to vertical position for 3 minutes before applying Petit’s tourniquet. This was a new landmark in the development of “conservative surgery”, as an alternative to ruthless amputation of a diseased limb.

Lister was early to suggest a safer operation for amputation at the hip joint. He advised that the femur be disarticulated after amputation of the soft parts. He designed an external racket-shaped incision. The wound, being on the outer side of the limb, could be rendered aseptic easily. In order to control bleeding, Lister employed his aorta tourniquet.

In a letter to his father in July 1868, Lister wrote:

*Three days ago I had a nice case for antiseptic treatment, a ‘loose cartilage’ of the knee joint. 1 ¼ inch long by 1 inch broad by ¼ inch thick: the largest I ever saw; and causing the patient much inconvenience. I removed it by a free incision into the knee joint! A thing I should not have thought of doing without the antiseptic system. I had carbolic oil dropped on the wound as I cut, and drew out the cartilage under cover of an antiseptic rag, and dressed with the plaster. The patient has not had the slightest pain or symptom of any kind. Today the discharge is about one drop for 24 hours. So we may say it has been a complete success.*

To the orthodox surgeons of the time, such a procedure would appear criminal.

For the rest of his professional life, Lister followed the same route. The administrators of the Royal Infirmary at Glasgow did little to support him in his quest. For example, Lister’s wards were never cleansed for 3 years! It was with some ill feelings that he left Glasgow.

**Development and Dissemination of “Listerism”**

As a native Londoner, Lister had always considered himself as possibly only a “bird of passage” in Scotland, feeling that London was his natural place. He thought that if ever a southward migration were contemplated, Edinburgh would be a better stepping-off place than Glasgow.

In April 1869, Professor James Syme suffered a paralytic stroke and was forced to retire from his post in Edinburgh. At this same moment, Lister’s 10-year term of appointment at Glasgow was coming to an end.

In July, 127 medical students at Edinburgh signed a petition urging Lister to become a candidate for the vacant post. News of his election to the Edinburgh Professorship reached him in August 1869.

For the third period (1869–1877, University of Edinburgh) of Lister’s career, he returned to Edinburgh upon the retirement of Syme. This phase was devoted to the refinement and simplification of his methods and the beginning of his campaign to disseminate them throughout the surgical world. He stated his views carefully, explained other’s errors, and announced changes in his methods.

An analysis of Lister’s patients admitted to the Royal Infirmary during these 8 years indicated an abundance of cases that provided ample opportunity for his antiseptic techniques:

**General emergencies**

- Wounds and contusions: 209
- Simple fractures and dislocations: 239
- Compound fractures and dislocations: 61
- Infections of soft tissues: 139
- Burns: 44
- Head injuries: 68

**Cases selected by Lister:**

- Tuberculous arthritis: 381
- Pyogenic arthritis: 160
- Deformities of bones and joints: 60
- Varicose veins: 105
- Bone tumours: 53
- Breast tumours: 110

**General surgery cases:**

- Genitourinary conditions: 154
- Anorectal conditions: 96
- Hernias: 20
- Abdominal conditions: 11
- Goitre: 10
- Tuberculous lymphadenitis: 17
- Aneurysms: 7
It can be seen that Lister did not deliberately select abdominal conditions (perforated peptic ulcers, peritonitis, ovarian cyst, carcinoma of the gastrointestinal tract), which he referred to other surgeons.

Lister had even been described as a "superficial surgeon"! He seldom opened the abdomen because of the irritating effect of carbolic acid. Lister was thus in essence an orthopaedic surgeon, and his orthopaedic contributions were many. For the first time on battlefield in the Franco-Prussian War of 1870, French and German army surgeons applied antiseptic methods in the management of war wounds using Lister's carbolic acid.

The problem of constructing an effective spray for use during operation occupied too much of his time. Lister was mistaken in his imagination that he could sterilize the atmosphere by carbolic acid spray. Subsequently, he developed the carbolic acid spray to sterilize the air overlying the wound at operations from 1871 to 1887. The clumsy prototype mechanical pump was nicknamed the "donkey engine" (Figure 4) and had to be carried around in a cart and worked by hand by a relay of dressers. Later, a more compact steam spray was developed (Figure 5).

His former assistant, Sir Hector Clare Cameron (1843–1928), later Regius Professor of Clinical Surgery at the University of Glasgow, recalled:

To the spectator, the spray and the cloud of highly irritating vapour which it emitted was the most striking feature of the scene. As Lister entered the crowded theatre, his mobile face set and solemn as he bethought himself of the responsibilities he was about to undertake, he was followed in procession by his train of dressers, the first of whom bore aloft the sacred spray. Once the silence was broken by some student whose voice was heard intoning, "Let us spray!"

Breakdown of the spray during an operation was common. The irritating mist generated clouded everything in the operating theatre. Hospital staff and patients developed sensitivity and even toxic side effects to the carbolic acid. The spray not only was frequently ineffective but also was causing harm to the surgeons and patients by its irritant properties. A German Professor at Tubingen, von Bruns, cried out: "Fort mit dem spray [Away with the spray]!" Finally Lister abandoned the spray in 1881 when he
realized the futility of sterilizing the atmosphere during operation. He eventually accepted that it was impossible to exclude all microbes from wounds. With the abandonment of the spray, Lister’s antiseptic system assumed simplicity and direct relation to natural observations characteristic of him. He confessed in 1890: “I feel ashamed that I should ever have recommended it for the purpose of destroying microbes in the air.”

During this Edinburgh period, Lister was engaged in perfecting his antiseptic dressing as well as the carbolic acid spray. He spent much time in his wards, paying special attention to wound healing, repair of ulcers, absorption of bone by granulation tissues, and organization of blood clots. Even on Sunday afternoons, many of his pupils received their introduction to the antiseptic principles of surgery in the wards!

Lister devised a carbolized catgut suture, better than any previous products. He soaked catgut sutures for 4 hours in carbolic acid and tied the carotid artery of a calf. He was able to cut short the ends of the ligature, closing the wound and avoiding bringing the ends of the ligatures out through the wound. A month later, the calf was dissected, and Lister observed that the sutures had disappeared to be replaced by fibrous tissue. Further experiments were conducted in hardening catgut by soaking in chromic acid, tannin, and chromic alum, methods rather similar to modern use.12

In Edinburgh, the academic duties were less onerous, delivery of two clinical lectures a week, in contrast to daily systematic lectures in Glasgow. The class was enormous, with an intake of 170 or 180 new students a year. The spacious lecture hall that had a capacity of 500 was packed to the top row. Dressers brought in the patients in a large basket for demonstrations of a particular problem, be it leg ulcers, chronic abscess, or old joint dislocation. The relevant clinical notes were read out by the ward clerk. And the Professor proceeded to discourse on the pathology, clinical diagnosis, and management of a particular disease. In the course of a single lecture, 3 or 4 patients were brought into the theatre. Sometimes, an operation would be performed upon the last patient, demonstrating the principles underlying the mechanical art of surgery.

Among Lister’s colleagues in Edinburgh were the Professor of Medical Jurisprudence, Sir Robert Christison (1797–1882), the renowned toxicologist; James Matthews Duncan (1826–1890), the gynaecologist; Thomas Keith, the pioneer of ovariotomy; Joseph Bell (1837–1911), the model for Sherlock Holmes; and John Chiene, the successor to Lister; and not least the Matron, Mrs Porter. Fifty beds at the Royal Infirmary provided ample field for clinical work. Edinburgh had become a pleasanter place than of old. Lister was thus happy within this circle of devotees.

Joseph Bell, Lecturer on Surgery and assistant surgeon at the Royal Infirmary, described his experience on the use of carbolic acid in a report read before the Medico-Chirurgical Society of Edinburgh on 7 April 1869. In several cases of abscesses, limb amputations, and compound fractures and dislocations, he concluded that

“In the antiseptic principle, explain it as you will, we have a very great addition to our means of combating disease. Even if on theoretical grounds surgeons may deny the possibility of preventing suppuration...still if it be granted that by this method we can diminish the amount of pus and destroy the foetor of pus, we have done much to improve the sanitary condition, and diminish the fatality of our great hospitals.”

At that time, new doctrines were not in general favour among the medical profession. Lister had, however, in his students, ward clerks and dressers, intense loyalty and minds ready and eager to learn.

There was no class in Edinburgh University more regularly attended than his. Strangers came from all parts to Edinburgh to listen to his lectures and watch his practice. Glasgow and Edinburgh had to wait for the advent of a new generation. In Dublin and Belfast, the other two principal surgical centres, leading surgeons either smiled at the innovation or ignored it.

In September 1871, Lister was informed by the Queen Victoria’s physician in Scotland that the monarch suffered from a large left axillary abscess 6 inches in diameter. Being Surgeon-in-Ordinary to the Queen in Scotland, Lister hurried to Balmoral Castle with Sir William Jenner (1815–1898, Physician-in-Ordinary to the Queen and President of the Royal College of Physicians) and recommended incision and drainage as soon as possible. Jenner administered chloroform while Lister operated. The Queen said after the operation, “a most disagreeable duty most pleasantly performed.” Carbolic acid was accidentally sprayed into Her Majesty’s face. When she complained, Jenner protested, “Madam, I am only the man who worked the bellows!” The operation was successful. Lister inserted a strip of lint for drainage. But the abscess did not resolve quickly. The next day Lister exchanged the lint with a piece of rubber tubing that has been soaked in carbolic acid, the Queen made a rapid and complete recovery. Lister later boasted to his friends: “Gentlemen, I am the only man who has ever stuck a knife into the Queen!”

“Listerism”, as these principles were known, met with a mixed reception. It was acclaimed by those who had worked with him or had followed his methods carefully. On the other hand, the new system was disparaged by those who tried his methods half-heartedly. In Britain, it was the junior surgeons who welcomed the new system. The general recognition of the value of Listerism coincided closely with the Franco-Prussian War of 1870–1871. The German military surgeons secured the benefits accruing from the system to the wounded on the field. Amputation of the limbs was avoided by antiseptic dressings. In Denmark, France, Italy, Austria, Germany, and Switzerland, many distinguished surgeons—Oscar Bloch (1847–1926) of Copenhagen, Just Marie Marcellin Lucas-Championniere (1830–1913) of Paris, Richard von Volkman (1830–1889) of Halle, Edoardo Bassini (1844–1924) of Rome, Theodore Billroth (1829–1894) of Vienna, Bernhard von Langenbeck (1810–1887), Karl Thiersch (1822–1895), Johann Friederich August von Eschmar (1823–1908), Ernst von Bergmann (1836–1907) of Berlin, Friedrich Trendelenberg (1844–1924) of Bonn, and Theodore Kocher (1841–1917) of Berne—were loud in their praises of the new technique.

Lucas-Championniere, surgeon to the Hotel Dieu in Paris, attended Lister’s department at Glasgow in 1868 and had become an ardent follower ever since. Faithfully applying the antiseptic principles, he extended surgery to the peritoneum, the synovial membranes, brain, and spinal cord.

Austria and Germany were slower than France and Denmark in accepting Lister’s methods. Billroth sent his assistants from Vienna to King’s College Hospital to learn about the new technique at the fountainhead. All of them, including Professor Johann von Mikulicz-Radecki (1850–1905) of the University of Breslau, became grateful and enthusiastic adherents of Lister. Another Billroth assistant, Vincenz Czerny (1842–1931), introduced Listerism to Heidelberg in Prussia.

Professor von Bergmann of the University of Berlin adopted Lister’s methods in operations in organs deep down in its cavities: (1) resection of the maxilla, (2) resection of the tongue, (3) resection of the rectum, and (4) total extirpation of the larynx. Wounds were protected from contact with all outside morbid agents that tend to produce inflammation and suppuration; and blood and exudates were conducted from the wound into iodoform gauge capable of absorbing them and neutralising their action. He demonstrated that the most formidable surgical procedures have, by deduction from Lister’s principles, become a matter of everyday surgery.

The United States of America and Canada unaccountably lagged behind Europe. It was not until 1876 when Lister attended
a Medical Congress at Philadelphia that the full impact of his work was realized.
(To be concluded in part 2)

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