

# History of Bloodletting

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*Medicinal bloodletting or venesection is the removal of blood from the body by opening a vein so as to reduce the volume of blood within the body. There were two main bloodletting techniques used during antiquity: venesection, the cutting open of a vein; and cupping. With the advent of more modern times, the methods used in antiquity, though not entirely supplanted by leeching, became less widely practiced. During the Middle Ages 500-1500 AD, barber surgeons were known to use bloodletting as a cleansing and purifying process in bathhouses, sometimes using leeches; the red and white stripes of the barber pole began as bloody and clean rags from bloodletting with a sliver-like bleeding cup on the top. Beginning in the late 1700s, the leech became more popular because it caused less pain to the patient and was more reliable in regulating the amount of blood removed. However, due to the advent of physiology, pathology, and microbiology in the late 19th century, the leech fell out of favor. In 1960, however, M. Derganc and F. Zdravic, two Slovenian surgeons, revived the leech's use, and it was brought back to the medical field for reconstructive surgeries and microsurguries. Leeches were and still are used in reattachment surgeries of fingers, toes, legs, ears, noses, and scalps—even in breast reductions. Through the ages, bloodletting has evolved from bleeding people to almost to death, as in George Washington's case in 1799, to the mania of leeching in the 19th century to the controlled use of leeches in microsurgery today. The leech is no longer ubiquitous, but has wormed its way back into the medical field. Although it is doubtful that the demand for leeches will ever again place them on the endangered species list, they've assumed a valuable role in the treatment of human disorders.*

**P**HLEBOTOMY, OR BLOODLETTING, IS THE longest-running tradition in medicine. It originated in the ancient civilizations of Egypt and Greece, persisted through the Medieval, Renaissance, and Enlightenment periods, flourished in Arabic and Indian medicine, and lasted through the 19th century. Through the centuries, bloodletting has evolved from venesection and cupping to the use of leeches. Likewise, the uses and methods of medical bloodletting—the removal of blood from the body by means of opening a vein, cupping, or leeching so as to reduce the volume of blood held within the body in accordance with ideologies corresponding to treatments of diseases—has evolved.

Bloodletting was based on an ancient system of physiology called “humoral medicine.” Originating in the Hippocratic Corpus in *On the Nature of Things*, humoral medicine was based on the premise that the elements of the body reflected those of the natural world; those natural elements included air, water, earth, and fire.

The Greeks believed that the interplay of those elements affected all the forces of the universe. Greek physicians maintained that health depended on maintaining a balance of the humors: black bile, yellow bile, phlegm, and blood. In order to restore health, doctors would drain “excess” humors by purging the digestive tract or draining blood.<sup>1</sup> In *Epidemics Book II*, bloodletting is the cure for flatulence, sphacelus (necrosis, or the localized death of living cells), sudden loss of speech without fever, fractures of the skull, hydrops with cough (an inner-ear problem), and fever.

Venesection and cupping lost favor as time went on and a new method of bloodletting arose—the leech, which was determined to be less painful to the patient. Leeches are part of the phylum *Annelida*, and there are about 300 species of leeches in the class *Hirudinea*. Leeches are freshwater invertebrate parasites found in swamps, ponds, and streams in Central and Northern Europe and America.<sup>2</sup> The leech has

two suckers: a caudal one, which allows for attachment to a substrate from which they are feeding as well as movement, and a cephalic one, by which they bite the host and suck blood.<sup>3</sup> The cephalic sucker houses the chitinous jaws. There are three jaws, each have 70 pairs of horny cutting teeth.<sup>4</sup>

The species of leech used most often in medicine is the *Hirudo medicinalis*, for it inflicts the deepest bite and has the longest time of post-bite bleeding. The medicinal leech can ingest an amount of blood close to that of eight times that of its own weight, 790 percent,<sup>5</sup> seven to fifteen milliliters, and may not need to feed for up to one year after its meal.<sup>6</sup>

In their heyday, leeching could be an expensive treatment. Leeches were carefully selected and graded, then starved for a day. The wound or spot to be leeches was rubbed raw. The patient placed their feet in a tub of hot water to facilitate blood flow, and the leech was attached. Occasionally a leech would bury itself completely inside the patient's body. In these cases, a salt-water enema would be employed to rid the leech from the body.<sup>7</sup> Sometimes it was difficult to persuade the leech to attach itself to the patient. Rubbing the skin until it was red; moistening the skin with sugared water, milk, or blood; rubbing the skin with a piece of meat; and even piercing the skin of the patient until a droplet of blood was in front of the leech were not uncommon methods of persuading the leech to attach.<sup>8</sup>

The leech gained popularity not only because it could be employed in difficult-to-reach places such as the tonsils, hemorrhoids, and the cervix,<sup>9</sup> but also because it didn't cause the patient as much pain as did previous methods of bloodletting. The near or total painlessness of the leech's bite is due to the contents of the leech's saliva, which contains a number of different chemical compounds useful in medicine even today. There is an anesthetic, which makes the bite of the leech painless to its host, who might not even know he or she has been bitten; an antihistamine-like vasodilator, which increases the blood flow to the feeding area by increas-

ing the diameter of blood vessels; and a chemical enzyme called hyaluronidase, which facilitates the degradation of the connective tissues around the bite site, allowing the vasodilatory substance wider access to the area.<sup>10</sup> Along with these three compounds, there is also an anticoagulant, hirudin, which has seen much medical coverage. It was discovered and named in 1884 by J.B. Haycraft. The anticoagulant covalently binds thrombin and prevents the conversion of fibrogen to fibrin. It is the most potent natural inhibitor of clotting known.<sup>11</sup>

The anticoagulant properties of hirudin may be a more effective than those of heparin, a widely used natural anticoagulant discovered in 1916. In a recent study by British physicians, a drug synthesized from hirudin was tested internationally on 17,000 patients in 46 countries, all of whom had previously suffered a heart attack. During the first month after a cardiac arrest, many patients will often suffer a second, fatal heart attack. The British physicians found that patients given the hirudin-synthesized drug were a third less likely to experience a heart attack than patients on traditional treatments, such as heparin.<sup>12</sup>

No one knows exactly when leeches began to occupy an important role in medicine. Varying sources date the leech to 2,500 years ago, when it was used for bloodletting in ancient Egypt.<sup>13</sup> The use of leeches can be seen in the wall paintings found in a sepulchre of pharaohs of 1567-1308 BC.<sup>14</sup> Leeching is also mentioned in a medical encyclopedia from India written in Sanskrit completed between 500 BC and 200 AD.<sup>15</sup>

Leeching reached the height of its popularity in the middle 19th century, when it was espoused by the French physician François Broussais (1722-1838). Broussais was the head French physician of the Val De Grâce Hospital in Paris and a surgeon in Napoleon's Grande Armée.<sup>16</sup> Broussais believed that all diseases were due to inflammation caused by an irritation in the gastrointestinal tract by "sympathy," a concept involving both the neural and circulatory systems. The inflammation in the gastroin-

testinal tract would bring about irritations in other organ systems, bringing on a downward spiral. In order to reduce the building irritation, remedies consisting of changing the diet and bleeding were applied, frequently using leeches for the latter purpose.<sup>16</sup> Broussais promoted the idea that bleeding did not just remove a local excess of blood but created a constitutional weakness. This was his “weakening antiphlogistic regimen.”<sup>17</sup> Convinced of his own treatise, Broussais treated his own gastrointestinal indigestion with fifteen applications of fifty to sixty leeches in the course of eighteen days, for a total blood loss of twenty ounces.<sup>19</sup>

Leeching was prescribed for every known disease and ailment, including laryngitis, nephritis (acute kidney pain), mental illness, and even obesity. Broussais treated such diseases as typhoid fever, syphilis, variolosa, tuberculosis and even mental illnesses by applying leeches to the abdomen.<sup>20</sup> He would apply ten to fifteen leeches at one time to any one patient, exploiting hundreds of leeches daily in his practice.

The superfluous use of leeches by this illustrious doctor encouraged other French physicians to do the same. It was often the case that physicians would commonly prescribe the treatment of leeches prior to seeing the patient.<sup>21</sup> According to French import records, over a billion leeches were imported into France during the 19th century.<sup>22</sup> Broussais was in fact the biggest consumer in France, ordering two to three million leeches in 1824, and his requisitions rose to 42 million in 1833. A record of 57 million leeches were used in 1854.<sup>23</sup> Between the years of 1829 and 1836, five to six million leeches were used annually in the hospitals of Paris, drawing 673,200 kilograms of blood from patients of Parisian hospitals.<sup>24</sup>

About the same time, leeches were applied to patients in countries outside of France as well. Russia consumed about 30 million leeches annually. There, physicians M.J. Mudrov and I.E. Diadkovsky were equally enthusiastic about leeches. The United States imported 30 million leeches annually from Germany between 1824

and 1833. Given these large numbers, however, German authorities were wary of whether they could supply their own domestic needs. Obtaining European “Swedish” leeches became more difficult for Americans, and in 1835 they were forced to offer a \$500 reward to anyone who could breed the Swedish leeches in the United States.<sup>25</sup>

In the treatment of fevers, Robert Jackson, an early 19th-century American physician from Georgia, wrote, “Bleeding is the most important whenever there appear marks of local congestion, inflammation, or that sluggish or torpid action which marks incapacity in the circulation vessels.” He continues to discuss the use of leeches as treatment for myocarditis, peritonitis, pleuritis, hepatitis, gastritis, tonsillitis, nephritis, pneumonia, whooping cough, acute laminitis, dysentery, hemorrhoids, acne, and pimples.<sup>26</sup>

The popularity of leeches around the middle of the 19th century even spawned a craze of wearing clothes decorated with a leech motif. Women wore imitation leech decorations and brooches on their dresses.<sup>27</sup>

As the leech was exploited to the fullest extent, it began to disappear from its natural habitats. The French began to offer rewards to those who could develop new stocks in marshes, streams, and ponds. To feed cultivated leeches, elderly horses were driven into the waters where leeches lived, and frequently died due to loss of blood from feeding the leeches. It was common to see horse carcasses in the countryside.<sup>28</sup> Despite efforts at conservation and cultivation, for a short time the medicinal leech was considered an endangered species.<sup>29</sup>

The reuse of leeches was discontinued when this practice was rumored to transmit some diseases.<sup>30</sup> Several infectious diseases were thought to be transferred from person to person through their applications—syphilis, puerperal fever and erysipelas being a few.<sup>31</sup> Previously, leeches were used multiple times on different patients. However, due to ever-increasing concerns about the potential for infections, each leech was used once on a single patient to minimize infection

from the regurgitation of the leech gut contents.<sup>32</sup>

With the advent of modern pathology, physiology, and microbiology in the late 19th century, bloodletting with leeches fell out of favor.<sup>33</sup> The leeching mania faded slowly away after Broussais's death.<sup>34</sup> After the craze, in the late 19th century, one could purchase 100 Swedish leeches for \$5.<sup>35</sup> (Nowadays, one leech costs between \$4.75 to \$6.50 a piece.<sup>36</sup>) During this period, few references were made in literature with respect to the removal of blood by leeches. It was noted that in one English hospital almost 100,000 leeches were used in 1832; fifty years later, however, less than 2,000 were used.<sup>37</sup> The last famous person to be treated with leeches for bloodletting was 73-year-old Joseph Stalin. On March 16, 1953, Stalin's doctors thought an old remedy would work—leeches to suck the dying man's veins. Stalin died within hours after the application of the leeches.<sup>38</sup> There are a few scattered references to leeching in 20th-century medical texts. Physicians became increasingly disenchanted with leeching, although they were still used occasionally into the 1940s.

The leech was brought back into the medical domain in the middle of the 20th century; its use was called *hirudotherapy*. Its return can be attributed to two Slovenian surgeons, M. Derganc and F. Zdravic from Ljubljana, who published a paper in the *British Journal of Plastic Surgery* in 1960 describing a leech-assisted tissue flap surgery, in which a flap of skin is freed or rotated from an adjacent body area to cover a defect or injury. These surgeons credited their own use of leeches to a Parisian surgeon, Philippe-Frédéric, who reported in 1836 that he had used leeches to restore circulation following the reconstruction of a nose.<sup>39</sup>

With the advent of microsurgery, including plastic and reconstructive surgeries, these doctors found a use for the leech in modern medicine, primarily in the reattachment of fingers, toes, legs, arms, ears, and noses, and even in breast reconstructions.

In operations, one of the biggest problems

that arise is venous congestion; the excess blood from injured or reattached tissue needs to be removed. If the blood is not cleared quickly, the blood begins to clot, the arteries that bring fresh, oxygenated blood will become clogged, and the tissues that were reattached will decay and die. Venous congestion may lead to edema, capillary and arterial slowing, arterial thrombosis, flap ischemia, and eventual necrosis.<sup>40</sup> The main reason why leeches are employed in microsurgeries is to reduce this venous congestion.

When attaching the graft or organ, the arteries and veins need to be reattached as well. Arteries are the most important in reattachment because they supply oxygen-rich blood to the newly reattached graft. But there is usually an inadequate number or size of veins available to accommodate the arterial inflow into the graft. The leech removes excess venous blood until the vessels have had a chance to repair themselves. If the leech were not present, arterial blood flow would decrease because the venous blood would become congested and thus cause necrosis of the tissue and ultimate failure of the attached organ or graft. Instead, the leech acts as a substitute vein, reduces swelling in the tissues, and promotes the healing of the new vessels, allowing circulation to be restored.<sup>41</sup>

After the operation has been performed, the use of the leeches is withheld as long as possible. This is due to the anesthetic in the patient's body. A leech in contact with anesthetic will not feed, a phenomenon that has been called the "lazy leech syndrome." Furthermore, wearing gloves is imperative when applying the medicinal leeches to patients; it would be detrimental for the medical personnel, as well as the patient, if the leech were to attach itself to the incorrect host.<sup>42</sup>

Although the main use of leeches was for bloodletting techniques to relieve excess accumulations of blood in the main parts of the body, leeches have been also used in modern day to relieve excess blood around a bruised eye. Indeed, the phrase "black eye" probably came from the application of leeches surrounding a

bruised eye.<sup>43</sup> Leeches have also been known to reduce pain in osteoarthritis. Studies by researchers from the Essen-Mitte Clinic in Germany have shown that when leeches were applied to the knees of patients with osteoarthritis, the pain as well as the inflammation was alleviated.<sup>44</sup>

In one surgical case, thoroughly described pictorially as well as linguistically, the top two-thirds of a 45-year-old male's ear was amputated. The ear was reattached by means of microsurgery. No veins were available during the reattachment process, and thus there was venous congestion about the attachment point. Initially, no leeches were attached within the first 24 hours, but during the subsequent 24-hour period, three leeches were attached every eight hours. At 72 hours, three leeches were applied every eight hours for 15- to 30-minute intervals. The pictures shown at 24 hours, 48 hours, 72 hours, six days, and two months show the progression of the venous congested attached organ to the pink completely healed organ. Over the process of the two months, many leeches were used, and the reattachment surgery was ultimately successful.<sup>45</sup>

Jonathan Osborne, in 1833, wrote about the traveling leech, a problem that continues to occupy doctors. In "The Case of the Disappearing Leech," a case study of a patient who had just undergone a breast reconstruction, he wrote that a leech applied to the breast after the reconstruction migrated into the incision site and was unwilling to become disengaged from the deep tissue. In another case, a leech that was feeding on a forehead flap nasal reconstruction migrated its posterior end across the patient's upper eyelid to attach at the lateral canthal skin. When the patient awoke, the leech body was bridged across his field of vision.<sup>46</sup> In Osborne's day, tying a piece of string through the leech's body prevented it from venturing to places unknown and restricted. Today, utilizing the leech's aversion to salt, doctors employ a saline-dampened piece of gauze with a hole cut in the center, placing it on the site before the

leech attaches itself.<sup>47</sup>

Not only does a leech have a propensity to travel while it is attached to the host, there are a few other negatives of using the medicinal leech in microsurgery. Hosting an annelid that is eating your excess blood strikes many people as grotesque.<sup>48</sup> However, according to Biopharm, a leech farm in Swansea, Wales, most patients are happy to be treated with leeches as long as the procedure is clearly and precisely explained prior to the application of the annelids.<sup>49</sup> In fact, Leeches USA recently shipped 240 medicinal leeches to four Philadelphia hospitals. The organization yearly imports leeches from a European source and ships about 30,000 leeches to various medical centers.<sup>50</sup> When pain, disfigurement, or dysfunction is the alternative, patients are tolerant of the medicinal leeches.

Despite the visual absurdity of having leeches attach to a person's skin, some patients are locally allergic to the leech's salivary secreted products.<sup>51</sup> Also, the leech sometimes fails to detach itself from the hosts' skin after a prolonged period of time, probably due to an arterial insufficiency. The leech should not be forcibly removed from the host, as the teeth of the leech may be dislodged from the leech and remain in the bite site, causing infection.

The leech, if still attached for a long period of time, should be treated with a topical solution of cocaine. This solution paralyzes the leech, and then the leech is removed from the patient. One should not place the leech in a solution of alcohol or hypertonic saline solution, for the leech may regurgitate the blood and possibly infect the bite site with its own bacteria. Once the leech has been removed, the patient's continued bleeding, caused by the hirudin of the leech's saliva, allows for more decongestion. However, if the bleeding continues and pressure and a coagulant don't stop the bleeding, the loss of blood to the patient can become detrimental, and a blood transfusion might be necessary.<sup>52</sup>

Possibly the most worrisome complication from using leeches, other than superficial scarring, is *Aeromonas hydrophila*. The bacteria are a

normal inhabitant in the foregut of the medicinal leech. The leech does not contain digestive enzymes to break down red blood cells from the blood, so it relies on bacterial enzyme secretions to digest blood.<sup>53</sup> *A. hydrophila* can infect the bite wound or surrounding skin during feeding. If the leech is squeezed, it regurgitates its gut contents, further increasing the likelihood of infection.<sup>54</sup>

Such an infection presents itself as a local abscess. The infection is not reactive to penicillin but to chloramphenicol and aminoglycosides. The two antibiotics are started on the patient prior to the leech's application to prevent the infection. There is, though, a 20 percent incidence rate of contracting the infection.<sup>55</sup>

During the 19th century, the leech became a prized possession. Not only were leeches hard to find in the wild, but it was difficult for rural doctors to keep them alive for very long. There were attempts to create "artificial leeches" to replace the natural leech. The artificial leeches of the 19th century were usually adaptable to a small area of the anatomy. The puncture wound generally attempted to imitate a leech bite.

The earliest substitute was Sarlandière's "bdellometer" from the Greek *bdello*, "leech." This French manufacturer introduced his device in 1819. The bdellometer consisted of a glass bell with two protruding tubes, one for scarification and one aspirator. It was determined to be no more successful than the cupping devices of the time period.

The second French invention was called the "terabdella" (large leech), created by Damoiseau. The device was introduced some time before 1862. It was similar to that of the bdellometer, more of a cupping device than an artificial leech.

The most successful of the mechanical leeches of the 19th century was Heurteloup's Leech, created by Frenchman, Charles Louis Heurteloup. It consisted of two parts, a scarifier and a suction pump. It could hold about an ounce of blood. It was sold in the late 19th century for as much as \$15. It was created for eye ailments and was applied to the temples.<sup>56</sup>

Over the past decade there have been advances in phasing out the natural leech and replacing it with mechanical devices. The thought is that there are too many negatives of the natural leech that are not outweighed by the positives. In a 2003 study by Hartig, Connor, Heisey, and Conforti, the medicinal leech and the mechanical leech were compared to give data about the volume of blood removed, surface tension, and oxygenation levels. The volume of blood removed from both the leech and the device was comparable, as was the surface tension of the skin. However, there were differences in the skin color and the levels of total decongestion and oxygenation of the surface and subcutaneous tissue oxygenation. The medicinal leech did prove to be productive at relieving congestion, but the number of leeches required over an extended period of time to do so do not outweigh the advantages of the mechanical leeches of the late 20th and early 21st centuries. In this study, on average, 215 leeches were used per patient over a 6.6-day period to save eight free tissue attachments.<sup>57</sup> The number of units of blood needed to retain the patient's hemocrit level was, on average, 13 units. The mechanical device has the ability to auto-transfuse the blood it collects, so no blood transfusions are necessary, and it was able to decongest a larger, deeper area, increasing tissue oxygenation levels. The mechanical leeches remove blood even more passively than the medicinal leech, releasing a heparin spray that mimics the hirudin of the leech.<sup>58</sup>

Despite the advantages of using a machine to remove excess blood, there are limitations to the mechanical leech. It is unable to treat small confined tissues such as replanted ears or digits due to the size of the machine, and the mechanical leech can only be used from four to six hours on a single device wound. The natural leech, thus, can not be replaced completely.

The symbiotic relationship, which has survived for over 2,000 years, is unlikely to disappear overnight, and indeed the closing decades of the 20th century and the early years of the

21st century have already seen a revival of interest in this amazing creature.<sup>59</sup> Through the ages, bloodletting has evolved from bleeding people almost to or to death, as with George Washington in 1799, to the mania of leeching in the 19th century by François Broussais, to the controlled use of leeches in microsurgery in the 21st century. The leech has not again become ubiquitous, but has wormed its way back into the medical field. Although it is doubtful that the demand for leeches will ever again place them on the endangered species list, they have again assumed a role in the treatment of human disorders.

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