INTRODUCTION

The term 'leech' tends to evoke quite a graphic and fearful image in a person's mind as bloodthirsty parasites that seek to attack their unsuspecting victims. Popular media has not helped their case. The 1959 film "Attack of the Giant Leeches" follows the story of a group of people who are abducted and killed by intelligent, larger-than-life sized leeches. The dictionary defines a leech as "a person who clings to another for personal gain, especially without giving anything in return, and usually with the implication of exhausting the other's resources." A discussion of the medicinal leech—its anatomy and physiology, as well as tracing its uses in history through to the modern period—should dissipate such dreadful fears. The use of medicinal leeches has been documented since Graeco-Roman antiquity. In the Middle Ages, leeching was largely consistent with prevailing Hippocratic humoral theory, and in 17th through 19th century Europe, leeching as a bloodletting technique became as popular as Advil for headaches is today. After a brief hiatus, leeching now plays an important role in modern surgery and postoperative care, and demonstrates a promising future in the field of medicine.

LEECH ANATOMY AND PHYSIOLOGY

More than 300 species of leeches are classified in the Phylum Annelida, Class Hirudinea. They typically live in the freshwater ponds, streams, and marshes of North America and Europe. Although most are not parasitic, some are parasites that feed on the blood of other organisms for sustenance. Disturbances in the water in which leeches live stimulate their feeding behavior, as do the proximity of high body temperatures typical of mammals. They are hermaphrodites, but cannot self-fertilize, requiring humid and shaded areas to lay their eggs inside of small cocoons.

The most commonly used species of medicinal leech is Hirudo medicinalis. The leeches of this species have been known to consume up to 9 times their own body weight, which ranges between 5 mL and 15 mL of blood. This volume can sustain them for anywhere between 3 months to one year. Once they are satiated, they do not feed again until digestion is fully complete. The anatomy of Hirudo medicinalis is relatively simple. Their bodies are divided into 102 annuli (segments). Its average adult resting length is about 4 cm, and its coloration varies from green to brown. It has a small anterior sucker for feeding, and a large posterior sucker for movement. At its anterior end lie 10 small eyes and 32 brains that coordinate a fairly complex nervous system. It should be noted that when a leech is injured, for instance the tail is cut off, it is able to regenerate the lost body part as well as regain motor and sensory functions. This is quite remarkable, given most animals are unable to regrow their neural synapses. Not all leeches bite, but among those that do, inside the anterior sucker are 3 jaws containing roughly 100 small teeth each to incise the host's skin. Their bite leaves a pattern in the skin that has often been likened to the Mercedes-Benz symbol.

Leech physiology is more complex, as their saliva contains a diverse mix of chemicals, including an anesthetic, antihistamines, hyaluronidase, and hirudin. The anesthetic and antihistamines help the leech remain unnoticed while it feeds, as the host will not experience discomfort or pain during the process. Hyaluronidase increases the permeability of the host's tissue to ensure efficient delivery of its chemicals, and is also postulated to increase blood flow to the wound made by the leech. Hirudin, arguably the most notable component of leech saliva, is the most potent natural anticoagulant currently known. Normally, when blood is running from a recent wound, an enzyme called thrombin converts the molecule fibrinogen into fibrin, which in turn agglomerates with platelets to achieve hemostasis. However, when a leech bites, the hirudin in its saliva works by inhibiting thrombin, preventing coagulation of the host's blood. The preservation in its liquid form allows the leech to consume, store, and subsequently digest large amounts of blood. Hirudin is extremely potent—on average, blood from a leech bite on a human will bleed for more than 10 hours if left untreated.

Leeches entirely lack digestive enzymes. Hirudo medicinalis has developed a symbiotic relationship with a bacterial species, Aeromonas hydrophila, which lives inside of its gut. In return for a safe place to grow and reproduce, the bacterium secretes several digestive enzymes to aid in breaking down the erythrocytes and hemoglobin in the ingested blood, providing energy for the leech. The bacterium also

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secretes an antibiotic that prevents the growth of other bacterial species. This is to preserve the blood from putrefaction during the long-term storage inside of the gut. This symbiotic relationship is not entirely beneficial for the purposes of human leech therapy, however, as the bacteria can cause serious wound infections. So, modern medical procedures require the use of prophylactic antibiotics before and after leech therapy.5

GRAECO-ROMAN ANTIQUITY

In Graeco-Roman antiquity, leeches were used for the treatment of a wide range of ailments, including eye disease, epilepsy, nasal congestion, and stomach ailments.

Nicander of Colophon, a Greek physician of the second century BC, wrote a medical poem called Theriaca about poisons and their antidotes. He described the medicinal use of the leech for the first time in medical history, recommending it for the extraction of blood after being bitten by a poisonous animal.10

Later, in the first century AD, Pliny the Elder, a distinguished Roman encyclopedist, wrote a 37-book work on natural history. He states, “leeches [are] used…to relieve the body of superfluous blood, and to open the pores of the skin.” He also writes, “leeches may be successfully applied in cases of gout.”11

In the second century AD, Galen, a highly influential Greek physician and philosopher, advocated leech therapy according to Hippocratic humoral theory, as is made clear in his treatise Definitiones Medicæ.12 Humoral theory dictated that health was a balance of the four humors—blood, yellow bile, black bile, and phlegm—which correlated to the four elements—air, fire, earth, and water—as well as to the four seasons. Furthermore, it insisted that an imbalance in these humors caused disease. Since blood was the dominant humor, bloodletting was regarded as an effective therapeutic method for rectifying any imbalances.8

Galen described in his work, Opera Omnia, the steps involved in leech therapy.12 He suggested that after catching a leech to store it in a jar for at least a day to reduce the ‘poison’ that it inherently possessed. Then, to prepare the patient’s skin, the desired area was cleaned and shaved, scratched lightly with the nails, and smeared with animal blood, warm oil, milk, or sugar-water to encourage the leech to bite. After a sufficient quantity of blood had been removed, salt or frankincense ash was sprinkled on the leech’s mouth to detach it. Blood from the wound continued to be removed by cupping or letting the blood run freely.12 In retrospect, this was wise because it was less likely for the Aeromonas hydrophila bacterium to remain in the wound and cause an infection. A bit of flour or cumin, along with a bandage, would eventually stop the bleeding.12

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MIDDLE AGES

The etymology of the term ‘leech’ has its origins in the Middle Ages. It was first derived from an Old English word meaning ‘worm,’ and it also possessed another meaning—‘one who heals,’ or ‘physician.’ Eventually the two meanings overlapped, and doctors became known as leeches.8

The most common technique of bloodletting practiced throughout antiquity was venesection, the incising of veins in specific locations, typically in the arm or leg, to withdraw blood and secure humoral balance.8 Venesection could also be used with cupping, where after the incision, a heated bronze cup was applied over the site, and the amount of blood withdrawn would be proportional to the size of the cup and the vacuum created. Others used a scarifier, also known as a fleam, which was a knife with several small sharp blades, or with a needlelike lancet.13 These methods, however, were often very painful, if not dangerous, because carelessness or lack of skill could damage an artery or a nerve. Medical leeching had considerable advantage over such techniques, as it was less painful, more reliable, slower, and allowed better access to certain hard-to-reach parts of the body, such as the nostril or esophagus.3 These areas were sought out for leeching because generally, the leeches would be placed as near as possible to the site of complaint to maximize effect.8

In this period, barber-surgeons, rather than physicians, were primarily responsible for bloodletting.9 They were equipped with a staff for their patients to grasp to encourage their veins to stand out, a basin to catch excess blood or to hold leeches, and linen bandages.13 In fact, the barber’s pole originated as bloodstained bandages wrapped around the barber-surgeon’s staff with a leech basin sitting on top.13

In the early Renaissance period, a Frenchman named Ambroise Paré, a pioneer in surgical techniques and battlefield medicine, articulated his opinions about the medicinal leech. In his 1634 work, he cautions: "if the leeches be handled with the bare hand, they are angered… and will not bite; wherefore you shall hold them in a white and clean linen cloth…[and] they will take hold of the flesh.”14 To determine the exact quantity of blood removed, he recommends that one “sprinkle them with salt…for thus they will vomit up what blood soever they have sucked.” If more blood needed to be removed than the leech was capable of removing, he suggested “cut(ting) off their tails as they suck, and will not bite; wherefore you shall hold them in a white and clean linen cloth…[and] they will take hold of the flesh.”14
17TH THROUGH 19TH CENTURY EUROPE

The 17th through the 19th centuries were marked by a dramatic rise in the medicinal use of leeches, particularly in Europe. The technique was popularized by Dr. François Broussais, a surgeon in Napoleon’s Grand Army and a professor of general pathology in the Paris Academy of Medicine. His 1816 work *L’Examen des doctrines médicales* explained that all symptoms of ill health were not caused by disease, but rather by the inflammation of the gastrointestinal tract. According to his theories, these malicious symptoms spread to other organs “sympathetically,” and he believed that in order to alter this ‘sympathy,’ the body must be weakened before it was cured.  He advocated a starvation diet and much bloodletting via leeches, applying up to fifty leeches at one time to any given patient. He claimed that leeching could treat a wide variety of diseases, including typhoid fever, syphilis, tuberculosis, and several mental illnesses. He even developed a habit of prescribing leeches to newly admitted hospital patients even before seeing them.

Broussais’ theories were widely accepted in the West, triggering an international “leeching craze” between 1825 and 1850. *Hirudo medicinalis* was particularly popular due to its ability to draw larger volumes of blood than other species. Leeches were exported in huge quantities from Germany, Poland, Turkey, and Egypt. At the peak, France, Russia, and the United States each imported 30 million leeches per year, and over 673,000 kg of blood were drawn from patients in Paris hospitals alone. It is estimated that France imported more than 1 billion leeches between 1800 and 1900.

The “leeching craze” led to the invention of various technologies to make their use more convenient. In 1824, Dr. Richard Reese presented a device he called the ‘leech glass’ in London’s Monthly Gazette of Health. It was a small glass tube used to place leeches precisely on the desired spot on the patient’s body. Reese invented this device after receiving complaints from his fellow physicians about the difficulty of wandering leeches. In such cases, leeches were sometimes threaded at the tail with silk thread to ensure safe removal, as some patients suffocated after a satiated leech detached itself in the esophagus. One would have to be sure that it was threaded from the dorsal to ventral side, as not to cause harm to the leech’s own blood vessels. With the advent of modern physiology, pathology, and microbiology, leeching fell out of favor by the early 20th century, as the emphasis upon experimental, rather than empirical, methods increased. In this way, the harmful affects of leeching were recognized. In the 1820s, the French physician Pierre Louis concluded that excessive bloodletting via leeches was in many cases useless, and was in fact harmful rather than beneficial. He conducted a study finding leech therapy patients suffering from blood loss, infection by the leech’s gut bacteria, and the spread of blood-borne diseases, including syphilis. Because the demand for leeches was so high, there was pressure to use them on multiple patients, significantly increasing the risk of disease transmission. The high demand for a dwindling supply also caused the leech to join the endangered species list in Europe, and it still remains on this list today. By the end of World War II, leeching was no longer accepted as a medical cure.

MODERN USES

In the latter half of the 20th century, however, medicinal leeching experienced a revival that continues to the present day. Its contemporary uses include applications in microsurgery, maxillofacial, reconstructive and plastic surgery. When appendages are re-attached, excessive blood clotting in the veins of the attached portion often lead to necrosis and eventual rejection of the new parts. Leeching has been found to relieve this type of venous congestion in skin grafts and implanted appendages such as the fingers, ears, and nose tips. On average, it takes about 5 to 10 days of leech therapy to induce revascularization. For example, a patient whose thumb had suffered severe trauma at the tip underwent reconstruction using a skin graft. Immediately following graft attachment, the finger seemed to be healing normally. However, postoperative leech therapy was needed when the graft portion began to show signs of venous congestion, as it became purple and swollen. After 3 days of leech therapy, normal blood flow was re-established, and the finger successfully healed and also regained function after about one year.

Yet leech therapy is not limited to implants and skin grafts, as it has been proven to reduce pain and stiffness in the joints of osteoarthritis patients, and is also known for its efficacy in the treatment of complicated varicose veins, peri-orbital hematoma (black eye), and purpura fulminans.

The modern process of applying medicinal leeches is similar to the steps described by Galen, with extra precautions for accuracy and for minimizing the risk of infection. Leeches are kept in refrigerated containers filled with spring water or a special saline solution, and instead of scratching the patient’s skin with the nails, a drop of glucose solution encourages the leech to attach. Gloves are worn so that the leech attaches to the right person, and a gauze ring is placed around the area to guide it. An alcohol swab is typically used to remove it, or, in the rare case it resists, a topical cocaine solution is used to paralyze it. It is important to note that leeches are never removed forcibly, because if their teeth remain in the skin, the risk of subsequent infection is very high.

Past and present research has given hope for future uses of medicinal leeches. In 1884, Dr. John B. Haycraft successfully isolated the anticoagulant hirudin from leech saliva. Hirudin was purified and crystallized by Dr. Fritz Markwardt in 1957, and produced by genetic engineering in 1986. In the words of Markwardt, “the introduction of hirudin into clinical medicine would be a decisive progress in prophylaxis and therapy of thrombosis.” Hirudin has shown promising results of its potential use in the re-establishment of blood.
flow in coronary and arterial thrombosis after angioplasty.

Other studies have been done to investigate the possibility of eliminating the risk of bacterial infection after leech therapy. This is because prophylactic medication is not always cost-effective, and infection remains the predominant risk of undergoing leech therapy today. It has been proven that the treatment of medicinal leeches with the antibiotic ciprofloxacin rids them completely of the Aeromonas bacteria, without hindering their ability to remove blood. Although these results are still preliminary, it is a promising step towards making modern leech therapy a safer process.

In 1850, a medical journal published in London featured an advertisement for ‘Kidston’s Mechanical Leech,’ with illustrations demonstrating its features accompanied by several very positive testimonials. One surgeon states that “the following are its advantages: it is always available, the mode of using it is very simple, it can be applied to any part of the body, and any quantity of blood may be drawn, and that in much less time than by leeches.” Inspired by Kidston’s design, engineers at the University of Wisconsin-Madison are currently developing a new mechanical leech, which dispenses the synthesized anticoagulant to compromised human tissue better than an actual leech. The prospect of diminishing the qualms of patients who are uneasy about attachment of a live leech for treatment is enticing, as such a highly effective treatment should not be neglected. The mechanical leech is a closed glass contraption, with a suction tube for excess blood, an air inlet, and a drug dispenser with a microporous disk at its base.

CONCLUSION

In conclusion, as stated in a 7th century Latin riddle regarding the leech, “I bite unfortunate bodies with three-furrowed wounds/And bestow a cure from my healing lips.” Indeed, despite their negative reputation for being harmful and terrifying parasites, it is apparent that leeches have been used extensively throughout medical history, and remain in vogue today for a number of medical treatments. Although they may never again be as popular as they were in 19th century Europe, leeches seem to be much more of a friend than a foe to mankind with regard to their use in medicine from antiquity to the present day.

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