Herophilus of Chalcedon and the practice of dissection in Hellenistic Alexandria

Goran Štrkalj, David Chorn

The dissection of human cadavers is a complex topic that can be comprehended only if a number of factors are taken into account, as illustrated by the example of Herophilus of Chalcedon, who was the first dissector in the Western medical tradition. The social, cultural, political and intellectual climate of Hellenistic Alexandria in the third century BC provided Herophilus with opportunities to dissect – and possibly vivisect – human bodies. He was thus able to make an unprecedented number of anatomical discoveries and accompanying accurate descriptions. Subsequent changes in Alexandrian society and its intellectual climate saw the rapid demise of the practice of dissection – its resurgence occurring only some 15 centuries later.

Goran Štrkalj is a physical anthropologist and Senior Lecturer in the School of Anatomical Sciences, University of the Witwatersrand. The history of science is one of his main research interests.

David Chorn was previously Anatomy Teaching Prosector in the School of Biomedical Sciences, Queen's Medical Centre, Nottingham, UK, and is currently Senior Tutor in Anatomy in the Faculty of Health Sciences at Wits.

Corresponding author: *G Štrkalj (goran.strkalj@wits.ac.za)*

Probably no issue in medicine has caused as much controversy and dilemma – scientifically, educationally and morally – as dissection of the human cadaver.[1-5] For most of recorded history and within the various medical traditions, dissection of human bodies was forbidden and often harshly punishable by law. Even when dissection was permitted and tolerated, ' … the motivating reasons for doing them were by no means uniform'.[6] It was a long time before human dissection was introduced into Western medicine. Yet, for a brief period, two scientist-physicians in Hellenistic Alexandria during the third century BC, Herophilus and Erasistratus, performed such dissections. Only some 15 centuries later was the practice re-introduced in Western medicine.[7]

This paper focuses on the period during which dissection was known to have been performed for the first time, and, specifically, on one of its two main protagonists, Herophilus of Chalcedon. The sudden inception of human dissection was remarkable and can only be understood fully if complicated and interrelated scientific, medical, social, political and cultural factors are considered. Likewise, some current dilemmas concerning dissection[8] can be better comprehended if considered in their contextual complexity.

Dissection in antiquity

Despite the paucity of historical documentation, it may fairly be stated that the Alexandrian physicians were the first in the

Western medical tradition to perform dissection of the human body. However, they might not have been the first dissectors in the world. Human dissection, albeit in very different fashion (without the dissectors' hands touching the cadaver – touching the dead human body was forbidden by religious laws), might already have been carried out in India as early as the sixth century BC.[2]

There is no evidence that dissection of human cadavers was practised in pre-Alexandrian Greece. At the time, knowledge of anatomy, assumed to be important in medical practice, was obtained by dissection of animals and the study of external anatomy and wounds and injuries. The famous philosopher Aristotle, for instance, performed many dissections, vivisections and experiments on various animals, leading to numerous novel anatomical insights.[1,2]

Reasons among scientists and medical practitioners in ancient Greece for the non-practice of dissection are many and varied, with some appearing strange and incomprehensible. Indeed, '… religious, moral, and aesthetic taboos, and their psychological concomitants, inhibited practically all ancient and medieval physicians from opening the human body for anatomical purposes …'.[7] For example, there was a strong belief that the dead body was a source of pollution and therefore to be avoided, and handled only when necessary. Elaborate and stringent rules and regulations dealt with the handling of the human corpse and subsequent purification process. Factual and symbolic beliefs about the integrity of the skin and the perceived violation through sectioning of the body were prevalent and respected.[7] Dispelling these restraints so as to render human dissection possible, required significant social, cultural and political changes, as well as willing practitioners,[9,10] which first began to occur in Hellenistic Alexandria.

Alexandria

After conquering Egypt, the young Macedonian king, Alexander, decided to build an exemplary city named after himself.[11] However, driven by his ambitions for conquest, he soon left Egypt, never to see his city again. Alexandria, however, became in a few decades one of the greatest cities of the ancient world. Following the death of Alexander the Great, his 13 generals divided the vast empire between themselves. Alexander's close friend Ptolemy acquired Egypt and made Alexandria its capital. The Ptolemaic dynasty ruled Egypt for almost three centuries, until Rome conquered the land. Ptolemy I and his successor, Ptolemy II Philadelphus, were determined to make Alexandria the artistic and scientific centre of the world. The two autocrats succeeded magnificently. The famous Alexandrian Museum and Library, together with substantial royal incentives, attracted learned scholars and students from across the ancient world. Among them were Archimedes, Euclid, Eratosthenes, Aristarchus, Conon and Ctesibius – as well as Herophilus and Erasistratus, two physicians who made an extraordinary contribution to anatomy and medicine. When the two physicians were living in Alexandria, its population was almost half a million; it was a veritable cosmopolitan melting pot which absorbed influences from all corners of the ancient world.

While the previous mindset had been inimical towards dissection, the new *Zeitgeist* of early Hellenistic Alexandria embraced it.[7,9] Significantly, Ptolemy I was an autocrat and there was no regulatory means to meddle with his decision to make Alexandria the leading centre of learning, irrespective of cost and consequence. He built an unprecedented infrastructure and provided financial support for all manner of scientific pursuit. He and his successors were also prepared to transgress the boundaries of Greek traditions and taboos, and Alexandria provided the perfect opportunity.[7,9] Older Egyptian customs, or perceptions thereof, that appeared to be more advantageous, were simply adopted. Thus, some Ptolemaic dynasty kings readily abandoned Grecian incest taboos and, following Egyptian custom, married their own sisters; and regulations concerning the sanctity of the human body and skin quickly became less rigid. The Egyptian practice of mummification might also have contributed to the greater acceptance of working with cadavers. However, mummification was essentially a religious custom with no bearing on anatomical dissection; sectioning for the sake of anatomical knowledge was then as preposterous in Egypt as it was in Greece. Finally, intellectual influences – mainly from Aristotle – and the philosophies of the Stoics and Epicureans might also have played a part. These philosophers demystified the deceased human body, viewing it more materialistically as nothing other than an inert object.

But an atmosphere conducive to dissection would not of its own have been sufficient were it not for physicians who believed in the importance to medicine of anatomical knowledge, and who were prepared to engage therein. Herophilus of Chalcedon was undoubtedly such a figure, as was his younger contemporary, Erasistratus.[12]

Herophilus of Chalcedon

Many documents about Herophilus have been lost or destroyed.[9,12] His own writings, in fragmented form, are preserved only in the works of later authors. Classical scholars and medical historians have reconstructed the general profile of his life and work, but many aspects are still cloaked in uncertainty.[9] Herophilus was born between 330 and 320 BC in the provincial town of Chalcedon, situated on the Asiatic side of the Bosphorus; he died between 260 and 250 BC. Like many of his contemporaries, he used the social climate of growing Hellenistic cosmopolitanism to forge a distinguished career in Alexandria, probably during the rule of Ptolemy I and Ptolemy II. He was educated under Praxagoras,[12] a prominent

physician of the Hippocratic School, in all likelihood at the school's centre on the island of Cos. Although various sources attribute authorship of 11 books to him, it is generally believed that in fact he wrote between 6 and 8. These covered various medical topics, were widely distributed, and remained current for a considerable length of time. Herophilus was said to have been a brilliant teacher who attracted numerous students from around the known world.[1] The Herophilean School continued to flourish after his death, although his work was later '… plunged into obscurity in part by the popularity of rival schools and in part by the durability and canonicity of Galen's subsequent system …',[9] and was resurrected much later by the Renaissance physicians.

Anatomy by dissection

Dissection was a potent research tool, affording Herophilus unparalleled advantages over previous students of human anatomy who had formulated their insights mainly on indirect evidence and speculation (' … without human bodies for study by dissection, there could be no meaningful anatomy').[13] According to later commentators, Herophilus performed no less than 600 dissections, privately and for the public.[2] Sources from antiquity, such as the renowned Roman medical encyclopaedist Celsus, claim that Herophilus also practised vivisection. The Egyptian ruler apparently sent convicted criminals to Herophilus, who was free to perform any experiment on them. The authenticity of this claim is often questioned, though the knowledge presented by Herophilus might have been acquired through dissection of human cadavers and vivisection only of animals. Yet in the light of the atmosphere prevailing in Alexandria and Herophilus's propensity for entertaining radically new approaches which were acceptable there but an anathema in his city of origin, it may be deduced that he practised vivisection. Herophilus's younger contemporary, Erasistratus, might have been even more likely to have conducted human vivisection as he seemed to be interested more in physiology than anatomy.[1]

Herophilus's research into the structures of the human body, as presented in the book *On Anatomy*, were unprecedented.[1,2,9,10,12,14] Although he was not as well known as other physicians in antiquity, such as Hippocrates and Galen, Herophilus has been hailed as the father of anatomy[2,10] and of other disciplines such as neuroscience.[14] Herophilus ' … made basic discoveries in nearly every system of the body … '.[15] Although some of these assessments may seem exaggerated, his contribution to anatomy and medicine in general was profound, while his influence on subsequent generations of physicians was substantial.[1,9,12]

The number of structures that Herophilus discovered, accurately described and named is encyclopaedic. However, because *On Anatomy* was lost to posterity, secondary sources reveal that it is likely that Herophilus made more contributions than those of which we are aware. Perhaps the most spectacular of his insights relate to the nervous system. Like the earlier Greek physician Alcmaeon of Croton – but unlike Aristotle and the majority of experts before him – Herophilus believed that the brain, and not the heart, was the 'seat of the soul'. He was the first to distinguish between motor and sensory nerves and also between spinal and cranial nerves. He described at least seven cranial nerves and named six pairs: the optic, oculomotor, trigeminal, facial, auditory and hypoglossal nerves. He also described the cerebrum, cerebellum and meninges; distinguished between the four ventricles; and described and named the calamus scriptorium of the fourth ventricle, and the choroid plexus (termed thus because of its resemblance to the membranes wrapped around a fetus). He also studied the internal surface of the skull and described the confluence of sinuses. The concavity on the internal surface of the occipital bone, in which lodges the confluence of sinuses, was eponymously termed the torcular herophili, which is sometimes erroneously used to denote the confluence of sinuses itself.[16] Herophilus also named the styloid ('pen-shaped') process of the skull and differentiated and described the various layers of the eye. He provided detailed descriptions of the salivary glands, the liver (including the hepatic portal system, the significance of which he recognised) and the pancreas, as well as the first part of the small intestine which he named the duodenum ('twelve fingerbreadths'). He recognised that the testicles produce spermatozoa, and identified the various parts of the spermatic duct. He described the prostate and the womb, showing that the latter was attached by the broad ligament and thus not mobile about the body as had been previously thought. A description of the lacteals, lymphatic fluid, the ovaries and at least part of the uterine tubes, flowed too from his keen observations. Pursuing the fields of interest of his teacher Praxagoras, he accurately distinguished, both anatomically and functionally, between veins, arteries and nerves.

For Herophilus, a knowledge of anatomy contributed towards medical practice and particularly surgery.[9,12] Some medical insights, such as the recognition that tremor was the result of nerve failure, probably resulted from his anatomical research. His book on midwifery was based largely on his dissections of the female genital organs.[10,12,15] Herophilus, like Praxagoras, was interested in the diagnostic value of the pulse and constructed a special clepsydra to measure this.[12]

Cessation of dissection

As suddenly as the practice of dissection appeared within medical and scientific milieu, it as rapidly disappeared following the deaths of its two chief protagonists, Herophilus and Erasistratus. The reasons for cessation are as complex as those for inception.[7] Curiously, dissection and vivisection (if ever the latter was performed) ceased despite persistence of the

factors contributing towards their introduction.[7] To account for this sudden reversal in outlook and practice, additional factors must be recalled and considered.

Apparently, some Alexandrian Greeks harboured strong sentiments about the transgression of old values and taboos. Their dissatisfaction became so vocal and bold that they even challenged the Ptolemaic autocrats. In addition, significant intellectual changes concerning medical theory and practice were beginning to take root. After the death of Herophilus, medicine witnessed the rise of the school of 'Empiricists'[12] – practically orientated physicians who placed emphasis solely on knowledge that was of immediate medical value and relevance for a particular procedure. For them, a sophisticated and detailed knowledge of anatomy was of little practical use as they maintained that the dead human body was dissimilar to the living, rendering it an inaccurate guide to the understanding of living anatomy. Moreover, they were convinced that opening a body significantly altered it and that it could no longer provide useful insights into its internal structures. Lastly, a fundamental change in the approach to medicine, which included the followers of Herophilus, resulted in the adoption of a more theoretical perspective. Instead of continuing with experiment and dissection, greater value was placed on reading and analysis of the old masters' works. It appears that these social and intellectual factors together contributed to the sharp reversal in attitude towards dissection of human bodies, and its sudden abandonment.[7,9]

In the case of human dissection, history clearly reveals that '… the body is pregnant with symbolic meanings, deep, intensely charged and often contradictory …', and that '… medical beliefs are always underpinned by cultural attitudes and values about the flesh'.[17]

Dr Štrkalj was a Research Associate at the Wellcome Trust Centre for the History of Medicine, University College London in 2007 and thanks the staff for their hospitality and support.

1. Singer C. *A Short History of Anatomy from the Greeks to Harvey*. New York: Dover Publications, 1957.
2. Persaud TVN. *Early History of Human Anatomy: From Antiquity to the Beginning of the Modern Era*. Springfield, Ill.: Charles C Thomas, 1984.
3. Persaud TVN. *A History of Anatomy: The Post-Vesalian Era*. Springfield, Ill.: Charles C. Thomas, 1997.
4. Richardson R. *Death, Dissection and the Destitute*. 2nd ed. London: Phoenix Press, 2001.
5. MacDonald H. *Human Remains: Dissection and its Histories*. New Haven and London: Yale University Press, 2006.
6. Kevorkian J. *The Story of Dissection*. New York: Philosophical Library, 1959.
7. Von Staden H. The discovery of the body: human dissection and its cultural contexts in Ancient Greece. *Yale J Biol Med* 1992; 65: 223-241.
8. Patel KM, Moxham BJ. Attitudes of professional anatomists to curricular change. *Clin Anat* 2006; 19: 132-141.
9. Von Staden H. *Herophilus: The Art of Medicine in Alexandria*. Cambridge: Cambridge University Press, 1989.
10. Wiltse LL, Pait TG. Herophilus of Alexandria: the father of anatomy. *Spine* 1998; 23: 1904-1914.
11. Fraser PM. *Ptolemaic Alexandria*. Oxford: Oxford University Press, 1972.
12. Nutton V. *Ancient Medicine*. London: Routlage, 2004.
13. Knight B. *Discovering the Human Body: How Pioneers of Medicine Solved the Mysteries of Anatomy and Physiology*. London: Heinemann, 1980.
14. Acar F, Naderi S, Guvencer M, Türe U, Arda MN. Herophilus of Chalcedon: a pioneer in neuroscience. *Neurosurgery* 2005; 56: 861-867.
15. Potter P. Herophilus of Chalcedon: an assessment of his place in the history of anatomy. *Bull Hist Med* 1976; 50: 45-60.
16. Tubbs RS, Oakes WJ. Letter to the editor. *Neuroanatomy* 2002; 1: 14.
17. Porter R. *Blood and Guts: A Short History of Medicine*. London: Allen Lane, 2002.