

Dracunculiasis over the centuries: the history of a parasite unfamiliar to the West

Omar Simonetti¹, Verena Zerbato¹, Stefano Di Bella², Roberto Luzzati², Fabio Cavalli³

¹Infectious Diseases Unit, University Hospital of Trieste, Trieste, Italy;

²Clinical Department of Medical, Surgical and Health Sciences, Trieste University, Trieste, Italy;

³Research Unit of Paleoradiology and Allied Sciences, LTS - SCIT, ASUGI Trieste, Italy

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SUMMARY

Dracunculiasis (Guinea Worm Disease) is a terrible disease limited, even historically, to the arid and poor areas of our planet and which in the West has always been seen as an exotic disease and therefore has never taken root in the collective imagination. This parasitosis is transmitted to humans by drinking water contaminated with crustacean harboring larvae of *Dracunculus medinensis*, a nematode. The natural history of the disease is caused by adult worms invading connective tissues and causing blistering, ulceration and edema. Well known in Ancient Egypt where the disease was endemic in its southern area, was known in Europe mainly from the reports of medical writers starting from the

Roman imperial period but without direct knowledge. In Middle age the descriptions of this disease that physicians and surgeons could read on medical books, at the end, were attributed to veterinary parasitic disease. In Modern age only during the colonialist era dracunculiasis was perceived as a problem, however sporadic. In 1986 Guinea Worm Eradication Program (GWEP) was launch without success. Thus, the disappearance of this parasitosis should still be postponed but not abandoned.

Keywords: Guinea worm disease, dracunculiasis, history of parasitosis, tropical medicine, history of medicine.

INTRODUCTION

The history of infectious-parasitic diseases is sometimes the story of a constellation of entities that seems to emerge from fantastic medieval bestiaries and then project themselves into the worst science fiction scenarios. Dracunculiasis, a parasitic disease little known in the West, is one such entity often referred to as horror in both scientific and public debate [1, 2]. Also known as Guinea worm disease (GWD), dracunculiasis is caused by the largest human-infecting female nematode, *Dracunculus medinensis* ('little dragon

of Medina'). The adult female, in fact, can grow up to about 1 meter in length inside the body of the human host [2, 3]. Dracunculiasis is a debilitating but not fatal disease that man has been fighting for millennia and whose eradication has been considered a noble goal by the WHO but difficult to achieve as it is endemic in critical areas of the world where a radical change in life habits and hygienic practices often clash with wars, tribalism and poverty [4].

A terrible but fundamentally exotic and 'wonderful' disease that has led several scholars, especially in the last century, to hypothesize historical presences and influences that are sometimes unsustainable, but which are still disclosed today. Without wishing to pretend anything complete or definitive, the purpose of this work is to try to take stock of the history of dracunculiasis, especially

Corresponding author

Omar Simonetti

E-mail: omarsimonetti89@gmail.com

from the point of view of doctors and medicine; which could be useful to understand the roots of this disease at a historical, geographic and anthropological level in view of new plans for the eradication of the disease.

■ THE PARASITE AND ITS LIFE-CYCLE

Humans are the main definitive host while some freshwater species of microcrustaceans of sub-species *Copepoda* of the *Cyclopidae* family (*Cyclops*) represent the main intermediate host [5]. It should be noted that cyclopids are an almost ubiquitous component of microfauna in marine, brackish and fresh waters. The cyclops actually responsible for dracunculiasis (as intermediate hosts) belong to the species *Thermocyclops neglectusdecipiens*, *Thermocyclops crassusconsimilis*, *Thermocyclops incisus*, *Thermocyclops inopinatus*, *Thermocyclops emini*, *Mesocyclops major*, *Mesocyclops ogonius*, *Mesocyclops kieferi*, *Cryptocyclops linjanticus* and *Cyclops vernalis* which are all freshwater species [5]. The infection is transmitted to humans by drinking water contaminated with *Cyclops*, in which the larvae of *Dracunculus medinensis* reach the infective stage [6].

Infective larvae released in the stomach invade the mucosa and the intestinal wall and migrate into connective tissues by 15 days. After two months the larvae mature into adult worms. After 100 days male and female worms mate. Interestingly, *D. medinensis* produces the opiate alkaloid morphine, producing a potent immunosuppressive and antinociceptive signal in order to down-regulate immune surveillance responsiveness and pain signaling in the hosts [7]. The male remains in the tissues and in a few months dies. The female moves down the muscle planes and emerges 1 year after infection, typically from the feet and lower legs skin [6, 8]. When the adult worm emerges from the skin, it can cause blistering, ulceration, edema, pain, and pruritus [8]. Furthermore, arthritis and paraplegia caused by direct invasion of the worm in the knee and in the extradural space are described [9, 10]. The process of emergence of the worm lasts up to 8 weeks or more. Before, patients are usually asymptomatic. To get relief from symptoms, patients put their legs in cold water and this usually helps the worm emerge from the skin. At this time, the larvae are released into the water and are ingested by the *Cyclops* restarting the life cycle again [6, 8].



Figure 1 - Past and present manual nematode extraction technique.

■ GWD DIAGNOSIS AND TREATMENT

Diagnosis is essentially based on the clinical presentation. There are no medications and vaccines effective against Dracunculiasis [8].

The disease is preventable by cases containment using some hygienic measures, for example filtering drinking water and - when infected - staying out of water until the worm exited the skin [11]. Other strategies rely on vector control, treating water with the organophosphorus larvicide Temphos [12]. To date the therapeutic approach is mechanical and consists traditionally of winding the emerged worm onto a stick, stopping whenever resistance is felt (Figure 1). The process could take 2 weeks to be completed and the secondary infections are managed by topic antibiotics [13]. Anthelmintic drugs were not effective against dracunculiasis. No drugs are available for treatment and no randomized controlled trials are ongoing. Unfortunately, vaccines for GWD do not exist [14]. Interestingly, as recently modelled, a drug that kills female worms at host level would have the highest impact in preventing morbidity and transmission [15].

■ DRACUNCULIASIS IN THE HISTORY OF MEDICINE

Dracunculiasis is an infrequent disease except in endemic areas, which in the ancient world as in the present one, are quite limited. In the geography of the ancient world we have the feeling that there was an endemic zone limited to the central-southern Egyptian area and the Arabian Peninsula.

la, while elsewhere the disease was, at least according to the sources, unknown. Despite some hypotheses, in fact unlikely, which foreshadow that dracunculiasis was described, albeit metaphorically, by the Old Testament (Numbers: 21), the first evidence of this disease is contained in a passage, somewhat controversial, of the Ebers papyrus [16-18]. The Ebers papyrus was written c.1550 BC but parts of it may have been derived from much older material. It therefore suggests that dracontiasis was already present in ancient Egypt by the beginning of dynasty XVIII, and perhaps even earlier. On the other hand, that dracunculiasis was present in Egypt, especially in the Blue Nile area, can be considered a fact: apart from the autopsy of the 1770 mummy in the Manchester Museum where the presence of the parasite was demonstrated, in the area of Deir el-Medina and Amarna, water supply systems consisting of open wells were widespread since the Paleolithic, which represented an ideal pabulum both for the development of cyclopids and anthropic water contamination [16, 18, 19].

Greek and Hellenistic medical texts do not report evidence of the disease, which was evidently unknown to them: on the other hand, even if the contacts with Egypt in the Minoan and Mycenaean times were rather close, the use of aqueducts and closed cisterns for irrigation and anthropic use evidently did not allow the development of the life cycle of the dracunculus [20, 21]. Starting from the Roman imperial era, certainly thanks to the geographical expansion of the Empire towards Egypt and Arabia Felix, our disease begins to be described from medical writers as drakontia (δρακόντια) (Gal. 8, 392-393 K [*De locis affectis* 6]; ps.? Gal. 19, 449 K [*Definitiones medicae* 187] or as dracontiasis (δρακοντίασις) (ps. Gal. 14, 779-780 K [*Introductio seu medicus*; Περὶ τοῦ δέρματος παθῶν, and Περὶ χειρουργίας εἰδῶν]), while Rufus of Ephesus reports it with the name of *ofis* (ὄφις) (Ruf. *Quaest. med.* 65-69).

Rufus of Ephesus, who lived at the time of Emperor Trajan, is the first medical author to describe the disease, which he claims to have observed in Egypt, and to observe its spread through water:

In Arabia there is a disease called 'Ophis', which in Greek means tendon (νεῦρον). The animal is thick like a string (of the lyra) and coils in the flesh like a snake, mainly in the thigh and calf regions, although also in other parts of the body. I saw an Arab in Egypt who had

this disease, and every time it [the worm] wanted to explode, he felt pain and had fever. The man now had this apparition on his calf, but his servant in the navel region and another woman in the loin region. But when I asked if this disease was common among Arabs, people said that both Arabs and many foreigners who came there and were affected when they drank the water suffered from this disease. Because this is mainly the cause (Quaest. med. 65-69).

Claudius Galen (II century AD) who had refined his medical training in Alexandria in Egypt before arriving in Rome states:

It is said that in a certain place in Arabia dracunculi, so called (τὰ καλούμενα δρακόντια γίνεται), of a nervous nature, similar to earthworms in color and consistency. However, although I have heard many who say they have seen them, I have never seen them myself, so I cannot accurately deduce anything about their origin or essence. (De locis affectis, 6, 3).

Therefore, in the imperial period it was known that in some parts of Arabia and Egypt this disease was present, but it was confined there, as indeed reported, in the following centuries, by various Byzantine authors such as Ezio di Armida or Paolo di Aegina (6th century AD):

In India and the upper parts of Egypt a class of worms called dracunculi resembling the intestinal are formed in the muscular parts of the body such as the arms thighs legs and in the sides of children under the skin and they move in a perceptible manner. Then in process of time at the extremity of the dracunculus matter is formed in the part and the skin being opened the head of the dracunculus comes forth. But if the worm be dragged it occasions pains and particularly when it breaks. (Paul. Aeg. 4.58.1).

In the Arab-Islamic world, the disease was known through translators and commentators of Greek medical texts, such as the Christian Arab writer Quṣṭā ibn Lūqā (820-912), translator and commentator of Rufus of Ephesus, or Hunain who in translating the pseudo-galenic *De locis affectis* specifies about dracunculiasis that this would be present in some regions of Tihâma, a coastal area southwest of the Arabian Peninsula [22, 23]. Dracunculiasis is obviously described by the Arab authors of encyclopedic works such as Rhazes (*Ad Almansorem* 7.24) [24]), Albucasis (*Practica*, 28.12 *De passion venae exeuntis*) and Ibn Sina. The latter, known in the West as Avicenna, in his *Liber Canonis* (Liber IV Fen II tract II: *De apostematibus frigidis et que currunt cursu eorum*, Chap. XXI: *De*

vena medeni) provides a detailed description of dracunculiasis referring in part to Galen and Rufus but also by later authors, Byzantines and Arabs. It will be through this Avicennian version and also through the surgical work of Albucasis that the medieval West will know after the translations of Gherardo da Cremona between 1134 and 1178 but that will enter, especially the *Liber Canonis*, in the curriculum of the Faculties of Medicine from the second half of the 13th century. The Avicennian term *vena medeni* was immediately adopted by commentators and other medical authors of the Latin Middle Ages, and that is why it is found, for example, in the works of Guy de Chauliac (*Chirurgia Magna* 2,2,8: *De elephantia, varicibus, et vena meden*), in the comments by Gentile da Foligno (... *et dicitur vena medena vel civilis*), or in the *Chirurgia* of a late author but still integrated in the medical textual tradition of the late Middle Ages, Leonardo Bertapaglia (1, 26 *De vena civil vel medena*).

Obviously, that of the commentators of the ancient medical texts of the Renaissance and of the early modern age was a completely theoretical exercise, given that in Europe dracunculiasis was unknown, so much so that ended up being assimilated to some bovine and equine subcutaneous parasitic diseases [25].

The nematode causing the disease was firstly classified by Linnaeus (1707-1778) in his masterpiece *Systema Naturae* as *Gordia medinensis* [26]. The Linnean term *medinensis* certainly comes from avicennian tradition but also may show the European perception that the disease was associated with the Holy City of Medina and pilgrimage routes [27].

Accounts of dracunculiasis during Modern colonialism and the Age of Exploration are many and are recorded by different European travellers across centuries. As an example, the Dutch navigator Jan Huyghen van Linschoten (1563-1611) saw evidence of the disease at Ormusz, Iran, in 1584. He described the local method of removing the parasite as follows:

[...] *common plague of wormes, which growe in their legges, it is thought theft they proceede of the water that they drink. These wormes are like unto lute strings, and about two or three fathomes longe, which they must plucke out and winde them aboute a straw or a feather, everie day [...], and so in ten or twelve dayes, they winde them without any let, in the meane-*

time they must sit still with their legges [...] [28]. James Bruce, travelling in the 1760s from Ethiopia to Sudan and Cairo concluded that *farenteit* was a waterborne disease linked to wells and holes dug in the sand to collect water. The term *farenteit* or *ferentik* translates as *pharaoh's worm* indicating an association of the disease with pharaonic Egypt [28, 29]. Another similar report came by the quill pen of Sir James Emerson Tennent (1804-1869), the Colonial Secretary of the British Government in Ceylon from 1845 to 1850:

of these entozoa, [...] which burrows in the cellular tissue under the skin, is well known in the north of the island, [...] the natives attribute its occurrence to drinking the waters of particular wells [30].

Is interesting to note that Tennant is also the responsible of the common name, Guinea worm, of the disease.

In 1819 Carl Rudolphi (1771-1832) demonstrated that the adult female parasite contained larvae and in 1836 Forbes found the larvae in water [31]. Only in 1870 Alekei Pavlovitch Fedchenko (1844-1873) discovered the crustacean intermediate host stages. His work reached wide knowledge in the West after 1895, when it was re-evaluated by Patrick Manson (1844-1922), one of the British pioneers of tropical medicine [27]. Finally, the Indian bacteriologist, Dyneshvar Atmaran Turkhud (c. 1863-1943), solidified this knowledge in 1913 by successfully infecting volunteers using infected Cyclops water fleas [32]. Since then, the disease has been studied by thousands of parasitologists, and in 1986, the WHO initiated a worldwide eradication program that continues to have a controversial success [4].

■ NOTES ON THERAPY

The ancient sources, while constantly declaring that the therapy of dracunculiasis must be surgical, never mention today's traditional system of extracting the worm through its progressive rolling on a stick. The Ebers papyrus, while describing dracunculiasis (and its surgical therapy by means of a flint knife to remove the worm) while the method of rolling it around a stick has been hypothesized by interpreting in this sense a very obscure term (*dqr*) interpreted as 'spinning' by Gardiner in 1916 [33], a theory rejected by several more recent authors [17, 18]. On the contrary, one gets the impression that, given the modern (and

very risky) technique of extracting the worm, it was taken for granted that even in ancient times the same was done.

If Rufus of Ephesus gives no indication on the therapy, the pseudo-galenic author of the Introduction states that *dracunculi* resemble varices and that when they project or move about it is occasion of great pain and are to be removed by making an incision of the skin as for varices. Aëtius (Aet., *Liber medicinalis*, I) suggests putting a ligature round the arm and to tighten it every day so that the dracunculus may come forth by degrees without breaking. The part is to be washed with honied water with oil in which wormwood or southernwood has been boiled or with some such anthelmintic decoction but all acrid things are to be avoided for fear of inflammation. Paolo di Aegina, on the other hand, reports a very inter-

esting practice of extracting the worm, which will be reported later by most of the Arab authors and later by the medieval European authors of surgery:

some say that it is proper to fix a piece of lead to the worm in order that its discharge may not take place at once but gradually with the weight of the lead. Some disapproving of this practice inasmuch as the worm is apt to break with the weight of the lead and occasion violent pains direct the part to be put into hot water in order that the dracunculus being warmed may come forward when it is to be seized with the fingers and dragged forth by degrees. (Paul. Aeg. 4.58.2).

In practice, as can be seen from Avicenna and Avenzoar, the dracunculus had to be quickly released through an adequate diet, ripening compresses and incision. Subsequently, the extraction was carried out by tying the dracunculus to a

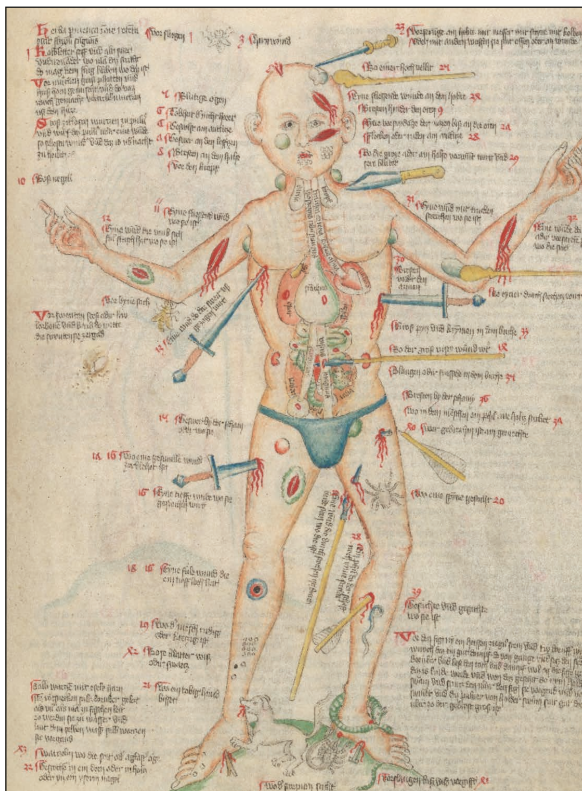


Figure 2a - One example of the graphic drawings of European surgical treatises from fifteenth century. Of note the pale tape-like lesion on the left leg. The Wound Man from a manuscript made in Germany probably around 1420 (London, Wellcome Apocalypse. Wellcome Collection. MS 49).



Figure 2b
Saint Roch
(Anonymous painter,
Pinacoteca di Bari,
Italy. Tempera on
canvas; 15th/16th
century ca).

lead weight. In other cases, it was preferred to attempt the extraction by cutting along the direction of the dracunculus, extending the manual extraction. It should be noted that even in the nineteenth century some Western surgeons who were faced with a dracunculiasis tended to use the Avicennian surgical indications [34].

■ ARTISTIC REPRESENTATIONS OF DRACUNCULIASIS IN EUROPE

Apart from the surgical texts of the fifteenth century, which evidently report the lesson of Albuca-
 cis representing a worm inside the thigh or leg (Figure 2a), a representation that has recently been hypothesized as an example of dracunculiasis is that of a painting by XV century representing San Rocco of the Pinacoteca di Bari (Figure 2b) [35] even if the hypothesis of a representation of the dracunculus could be it is perhaps more likely that it is a long series of drops of putrid material gushing from a bubo, as can also be observed in a statue of San Rocco in Venice (Figure 3). Furthermore, in the devotional painting of a saint invoked against the plague it is more likely that the client asked the painter to represent a known than a completely unknown disease and therefore not very effective at devotional level.



Figure 3 - A bubo representation for devotional purposes. Venice, Church of Saint Roch. Altar and tomb of Saint Roch: statue of the saint by Giovanni Maria Mosca (before 1495, after 1573); particular of the lesion on the left thigh.

■ A RE-EMERGING AND NEVER-ENDING DISEASE

Dracunculiasis is included in the WHO group of Neglected Tropical Diseases [36]. All these diseases have significant health, social and economic consequences to the people they affect. Dracunculiasis used to be called the ‘disease of empty granaries’ because patients usually are unable to farm, work or attend school for months or years [37, 38].

In 1986, 3.5 million cases of Dracunculiasis were estimated by WHO and they occurred in 20 countries worldwide, 17 in Africa and 3 others in Asia [39]. In the same year the global Guinea Worm Eradication Program (GWEP), led by the Carter Center and endorsed by the World Health Assembly, was launched, making Dracunculiasis the second human disease (after smallpox) to be targeted for eradication [12, 37]. The deadline was initially set in 1991. Afterwards, it has been delayed to 2009, 2015, 2020, and, recently, to 2030 [12].

In 2020, WHO reported 27 human cases of Dracunculiasis. All the cases were reported in a few African countries: Angola (1), Chad (12), Ethiopia (11), Mali (1), South Sudan (1), and Cameroon (1). In 2021, WHO reported 14 human cases in Chad (7), South Sudan (4), Mali (2), and Ethiopia (1) [40]. The GWEP has reduced the incidence of Dracunculiasis by over 99%, but still there are some problems related to its eradication. One of the most important consists in the discovery of a new reservoir of the disease in domestic dogs. Dracunculiasis outbreaks in dogs were first reported in Chad in 2012 and were eventually reported in other countries, like Ethiopia and Mali, where also cats and baboons have been infected [36]. Before, only sporadic Guinea worm infections were described in dogs [41]. It’s not yet clear whether dogs, as cats and baboons, can sustain transmission independently, but a probable new route of transmission concerning only these reservoirs has been described [37]. It is a food-borne route of transmission sustained by the ingestion of paratenic (frogs) or transport (fish) hosts [42]. There is no evidence of direct transmission from other mammals to humans [12]. Surely this represents a concrete threat to the Dracunculiasis’ end.

■ CONCLUSIONS

Dracunculiasis is a terrible disease limited, even historically, to the arid and poor areas of our plan-

et and which in the West has always been seen as an exotic disease and therefore has never taken root in the collective imagination. Relegated to tropical parasitology manuals, it has only recently had a certain notoriety given the effort of international health organizations in its eradication, unfortunately at the moment of little success.

From the point of view of the history of Western medicine, the disease has not been confirmed except for the description made by the doctors of the Roman imperial period that reverberated in the Arab medical literature and, consequently, in the Western medical literature where, however, it ended up by to be confused with other parasites, especially in the veterinary field. Here it seems appropriate to observe, among other things, how it is very difficult to support the hypothesis that the caduceus of Asclepius is a rolled up dracunculus: both because the Greeks did not know the disease directly and because the possible therapy (also in the ancient Egypt) was not, as we have seen, based on rolling the worm on a stick. This hypothesis was used for advertising purposes, we would say, when the eradication of the disease was attempted, given that the WHO logo contains the caduceus [43].

The fact remains that this exotic disease, in a period like ours characterized by continuous alterations of ecosystems and with an evident trend towards global warming of the planet, could represent a potential danger even for temperate countries. Apart from the evidence of contamination of marine and fresh waters by copepods of Azov – Black Sea Basin from Asia with profound alterations in the biodiversity of plankton and potential adaptation of cyclopids suitable for hosting the larvae of *Dracunculus medinensis* [44, 45].

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Conflict of interest statement

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