A Broken Leg in the Year 1350: Treatment and Prognosis

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Interpretation

Analysing and reconstructing medical treatments: unique approach to heritageinterpretation through research and re-enactment.

It is the year 1350 in Gravendam (the medieval town of the archaeological open-air museum, (AOAM) Archeon, in the Netherlands). Master Roelof, a wood-and-bone processor, lies unconscious on the stone floor. Shortly before this, he had been climbing the ladder to the attic to grab a log of wood, but it slipped from under him and he ended on the floor. Roelof fainted from the pain, and his leg now lay at a strange angle (See Figure 1). His wife Mette sees that it is not right and hastens to the barber-surgeon for help immediately (See Figure 2). Accidents did happen in the Middle Ages. What could the barber-surgeon have done for Roelof's broken upper leg? Could he have treated the fracture and the possible complications from this injury? What were Roelof's chances of survival? In this first article about medical medieval treatments in Archeon, the treatment of this medical problem will be described and interpreted.

Background

Archeon aims to preserve Dutch cultural heritage. Dressed in authentic costumes, archaeo-interpreters make history tangible to a large audience. They are storytellers who bring prehistory, the Roman era and the Middle Ages to life. The archaeo-interpreters show how people lived, worked, and interacted with their environment and with each other. All 43 buildings in Archeon are either accurate reconstructions of archaeological finds, or based on architectural research (See Figure 3 for an example).
The house of the wood-and-bone processor is situated in the Damstraat and that of the barber-surgeon in the Herenstraat. In the house of the barber-surgeon the visitor can experience standard medical knowledge in the year 1350. The interior gives insight and facilitates a comparison with contemporary medical treatment.

Early medicine

Humourism

To understand how people used to think about medicine and health it is necessary to explain the idea of the body fluids (the humours) or Res Naturalis, and the rules of health (hygiene) or Res non-Naturalis. Medieval medicine was based on the insights of Hippocrates and Galen(Rosenman 2005: 214).
Hippocrates (460 to 377 BC) described the humoral doctrine as the four elements that were known to men. These four elements are air, earth, fire, and water, each of which have their own contrasting properties. He described these elements as the basic fluids of everything in the micro and macro cosmos. The humours were:

1. sanquis, or blood, which was hot and wet and melanchos;
2. black bile, which was cold and dry;
3. cholera, or yellow bile, which was hot and dry, and;
4. mucus or phlegma which was cold and moist.

Each individual person had a unique combination and mixture of these body fluids that were divided depending on one's nature. They either attracted or repelled each other, and had to be balanced. A balanced life meant order and health, but an unbalanced life could lead to illness. Hippocrates called them the four bodily fluids or humours.
Galen(131-210 AD) improved on the ideas of Hippocrates by using anatomical and physiological concepts. He placed the properties of the humours, divided by their dominance in a diagram where he also inserted the zodiac, the cycle of live and the seasons. His knowledge about anatomy was based on the dissection of monkeys and pigs. His idea was that all diseases originated from inside the body and were caused by the corruption of one of the four humours. Wounds, fractures, and abnormal swellings were able to heal as a result of the nourishing actions of humours in the blood (blood was a mixture of the four humours).

Rules of health

In addition to the natural things, the *Res Naturalis*, there were influences from outside the bodily fluids, the *Res non-Naturalis*. In the book, *General Surgery*, by the French surgeon Guy de Chauliac (1300-1368), the ideas of Galen about these six non-natural things were mentioned in the general introduction. These six rules were called *Hygieos*, but have nothing to do with our understanding of hygiene. Moderation and balance of these six rules are preferable:

1. The air we breathe.
2. Nutrition, or the balance between eating and drinking.
3. Working and rest and the proper use of exercise.
4. The sleep cycle and being awake.
5. The control of the excretion and retention of bodily fluids.
6. Mastering of joy, anger, fear and sadness (those emotions being the passions of the soul).


Master Roelof laying on the floor; photo by Vera Bos.


Fig 2. Master Roelof and his mourning wife, Mette; photo by Vera Bos.


Fig 3. Archeon; the Herenstraat; photo by Hans Splinter.


Fig 4. Master Jan the carpenter; photo by Hans Splinter.


Fig 5. The rope-maker; photo by Hans Splinter.


Fig 6. Fracture determination; photo by Hans Splinter.


Fig 7. Bone setting; photo by Hans Splinter.


Fig 8. Bone setting with a visitor; photo by Hans Splinter.

Fig 9. Cleaning the wound and application of black ointment; photo by Hans Splinter.

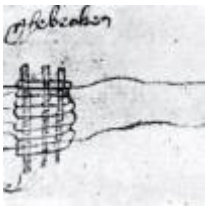

Fig 10. Drawing of the splint by Yperman (Leersum 1912: 292).

Fig 11. The splint bandage.

Fig 12. The cradle; photo by Hans Splinter.

Fig 13. Master Roelof on crutches; photo by Hans Splinter.

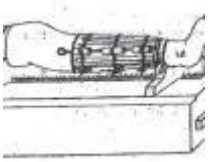

Fig 14. Albucasis Windlass Box drawing by Brunschwig (Rosenman 2005: 692).

Fig 15. Dummy in the house of the barber-surgeon; photo by Roelof Knijpstra.


Fig 16. Reconstructed Windlass Box; photo by Roelof Knijpstra.

Reconstruction in Archeon

Roelof's accident and the subsequent treatment were re-enacted two times, and followed the written script. The first rehearsal with archaeo-interpretors and the second performance with an audience.

The main medieval source

One of the most important sources in Archeon is the medieval book *Cyrurgia*, written by the Flemish surgeon Jan Yperman (1265-1335) in Dutch. He lived in the Belgian town of Ypres and and dedicated his book to his son, who was to succeed him. Little is known about Yperman because the archives of his home town were lost during a bombardment in the First World War. We also do not know where and how he was trained as a barber-surgeon. It is possible that he was educated as a basic surgeon in his hometown and completed his educationfrom 1297 to 1303 at the University of Paris, were the surgeon Lanfranc of Milan (1205-1306) may have been one of his teachers.

The Leiden Professor of Pharmacology and History of Medicine, Dr E.C. Leersum (1862-1938), compared and merged five copies of the original manuscripts in 1912. His book, *Cyrurgia of Jan Yperman*, was our main source (Leersum 1912).

The *Cyrurgia Yperman* divided the traumatic conditions and treatments of the human body into seven chapters, ranging from the head to the feet. In the seventh and final chapter 'from the neck and throat down' he addressed the fracture treatment. If necessary, the texts from the *Cyrurgia* were supplemented with information from the book about the surgery of Yperman's contemporary colleague, the Parisian surgeon Guy de Chauliac, who lived from 1300 till 1368.

Reconstructing of the necessary materials

First the relevant medieval text files were translated and a team of archaeo-interpretors discussed the meaning of the medieval texts. We considered how to manufacture the requirements and attributes and which materials and techniques each craftsman would use in the fourteenth century.

The **carpenter** used ash wood for manufacturing the splints because it is hard, tough, strong and flexible, and was well suited to absorbing large forces. The elder twigs were used for stretching the rope. The leg tray was made of oak, mainly because it was well available (See Figure 4).

The **roper** chose flax to twist the strings because in the 14th century flax was the most common and cheapest material while cotton was expensive material (See Figure 5).

The **felt-maker** made felt according to the conventional Flemish technique which used good quality wool that was utilised in the fourteenth century and that reached a good density and firmness

Middle Dutch texts about fractures in the seventh book

> *Of the neck and of the throat down to all limbs and all sites in the body. Chapter 31: "About fractures"* (Leersum 1912:162)

In this section we start with the translation of the original text and give an explanation based on medieval insights and thoughts. The modern titles of the subsections in bold were made to give more insight and they are not in Yperman's medieval text. The quoted and translated Middle Dutch texts are written cursive or italics. Sometimes the medieval text is translated literally.

About the diagnosis

> *If one has to deal with someone who has a broken leg, then it is imperative that the limb be taken in hand to assess where the bone is broken/get a sense of where the bone is broken.* (Leersum 1912:162)

Explanation: The state of a broken bone was difficult to determine from the outside, especially if it was a complicated (multiple) fracture. If there was any doubt about the source of the pain, care had to be taken in the Middle Ages before proceeding with treatment of a fracture (See Figure 6).

Bone setting

> *Two individuals sit on either side of the injured party, a person at the top and the other at the foot of the patient. The Master (surgeon) kneels between both helpers and holds the leg with his hand and pushes the fractured parts together. If bone fragments pierce through the skin they should be massaged inwards if possible, or extracted.* (Leersum 1912:162)

(See Figure 7 and 8)

Explanation: In the reconstruction, the person on top takes their place behind the patient with his arms under his armpits. His hands are then gripped together and placed on the chest as indicated in Figure 7. Repositioning would be very difficult due to pain and bodily resistance This will be discussed in more detail later.

Fastening the wound bandage

> *Take crack linen a half cubits long and half a span wide. Make it wet with the white of an egg, or any of the following: milk, mulled wine, hot water, black ointment or with popelioene. Wrap the crack linen seven or ten times around the leg wound. Then apply a felt bandage that is longer than a span.* (Leersum 1912:162)

(See Figure 9)

Explanation: A cubit is a linear measure of (at least in the Netherlands) approximately 69.4 cm. A span is also a linear measure and is the distance between the thumb and index finger. Measurements were different in most cities, so considerable variation is to be expected. We did not use all the different medicines or fluids in this reconstruction due to practical reasons, but used only black ointments as explained later.

The nature and strength of linen and felt

A linen bandage was (in the practice of the fourteenth century) the best material to use since cotton was rare and costly. According to the rules of health and balance, linen was cold and dry and it tempered the heat of the body, dehydrated ulcers and was good for hot humours. On the nature of felt (compacted wool) it was said that it was hot and dry, and that it protected the body against cold and kept it warm (Arano 1992: XLVII, XLVI).

The construction of the splint cast

> *Seven splints are applied on top of the felt, each one measuring a finger width and a span length or slightly longer. These are held with three cords, one in the middle of the fracture, the other above and below. Three hollowed elder branches are applied around each rope so tension can be applied to the bandage and the splint. A wooden pipe is inserted through the hollowed elder branches and prevents the ropes rolling down.* (Leersum 1912:162)

(See Figure 10 and 11)

Explanation: preceding the reconstruction we experimented with the bandage of the splint to ensure best practice. This was due to the fact that the text and drawings were not accurate enough. Insight and understanding grew during the bandaging process.

Inspection of the fracture and wound

> *The master (surgeon) shall visit the patient every day to inspect the fracture and if necessary to loosen or tighten the strings. He will apply ointment of poplar buds from the knee to the foot if swelling occurs. A rag soaked in vinegar will cool the leg from the foot to the knee, many will benefit from this.* (Leersum 1912:162)

Explanation: The swelling due to oedema and haematoma is most severe in the first days following the accident and it will increase or decrease due to healing or complications such as infection.

Application of a wax plaster

> *On the 12th day the surgeon will return to the patient to change the dressing. He wets the cloths with warm water in order to prevent the wound from being pulled open. The dressing is then removed and the leg washed and dried. He will then apply a plaster to the wound that is made of linen cloths soaked in wax, lard and white resin that has been melted in a pan. When the plaster is cooled slightly, apply it to the wound, wrap the linen cloth eight or ten times around the leg and tear off. Apply felt and the splint bandage as previously described.* (Leersum 1912:162)

The broken leg in a cradle

> *One leg is placed next to the other for control if they are at the same length. The broken leg is laid in a cradle after the ninth day. The master surgeon is required to keep the leg stiff and straight up to the twelfth day and until the eighteenth day as the fracture begins to stabilize.* (Leersum 1912:162)

(See Figure 12)

Explanation: Between the 12th and 18th day the body creates new bone tissue (callus formation). Yperman did not explain this in his text. The Chauliac mentioned in his chapter about fracture treatments that there is a period between days 12 and 14 where callus formation occursHe told us; after twelve or more days, callus formation is indicated, by freedom of pain, the absence of swelling, and a limb with a healthy colour. (Rosenman 2005: 410)

The healing process

> *The broken leg is checked regularly for 8 to 10 weeks and is inspected or the fracture heals by the nutrition that it gets and the time (the moon days). You can see that because the bone "cross-links", which means that there will be a bulge on it.* (Leersum 1912:163)

Explanation: The fracture heals due to nutrition, according to the rules of the humours. Bodily fluids that dissolve in the blood nourish the fracture and wind throughout the veins.

Rehabilitation

> *After that time, the patient is instructed to walk on crutches. But they should not get carried away as they have seen people walking too early and being too imprudent and the leg broke again. Also it happened that patients went to walk too early which resulted in a shorter leg and they stayed walking with a limp.* (Leersum 1912:163)

(See Figure 13)

Ointments used by Yperman

Black ointment

In the first book Yperman wrote about the efficacy of this ointment; The ointment is good for festering wounds, it cools and refreshes, soothes and heals and it stimulates the formation of pus (Leersum 1912: 21).

Wax plaster

In chapter 40 Yperman wrote about how Cirone or wax plaster was prepared; the plaster is made of bee wax and of lard, of sheep, or from the resin of pitch in which the resin is used the least. One adds this all together in a pan, melts it, then strains the mixture through a linen cloth and wraps it around the broken bone. (Leersum 1912:166)

Populos ointment

Yperman used this ointment in swelling as you can read in the description of the wound on the 12th day later in the text. However according to the recipe in the Boec of medicinen in Dietsche this popular ointment was used in cases of extreme heat caused by high fever (Daems 1967: 191).

Additional information

Pain relief

Neither Yperman as any other surgeon or doctor wrote about pain relief, we know that people in the middle ages were familiar with herbs and plants that were analgesic and sopoforic. We are not sure why, it is an assumption that speaking of and treating pain was dangerous as most herbs were very poisonous and probably there was a religious taboo as Jesus refused the sponge with opium in his last hours of his live. It is difficult to find any sources in this matter. In the modern view the long bones (upper and lower leg bones and upper and lower arm bones) are the largest, longest and heaviest bone in the human body. The muscles of the upper leg (the quadriceps muscle, the Sartorius and the Biceps femoris) are the most powerful in the human body. It was and is virtually impossible to successfully restore a broken bone without effective pain relief. (Kirchmann 1967:110,112)

Bone setting with the aid of a traction device

Yperman gave no information about the problems and difficulties that occurred in bone setting. His colleague de Chauiliac described in his book in the chapter about general treatment what the surgeon had to do:

> *If simple manual traction cannot align the fragments, you use thongs and instruments designed by Hippocrates, and later by Galen. I believe they consisted of a windlass and columns as described by Albucasis, and with pins to hold the position of the windlass. While the traction is in effect, the surgeon will manipulate the fragments and bring the limb to its proper length as compared with the normal side, as insisted by Galen.*(Rosenman 2005: 407-8)

(See Figure 14, 15 and 16)

Prognosis
Yperman described in his chapter that (open) femoral and other long bone fractures were very dangerous but he did not write about the prognosis of such a fracture. Statistics about prevalence and healing is unknown. For now the only way to get an idea of the prevalence of fractures is archaeological research of exhumed bodies.
Bioarcheological study of medieval burials
This study of medieval burials on the site of St Mary Spital London describes more than 10,000 skeletons from the medieval cemetery of St. Mary Spital. The bodies were exhumed and examined for injuries. The total number of fractures and thus also the number of fractures of the femur have been studied and detailed. Because of the large number of patients with fractures in this study, an indication of prevalence and subsequent complications may be given (Connell et al. 2012).
The number of fractures was 8471 of which 550 or 1.1% were shaft fractures (Connell et al. 2012: 95). Of these, 23 thigh fractures were identified comprising 0.3% of the total number of fractures. From this low percentage it can be concluded that the relative occurrence of femur fractures was low and rare in medieval London.
The number of complications in the total number of shaft fracture was 105 (19.1%). Of these, five were identified as femoral fractures (21.7%). This was not significantly higher than the average (Connell et al. 2012: 106).
The complications in shaft fractures were identified by the following means: insufficient fracture healing by poor bone growth, infection, nerve damage, and vascular necrosis. (Connell et al. 2012: 106).
Deformity by poor bone growing was identified in 23 femoral fractures (total 550) of which 17 were deformed, which accounts for 73.9% of the dataset.. This is exceptionally high. It was explained by the author of this chapter: The large muscle mass caused major contractions partly due to mobilizing too quickly, the latter was also mentioned by Yperman (Connell et al. 2012:107; Leersum 1912:162).

Conclusion

The reconstruction of medical treatment from the Middle Ages can not be seen as an archaeological experiment as described by Yvonne Lammers-Keyser (2005) as we did not perform archaeological experiments in humans or human remains. We translated and interpreted the medieval texts and we reconstructed the necessary attributes and medical devices. We performed the treatments described by Yperman in a role playing environment with the audience from the beginning of the accident to the rehabilitation. The whole process brought us a lot of new knowledge and understanding in relation to medieval medical treatments because we compared different treatments with each other. It also showed us how we have to translate this knowledge and insight and reflect the differences and similarities in the story we tell to our visitors.

Further developments

In 2016 we began with a performance using a dummy used in the education of nurses. We dressed the dummy as a medieval person and made a reconstruction of the traction device used by Albucasis. Showing the process of physical examination, observation of possible complications and treatment helped us in bringing our message to the audience in a vivid and convincing way. We will continue experimenting with the use of different materials such as other types of wood to construct the splints.

This paper is the first of three in which the findings of the historical research and the experience of presenting it to the public is published in written articles in the EXARC journal and power point presentations. Of course all material will be made available to all OpenArch partners.
The rehearsals with the audience in 2013 and 2014 will be improved by writing a script about the performance of the accident and the treatment. We will learn about the quality of our performance using the outcome of the adjusted visitor survey (thoughts before and after) that was developed for the OpenArch project in work package

Live Interpretation in Archaeological Open-Air Museums(Hasselt 2015).
One of the peer reviewers mentioned that interpretation is more than re-enactment, it is a combination of education, emotion and entertainment. We hope to achieve this goal in the rehearsals to come.

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Country:
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Era(s):
Late Middle Ages

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Images


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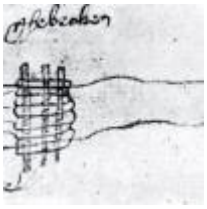
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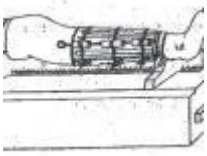
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