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The Conquest of Pus -- a History of Bitumen, Creosote and Carbolic Acid

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Abstract

In the Western world from antiquity on, open wounds were treated topically with petroleum-derived substances, such as bitumen, asphalt, pitch, and tar. The immediate aim was to stifle bleeding and ease pain but a potential benefit was preventing local corruption with pus formation. In the early 19th century, creosote was recovered from bitumen and found to reduce suppuration. Carbolic acid was later isolated from creosote and recognized as an underlying active agent. In the 1860s, carbolic acid was first employed by Jules Lemaire to treat local skin infections and later by Joseph Lister to prevent the suppuration in compound fractures. Based on Pasteur's discovery of bacteria in the air, Lister proposed that microbes invade open lesions and cause local purulent discharges. This knowledge led to a new paradigm in medicine -- aseptic surgery.

Keywords: Wounds; Pus; Bitumen; Creosote; Carbolic acid; Karl reichenbach; Jules Lemaire

Introduction

Prehistoric people knew from experience that open lesions on the skin often bled and were painful and might lead to fever, sickness, and sometimes death. Instinctively, they covered such injuries with materials at hand, such as plant products, animal parts, and substances found in the earth [1]. Ancient doctors in the Western world often coated wounds and burns with petroleum-based substances which we now know have antiseptic potency due to the presence of carbolic acid and other small organic compounds. This healing power is present in bituminous rocks, in oils seeping up from porous sandstone, and in tarry masses floating on the surface of certain lakes. These natural sources yield bitumen, asphalt, pitch, or tar [2]. The medical use of these crude substances was first recorded in an Assyrian tablet from the second millennium BC, which advised applying "bitumen externally to a septic foot or finger" [3]. Topical prescriptions for asphalt or pitch are contained in four works of the Corpus Hippocraticum.

The long history of surgery is marked by two divergent opinions about suppuration-- whether pus in wounds and abscesses is beneficial ('laudable') or is harmful. The former view prevailed among ancient and later surgeons for nearly two millennia. The advent of ether/chloroform anesthesia during the early mid-1800s allowed surgeons to cut without inflicting pain and thus to operate more freely. But the increased surgery was accompanied by many more cases of suppuration, which led finally to the realization in some surgeons that pus is a complication of wounds, impairing their healing. The new consensus prompted Lister's studies of compound fractures in the 1860s. This essay traces the treatment of open wounds from antiquity onward when crude petroleum products were used and concludes with some lesser known historical details leading to Lister's introduction of carbolic acid.

Greek and Roman Medical Use of Petroleum Products

The Corpus Hippocraticum contains four works prescribing petroleum-based substances for open lesions. On Wounds (5th century BC) contains receipts for burns, one of which involved a mixture of melted asphalt together with lard & resin smeared onto a linen cloth, warmed, and applied to the burn site [4]. On Fractures recommends putting "pitch cerate" [a paste] on a fresh lesion in the skin [5]. The author of On Wounds in the Head advised "anoint[ing] the wound with the dissolved black drug," which likely was some form of bitumen/tar [6]. Francis Adam's translation of the treatise On Ulcers describes treating them with vinegar, wine, various plant products, and 'raw tar-water', the last being equivalent to 'liquid pitch of Dioscorides', as explained in Adam's footnote #5 [7].

The Roman poet Vergil penned The Georgics in the first century BC. In it he recommended using "pitch from Ida" (Idaeas pices, mountains near Troy) and "black bitumen" (nigrum bitumen) to treat sheep when attacked by "foul scab" or when "prickly briars lacerate the flesh" [8,9]. Roman medicine as practiced by the pater familias was based in part on his successful veterinary practice [10].

During the first century AD, numerous Roman authors recorded the medical uses of petroleum-based substances. Pliny the Elder wrote that Babylonia bitumen mixed with barley-meal in a plaster "closes up wounds" [11]. He also mentioned that 'pissasphaltos' (pitch combined with bitumen) was a specific for itch-scab in cattle [12]. Aulus Cornelius Celsus (1c AD) , who coined the four signs of inflammation (calor, rubor, tumor, dolar), described various types of pus-thin or thick, white or bloody, etc. [13]. He sought to prevent pus developing in wounds and to promote its ready discharge by various plasters, several of which contained pitch, turpentine resin, and other ingredients [14]. Columella recommended that earthenware vessels be coated on the inside and outside with pitch to prevent spoilage of wine and other food stored therein [15].

Scribonius Largus (4/5-50 AD) was a Roman physician who accompanied Claudius to Britain in 43 AD. Scribonius' one work, Compositiones Medicamentorum, is a compilation of 271 remedies,

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many of which are believed to date from earlier Greek times. Fourteen of these remedies contain bitumen or pitch for treating wounds, contusions, punctures of muscles, and fractures. Remedy 207 was used by gladiators and involved pitch from Spain mixed with bitumen from Judaea. Other remedies included nearly a dozen ingredients to form a black plaster (emplastrum nigrum) [16].

Dioscorides (40-90 AD), was born and raised in Cilesia (SE Turkey). While traveling with Nero's Roman army in Italy, Greece, Crete, Egypt, & Palestine, he compiled a pharmacopoeia listing over 1000 drugs. In it he mentioned bitumen obtained from India, Babylonia, Phoenicia, and the Dead Sea and recommended it for "drawing together bloody wounds and all which ought to be cut away." Asphalt or pitch were also said to bring relief to fractures, wounds, "and other errors" [17]. His pharmacopoeia was copied and amended through many editions and became the major source of such information through medieval times. R.T. Gunther translated other passages in this work as "All bitumen hath a power of repressing inflammation and conglutinating," and dry pitch "hath a warming mollifying facultie, pus movens" ['removing pus'] [18].

Galen (131-201), a Greek physician who practiced in Rome, dictated over three million words for his medical texts. Early in his career, he had attended gladiators in the arena at Pergamon and treated their wounds with caustics and unguents [19]. A 4- volume Latin folio of his works lists five references to bitumen (bitumen) and seven to turpentine [20]. Turpentine (terebinthina) is an oily resin obtained from a shrub (Pistacia terebinthus) and various fir trees but is obtained from petroleum as mineral spirits [21,22].

Two Byzantine physicians wrote about bitumen/asphalt being useful in drying and sealing wounds -- Aetios of Amida (early 6th century) and Paulus Aegineta (625-690) [23,24]. The other medical authors of this period were mainly compilers of past writings. Few advances in medicine or surgery were made during the early Middle Ages, for European civilization was disrupted economically by foreign invasions from the east. The arts and sciences found refuge in the Islamic world, which in time extended to Spain.

Among the Middle Eastern doctors writing in Arabic, several referred to the medical use of bitumen. The 9c Arab philosopher Al Kindi composed 240 books, of which 22 concerned medicines. He mentioned various kinds of pitch and asphalt and recommended bitumen for abscesses and fistulas [25]. Avicenna (980-1037) used bitumen for abscesses, eruptions, and fractures [26]. Yaqud al-Hamawi (1179-1229) wrote that bathing in water from oil-asphalt pits "is good in clearing pustules" [27]. Knowledge of 'Arabist' medicine -- that written in Arabic by Arabs, Persians, and Jews -- spread from Islamized Spain into the Italy (Salerno & Bologna) and France (Montpellier & Paris).

Early Notions about Suppurative Wounds

Ancient and medieval surgeons characterized open wounds as either dry or wet. The former exhibited rapid healing by primary intent without any significant serous discharge, while the latter showed at best slow healing by secondary intent with pus and later granulation tissue. Some medical writings mentioned suppuration developing in wounds without qualifying it as good or bad. However, a passage from On the Prognostics (a work in the Corpus Hippocraticum) describing the course of an ulcer in the skin reads as follows in Adam's translation: "very white and thick pus is beneficial in such a case-a free discharge of pus takes place and carries off the mortification" [28]. This interpretation may have led some surgeons to regard the appearance of pus as critical to recovery of all wounds.

Arabist surgeons -- e.g., Albucasis of Cordoba, Spain, 12th century-cauterized lesions to arrest bleeding. The burnt skin 'invited' bacterial growth and likely often induced suppuration, which thus seemed a natural event in healing. The concept of laudable pus has been attributed to Galen, as explained by Freidberg [29]. Galen wrote that abscesses contain pus and do not resolve until drained. The importance of pus being released from abscesses could have been extrapolated to open lesions and led to 'the pseudo-Galenic' notion of laudable pus in all wounds.

The pro-pus, 'wet school of wound healing' was probably taught in 10th-11th century School of Salerno by Arabist surgeons and adopted by two early medieval surgeons who trained there -- Roger of Palermo (1140-1195) and his successor Roland of Parma (early 13c). Both believed in the delayed healing of wounds by second intent -- i.e., with the appearance of suppuration. The book Rolandina (c. 1264) was Roland's revised version of Roger's surgical work. It became a standard surgical text with glosses by 'Four Salernitan Masters' for many generations of medical students [30].

Guy de Chauliac (1300-1368) trained in surgery at Bologna, Montpellier, and Paris. He used salves and plasters to stimulate (sic) pus formation [31]. His Chirurgia magna, composed in 1363, have been found in 34 manuscripts in 8 languages dating from 1416 to 1669 and in over 70 printed editions in 8 languages starting in 1478 [32].

Other surgeons held the contrary view that suppuration was not a necessary stage in healing but something to be avoided or prevented. The anti-pus, 'dry school' of wound healing was taught by three notable early surgeons. Hugh of Lucca (early 13c) was an army surgeon from Bologna, who condemned the use of various agents to induce suppuration in wounds and advocated instead rinsing them with wine. His son and apprentice, Theodoric Borgognoni (1205-1296) adopted Hugh's aseptic treatment of wounds. Theodoric's Chirurgia, which appeared in 1267, rejected the pseudo-Galenic notion of laudable pus [33]. Henri de Mondeville (1260-1320), who practiced at Montpellier, also advocated surgical cleanliness and sought to avoid suppuration in wounds [34]. His Chirurgia was never completed and survived only in parts, which were not published until 1889. Anti-pus surgery was also taught by John of Arderne (1306-90) and Pietro d'Argelate (d. 1423) [35].

The pro-pus texts of Roger, Roland, and Guy overshadowed the anti-pus writings of Hugh, Theodoric, and Mondeville and dominated surgical thought through the 18th century. Later surgeons continued the dispute about wound healing. Pro-pus views were published by several German army surgeons in the 15th-16th centuries who treated gunshot wounds -- Heinrich von Pfolspeundt, Hieronymus Brunschwig, and Han von Gersdorff [36]. One medical historian concluded that "the advocates of pus won all along the line"-- i.e., dominated Western medicine until the time of Lister [37].

Medieval Period-Bitumen and Turpentine

Paracelsus (1493/4-1541), born Theophrastus von Hohenheim, was a controversial Swiss-German physician and alchemist, whose popular name, Paracelsus, means "comparable to Celsus." Paracelsus revered Hippocratic medicine but disparaged the writings of Galen and the Persian physician Avicenna (980-1037). Paracelsus' only book published during his life time concerned wounds. The index of a 1618

German edition contains no listing of bitumen (das Erdpech, or der Bergteer), asphalt (das Erdharz), pitch (das Pech), or tar (der Teer) [38]. But here he recommended turpentine (das Terpentin) in various complex balms, some of which contained crumbling pieces of bitumen from Egyptian mummies [39].

Ambroise Paré (1517-1590) was a chirurgien with the French army. During the 1536 siege of a castle near Turin, he ran out of the standard treatment for gunshot wounds, which was boiling oil of elder. He used instead a mixture of Venice turpentine, egg yolks, and oil of roses. The soldiers treated with this mixture suffered less post-operatively and healed faster than those receiving boiling oil. In the 1664 edition of Les Oeuvre, Paré recommended covering wounds with turpentine (terebenthina vulgaris) among other agents. His one reference to bitumen was in the context of embalming corpses [40]. Jean André Delacroix (c. 1573), a contemporary of Paré, recommended that wounds be washed out with a detergent liquid and then covered with "plasters composed chiefly of pitch and oil of turpentine" [41].

Peter Lowe (1550-1610) was a Scottish surgeon who trained in Paris and accompanied the armies of France for 22 years. He lived out his last two decades in Glasgow, founded the Faculty of Physicians & Surgeons of Glasgow, and wrote the first complete text on surgery in English. Like Paré, he recommended applying a mixture with turpentine to gunshot wounds [42]. During the Elizabethan era, William Clowes (1540-1604) was a notable English surgeon. His book on treating musket wounds and gun powder burns described countless cases and listed scores of theriac-like balms and plasters, most of which included turpentine [43].

Early Nineteenth Century Europe -- Creosote

Coal mining greatly increased with Europe's Industrial Revolution. During the 18th century, asphalt deposits in central Europe were mined for waterproofing roofs and constructing roads. Chemical engineers (latter-day alchemists) sought to extract other useful products from the coal and stones. Subjecting bituminous substances to an intense heat in the absence of oxygen releases gases (hydrogen and methane) along with a thick residue (coal tar). The mixture of gases constituted 'illuminating gas', which soon lite the streets and homes of Europe. The thick residue yielded valuable petroleum chemicals and created the coal tar industry [44]. Some of the same valuable ingredients recovered from coal had been found earlier in wood.

A noted chemist in this field was a German named Karl Ludwig Reichenbach (1788-1869) [45]. Around 1830 he found that the destructive distillation of wood tar (especially from beech trees) produced three products: illuminating gas, a dense liquid distillate, and charcoal. The distillate yielded turpentine along with a dark, viscous oil heavier than water. The oil had an odour which was "penetrating, disagreeable, and similar to that of smoked beef," an example of preserved meat [46]. Perhaps this association prompted Reichenbach to soak meat in the oil for half an hour, dry it in the sun, and examine it eight days later. He found that such treated meat developed a flavor "of good smoked beef" and did not putrefy thereafter [46]. He termed the viscous oil Kreosote (creosote) -- from the Greek words for "flesh" and "preserver".

Reichenbach later found a more abundant source of creosote in coal tar while working at the bituminous mines of Blansko, Moravia (central Czechoslovakia). He announced his discovery of creosote in a German chemical journal (Schweigger-Seidel Journal) in 1830. Initially, he promoted creosote as a preservative of wood products (fences, dock piers/pilings, railway ties and ship timbers).

While working with creosote, Reichenbach had noted that it removed calluses and skin on his hands (l'épidemere des doigts enlevé) [47]. This observation and the fact that creosote prevented putrefaction of dead tissue caused him to consider treating skin conditions with it. He could not interest Viennese physicians to undertake such a study. However, a country surgeon and an elderly pharmacist tested creosote in various clinical conditions and provided him with a series of remarkable 'cures' (une série de guérisons remarquables) [47]. The 25 short clinical reports published in 1833 included cases of burns, wounds, ulcers, gangrene, scabies, and other conditions.

In 1834, Marcellin Berthelot (1827-1907), a French organic chemist, described 12 clinical cases treated topically with dilute solutions of creosote -- i.e., cuts, ulcers, skin eruptions, burns, ear infections, etc. [48]. In ten cases the pain was reduced, in seven the pus dried up, and in four the lesion healed without suppuration. In 1836, John Rose Cormack (1815-1882) of Edinburgh sought to collect "all the information" about creosote from foreign and British journals and found that treatment with creosote reduced suppuration in burns, promoted cicatrization of wounds, arrested hemorrhages from capillaries, gave relief from tooth aches, and provided relief from pain in cancers and other conditions [49].

What seems remarkable in the history of creosote is how quickly physicians adopted it for treating various medical problems -- external and internal. In 1834, there were fourteen articles concerning the medical use of creosote cited in the Index Catalogue [50]. In America, The Medical Formulary of 1842 listed creosote liniment, lotion, and ointment [51]. Robley Dunglison(1798-1869), who authored the first widely used American medical dictionary, also compiled New Remedies [52]. The 1846 edition contained a 25-page review of over 70 articles in the medical literature detailing creosote's preparation, toxicity, and oral and topical uses [53].

Carbolic acid / Phenol

Reichenbach's original preparation was termed 'German creosote' and contains a solution of phenol (carbolic acid), cresols, guaiacol, and creosols. Cresole is phenol with an added methyl group (-CH3). Guiacol is phenol with a methoxy/ester group (-OCH3). Creosole is phenol with a methyl and a methoxy/ester group (-CH3 & -OCH3). When used as a topical agent, this crude mixture slowly releases these small organic compounds. Unlike carbolic acid, none of the other phenolic agents in creosote had been isolated during Lister's time in any quantity and thus were not tested clinically.

A distinction is made between an antiseptic, which can be safely used on the human body, and a disinfectant, which is toxic for living tissues but is used on inanimate surfaces, such as metal instruments, containers, tables, floors, walls, etc. The effectiveness of both germicides is measured in two ways -- *in vivo* by reducing odors of putrefaction and *in vitro* by arresting microbial growth. The former was initially studied using a tedious tube dilution test but in the later 1880s was more conveniently performed with Koch's agar plate culture system [54].

Based on laboratory culture tests, the American pharmacologist, Torald H. Sollmann (1874-1965) reported that the germicidal power of cresol is "three or more times that of phenol [while its toxicity to the tissues] is somewhat less" [55]. Guaiacol, which constitutes 60%-90%

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of crude creosote, has a greater germicidal power than phenol but is more irritating to the skin. Creosol's power is also greater than that of carbolic acid. The above laboratory rankings may have little clinical relevance, since they measure culture conditions and not clinical ones, where serum proteins and other factors may reduce an antiseptic's effect [56,57].

In 1834 Friedlieb Runge (1795-1867), a German chemist, who made the major discovery of aniline in coal tar, also isolated a compound which preserved meat and which he named Karbolsäure, 'carbon oil acid', or 'carbolic acid' [58]. Reichenbach was concerned about priority of discovery and asserted that Runge had merely found his "flesh preserving" creosote. Several years later Auguste Laurent (1807-1853), a French chemist, isolated carbolic acid in crystalline form and reported that it was different from creosote, which, as noted previously, is a mixture of phenols -- i.e., phenol, cresols, guiacol, and creosols. Laurent named his isolate hydrate de phényl, which later was termed alcool phénique and acide phénique [59]. It attracted little immediate clinical interest among French doctors. In 1842 the French chemist, Charles Frédérick Gerhardt (1816-1856) coined the name 'phenol' [60]. Only two decades later was the pure compound tested clinically by a French pharmacist?

Lemaire and L'acide Phenique

The seminal book on this subject, L'acide Phénique, was published in 1863 by Jules Lemaire (1814-1873), a pharmacist in Paris [61]. Most of the 27-page introduction summarizes Lemaire's studies with coaltar saponiné -- i.e., coal tar emulsified with saponin. This preparation originated with Ferdinand Le Beuf, a Bayonne pharmacist, who in 1850 found that an alcoholic solution of coal-tar mixed with saponin (a plant glycoside) yielded a stable emulsion which was readily absorbed. Lemaire's first clinical test with the emulsion was in a patient with a large gangrenous wound at a fold in the groin (une grande plaie gangréneuse située au pli de l'aine). The prompt healing of the lesion was so unexpected that this single case was immediately reported to l'Académie de Médecine [62]. Other investigators soon confirmed this surprising clinical result [63].

Meanwhile, Lemaire wrote that coaltar saponiné disinfects, prevents putrefaction, and kills microbes (le coal tar désinfecte et prévient la putridité and détruit les microzoaires) [64,65]. He concluded that putrefaction is the result of fermentation by microorganisms [66]. Lemaire wrote that they are in the air, thus restating in his 1863 text what Pasteur had shown in 1861 and what Spallanzani had first suggested in 1765 [67,68].

Most of Lemaire's book concerns his later studies with pure acide phénique, which included embalming, clearing the air of miasmas in prisons, hospitals, etc., and disinfecting abattoirs, cesspools, and sewage farms (les vidanges avec l'eau sale dans les egouts-servent a l'irrigation des terres) [69]. He stated that phenol (like saponized coal tar) kills the various microscopic organisms then recognized -- e.g., "bacterium, vibrions, spirillum." Killing (faire mourir) was based on phenol rendering various microorganisms immobile on a glass slide [70]. He reported that phenol disinfects fetid wounds and heals open wounds more rapidly without the formation of pus than other dressings [71]. These favorable findings led him to a 'novel' theory about the formation of pus (fait donner de la formation du pus une théorie nouvelle) -- that the spread of carbolic acid in hospital rooms would cleanse the atmosphere [72].

Lister and Sewage Farming

The turning point in the conquest of pus was the clinical studies on compound fractures by the English surgeon, Joseph Lister (1827-1912) in the 1860s. Since the fractures he treated generally occurred outdoors or in a mine or factory, those with breaks in the skin almost invariably became infected by pathogens in the environment. The local infection often spread via a septicemia and led to death. Amputation removed the infected limb area and yielded a 'clean' cut stump less likely to be infected. The mortality rate following amputation was reduced but was still appallingly high-60% in Paris, 45% in Glasgow, etc.

Lister was oblivious to the pathogens in the surrounding environment. But upon learning of Pasteur's report that microbes are present in the air, he considered them to be the likely source of wound suppuration. Surgeons had previously used impermeable dressings to insulate lesions from miasma, but Lister sought to kill airborne germs by treating open lesions with carbolic acid dressings and the air above with a carbolic acid spray. He instituted a strict treatment protocol designed to protect the open lesion with carbolic acid dressings replaced periodically.

He explained his interest in this newly isolated chemical as follows: "In the course of the year 1864 I was much struck with an account of the remarkable effects by carbolic acid upon the sewage of the town of Carlisle-preventing all odour from the lands irrigated with the refuse material" [73]. None of the dozen biographies and scores of essay about Lister identified the 'account' mentioning carbolic acid and Carlisle, which Lister claimed to have read in 1864.

The Search for Lister's Inspiration

Carlisle was then an important mill town and railway center in NW England on the border of Scotland (along Hadrian's wall). The "refuse material" mentioned by Lister was his euphemism for household wastes and human excrement collected from indoor toilets. Modern sewage disposal employs aeration tanks, sprinkling filters, and settling basins. Previously, cities and towns in 18th-19th century Europe and America lacking access to a nearby river, lake, or ocean transported such refuse material by cart or pipes for spreading over nearby farm lands. When one field became saturated or putrid smelling, the wastes were directed to another, if available. During some summer months, distressing odors from some fields might assail a community. Carlisle solved this problem by 'deodorizing' its sewage fields with German creosote (impure carbolic acid) added to the waste effluent as it was being spread. But where did Lister learn of this? He read The Lancet and the British Medical Journal, but no issues during 1863-4 mentioned carbolic acid and sewage farming in Carlisle. While professor of surgery in Glasgow (1859-1869), he undoubtedly read The Times of London and the Glasgow Herald.

The Times: Palmer's Index lists many articles and letters in The Times after 1785, but ignores many others which were sometimes reprinted in other newspapers, as noted below. Palmer's Index during the period 1860-1865 does not list the two key word -- 'Carlisle' and 'sewage farms'. A microfiche of The Times (22 November 1860) printed a letter from Alexander McDougall (1808-1899), a chemical engineer who managed the Carlisle sewage farm. He reported that the vapours emanating from the putrescent state of the land were "obviated by the use of an alkaline solution of carbolic acid" [74].

Glasgow Herald: There is no master index for items in past issues of the Glasgow Herald; so a search was made in microfiche copies of individual issues for 1860-1865 at the Mitchell Library in Glasgow. The 27 November 1860 issue reprinted the 1860 McDougall's letter to The Times and published an original one by John F. Bateman, a chemical engineer [75]. He praised the successful treatment by M'Dougall (sic) of the Carlisle sewage farm using a "disinfecting fluid...mixing with the sewage in transit" [75].

Carlisle Journal and Carlisle Patriot [76], Although Carlisle's population in the 1860s was around 25,000 compared to the 400,000 of Glasgow, it published several newspapers. During November 1864, the Carlisle Journal printed six items describing sewage farming. One, entitled "Carlisle Sewage Experiment," mentioned the use of "carbolic acid dissolved in lime water" (a distillate of pit coal) in Carlisle, Croydon, and Edinburgh. The topic first appeared in the Carlisle Journal in 1859 letter by McDougall to the Carlisle Health Committee, seeking a contract to establish sewage farming in land northwest of the town [77]. On 1 Dec. 1860 the Carlisle Patriot printed four letters about sewage farming, including the McDougall's letter to The Times (22 Nov. 1860) [78]. Several other letters mentioned 'disinfecting fluid' and 'disinfecting powder' -- referring to carbolic acid.

In summary, I did not find any item (article or letter to the editor) mentioning together both carbolic acid and Carlisle in 1864 issues of The Times or the Glasgow Journal. Although the Carlisle Journal printed six letters on sewage farming in 1864, it seems doubtful that in his busy practice Lister read the small newspapers from distant Carlisle. However, in 1860 The Times had published McDougal's letter mentioning carbolic acid or a 'disinfecting fluid'. And in 1860 the Glasgow Journal printed letters by McDougal and Bateman on the subject. Thus I could not establish that Lister encountered an article on Carlisle's sewage farming in 1864 and doubt that he remembered after four years the McDougall and Bateman letters of 1860. I suggest that instead he learned of the Carlisle sewage farming from an acquaintance -- most probably, Dr. Thomas B. Anderson.

Lister and Carbolic Acid

In a footnote to his 1867 paper on compound fractures, Lister indicated that carbolic acid was available in two forms -- the crude liquid (termed 'German creosote') and the crystalline (soluble in warm water, etc.) [79]. In 1865, he had "employed the liquid form in compound fracture" with poor success. He wrote "it would be better to use the crystalline form," as he did for the patients reported in 1867. The latter was obtained from Dr. Thomas B. Anderson (1819-1874), the Regius Professor of Chemistry at the University of Glasgow. Anderson had studied the sewage problems of Glasgow and Edinburgh and was likely aware of clinical studies on the continent employing this agent in wound infections [80]. But Anderson's other significant contribution to the story of pus was alerting Lister to Pasteur's studies showing microbes in the air [81].

Pure carbolic acid was first produced in Britain by Frederick Crace Calvert (1819-1873), a professor of chemistry at the Royal Institution, Manchester. A paper describing his findings was read to the Academe des Sciences by a French member in 1859. In 1863 Calvert published a report entitled "On the Therapeutic Properties of Carbolic Acid" in The Lancet which was reprinted in the Boston Medical and Surgical Journal in 1863 [82,83]. Neither of these reports in English nor those in French on creosote and carbolic acid were acknowledged by Lister in his early writings.

The vast literature on Lister has documented his efforts to convert surgeons to the aseptic-antiseptic approach for treating wounds [81,84-86]. Many rejected his view that air-borne germs invade open wounds and cause inflammation and suppuration. Many older surgeons likely had never seen bacteria through a microscope and were doubtful of their significance and skeptical of Pasteur's germ theory. In 1917, five years after Lister died, a long biography written by his nephew (Rickman John Godlee) summarized three reasons for their rejection of his method: 1) the treatment was too complicated, 2) Lister repeatedly changed it, and 3) the dogmatic " positiveness [of his] enunciation of the germ-theory" [87]. Godlee surveyed the global reception to Lister's ideas about surgical antisepsis. German, Swiss, and Scandinavian surgeons more readily adopted them compared with physicians in Britain, France, and the United States [88]. Surgeons in America showed a range of opinions.

Unknown to Godlee, and rarely cited in the Lister literature, was an American paper published two years after Lister's 1867 report on eleven cases of compound fractures. In 1869, David W. Yandell (1826-1898) of Louisville, Kentucky reported on 34 surgical cases treated with carbolic acid [89]. His article in the Richmond and Louisville Medical Journal summarized the favorable clinical outcomes in 32 patients who had received carbolic acid dressings for incised or crushed wounds (11 cases), abscesses (6), fistulae (3), compound fractures (2), and amputations (2).

A mixed view of Lister's work was held by a major American surgeon, Samuel D. Gross (1805-1884), who stated that he had "no confidence whatever in the [carbolic acid] spray". However, he had "unbounded faith in antiseptic treatment" and viewed it of great value in all fields of surgery [90]. Reservations about Listerism continued into the next century among some American surgeons, who argued that "older methods" were more expedient. A letter in 1910 to the NY Times asserted that "too much importance [is] attached to aseptics, antiseptics, and anti-infection outfits" [91].

Later Antiseptics

During the First World War there was a renewed interest in caring for wounds. Alexis Carrel (1873-1944), a French-American surgeon, sought a treatment for the many battle wounds which were not protected by carbolic acid or conventional germicides. Under his direction, Henry Drysdale Dakin (1880-1952), an English chemist, tested over 200 compounds in bacterial cultures and found that sodium hypochlorite was the most bacteriocidal and was 30 times more effective than carbolic acid. Carrel devised a detailed protocol for irrigating war wounds every two hours, but his method initially saw opposition like that which Lister had encountered a half century earlier [92-95].

The advent of penicillin during World War II and other antibiotics later represent a major therapeutic advance in combating pus. However, the possible development of microbial strains resistant to all available antibiotics may invite using past irrigation methods with chemical agent like carbolic acid or hypochlorite [96,97].

Conclusion

The early history of surgical sepsis involved two rival concepts: whether the development of pus in wounds is essential for healing (is laudable) or whether it retards healing (is harmful). The latter view was supported by observations that the topical treatment of open wounds with certain substances often prevented pus formation and yielded a more favorable outcome than that in similar non-treated cases. Until the antibiotic era, such treatment involved mainly petroleum products -- bitumen, turpentine, creosote, and ultimately carbolic acid. A landmark in this history occurred when Joseph Lister proposed that corruption in open wounds was caused by invading bacteria. He erred initially in focusing on airborne bacteria being the major source of wound infections and was slow to recognize iatrogenic and nosocomial sources. None the less, Lister became the apostle of aseptic surgery in a long line of surgeons seeking the conquest of pus.

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I am grateful for the assistance of Mrs. Amanda Williams (Medical Library, University of Kentucky) in locating many references. I also acknowledge the continued support of I.S. Tray II.

References

1. Endnote on a wounded Pennsylvania bear. Like people, some higher animals instinctively treat injuries. A striking example was related to me years ago by a Pennsylvania hunter who had shot a bear which was able immediately to stumble away. After several hours and many miles the wounded bear was tacked down and found dead. In a hole in its chest the bear had stuffed leaves which had the effect of countering a progressive pneumothorax and possibly stifling bleeding.
2. Endnote on petroleum products. They are commonly associated with their non-medical function -- e.g., bitumen for construction, asphalt for roofing, pitch for caulking boats, and tar for adhesion. In ancient times bitumen deposits were identified throughout the Middle East and found also in NW Greece, the Ionian Island of Zante, Italy, Sicily, E. Spain. It is estimated that several hundred tons of bitumen were mined yearly in the Middle East then. In modern times massive deposits have been found in Canada and Venezuela. A conspicuous example in California is the La Brea tar pits.
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45. Endnote on Reichenbach Karl Ludwig Reichenbach was a chemist, metallurgist, and geologist. The immense personal fortune he gained from exploiting his mining discoveries led to his being made a baron – hence 'von Reichenbach of Blansko'. He later pursued studies on meteorites and psychic phenomena, for which he became additionally famous. Reichenbach impregnated the wooden fences around his house with creosote to deter dogs from answering nature's call on his property. Parenthetically, Reichenbach Falls, where the fictional Sherlock Homes fought Professor Moriarty, is near Bern, Switzerland.
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