6. Ground-breaking pioneers or dangerous amateurs? Did early-modern surgery have any basis in medical science?

Dr Stephen M. Rutherford

Introduction

One of the key tenets for modern medical practice is the importance of 'Evidence-based Medicine', the foundation of medical practice on systematic clinical experience and empirical evidence of effective outcomes.[1] The concept of evidence-based medicine as a defined construct is relatively new, being developed in the 1990s, although using an evidence-base for medical practice is not in itself a recent phenomenon.[2] It is a common misconception, however, that evidence-based medical practice was absent from medical practice prior to the nineteenth century.

Early modern surgeons and physicians have a generally poor and unflattering image in the popular imagination. Anecdotes and tales of superstitious treatments, injudicious use of bloodletting and leeches, and barbaric operations performed without anaesthetic, all in unsanitary conditions, support this image of an ineffective and even dangerous practitioner. In particular, the common perception of medical practitioners in the early modern period precludes the use of effective, evidence-based methodologies; assuming a reliance instead on a reliance on folk medicine and superstitious and/or unproven practices. Indeed, Richard Gabriel in his history of military surgery largely dismisses the seventeenth century surgeon, especially the military surgeon, as being poorly trained, overly reliant on traditional theories and bizarre practices, and lacking in education or skill.[3] Indeed, the most common image used of medical practitioners from this period, seen almost ubiquitously in museum displays and textbooks alike, is the bird-beaked hood of the mid-seventeenth century plague doctor, an image which emphasises superstitious beliefs and practices. Yet a study of the writings of the practitioners themselves argues against this unfavourable image.

Surgeons, especially those involved in military conflict, have been at the forefront of medical innovation for many centuries.[4] It is a cliché that war drives innovation but in the case of surgery, this is certainly true. Roman and Greek military surgeons were accounted to be at the forefront of their fields, whilst the Crusades too led to the development of many effective techniques (principally through interactions with better-educated and more-effective Islamic physicians).[5] Even in more recent years, the Crimean War and American Civil War accelerated advances in anaesthetic use, amputation, and casualty care and processing.[6] The First and Second World Wars included significant advances in treatment of shock, reconstructive surgery, treatment of deep tissue wounds and blood transfusion, the use of sulphonamide drugs and antibiotics to combat infection, and treatment of post-traumatic stress disorder (shell

shock).[7] Advances in surgical techniques, investigative procedures, blood diagnostic tests, casualty evacuation and battlefield first aid in Korea and Vietnam, and more recently in Iraq and Afghanistan, have all had impacts upon civilian medicine.[8] The seventeenth century seems to have been no exception.

The impact of the British Civil Wars on the population of the British Isles was far greater than any subsequent conflict, with an estimated population loss of between 3 and 11.57% (compared to 3.04% and 0.64% in the First and Second World Wars respectively).[9] The writings of surgeons involved in the British Civil Wars reveal the extent to which surgery needed to adapt to a sudden and intense change in the requirements of medical practice. Weaponry in the seventeenth century was highly effective. A musket ball could pierce a steel breastplate or helmet, a sword cut could sever a limb, or at least cut straight to the bone.[10] Musket butts, heavy wooden stocks bound in iron, were favoured as a weapon of choice by Civil War musketeers when engaging in close-quarter combat and would result in concussion, craniofacial injuries, or other fractures.[11] Casualty numbers were high both in major conflicts and localised skirmishes. Yet there are examples of soldiers in the British Civil Wars who survived severe injuries, which does suggest that for some soldiers at least, medical care was effective. Such medical care would primarily be at the hands of the Surgeon, either one attached to the military unit or a civilian.[12] As the wars proceeded, these surgeons were able to practice their medical skills on a variety of patients with diverse and exceptional injuries, and thus many gained reputations as being highly effective. Moreover, the repetitious nature of many such injuries meant that a military surgeon would be able to observe the effects of their treatments on a large number of patients, therefore providing the environment for the development of an evidence-based approach to their practice.

This chapter will argue that far from being untrained and dangerous charlatans, military surgeons in the Civil Wars were potentially highly-skilled and well-trained individuals, despite their often lowly beginnings and lack of formal medical education. Indeed, this chapter will propose that many of the key approaches in contemporary surgery and medical care occurred during the early modern period, in concert with other scientific developments. Few, if any, paradigm-shifting breakthroughs in surgery or medical practice were made after the early modern period until the discovery of bacteria as a causative agent of disease and the development of anaesthetics in the mid-nineteenth century, safe and effective blood transfusions in the early twentieth century, and the development of antibiotics in the 1920s and 1930s. Far from being ‘quacks’, the surgeons of the early modern period, especially those who learned their trades in the conflicts of the Civil Wars, were pioneers of medical practice, with good understandings of physiology, anatomy, antiseptics, infection control and pharmacology, whilst much of their practice is still in evidence today with only modest refinements. In particular, this chapter aims to present evidence to show that practitioners in this period exhibited evidence-based practice. By making comparisons to later developments in history,

this chapter aims to show that key methodologies of Civil War surgeons were forward thinking and based on scientific principles and evidence-based methodology.

Medical Practitioners in the Seventeenth Century

There were three major branches of medical practice in the British Isles, and indeed most of Europe, during the early modern period: physicians, apothecaries, and surgeons/barber-surgeons.[13] Added to this were local cunning men and women, as well as nursing practitioners (nursing also being considerably more advanced than is commonly assumed).[14] The definition between these three practitioners was significant.

Physicians were highly-educated professionals (primarily through a university education, often at a continental institution) whose primary focus was on *physic*, the maintenance of the internal workings of the body, bodily homeostasis and treatment of congenital conditions and diseases. The apothecary was the equivalent in many ways of the modern pharmacist, dispensing not only the chemicals prescribed by the physician but also offering inexpensive medical advice of their own to those who could not afford the fees of a physician.[15]

The surgeon's purview was invasive operations, the treatment of external ailments, wounds, fractures and the removal of bodily parts, as well as the letting of blood, application of enemas, some gynaecology and dentistry.[16] They were forbidden by law from treating the inner workings of the body.[17] As his role involved surgical activities undertaken without anaesthetic, the surgeon had a general reputation as being somewhat of a butcher and was feared accordingly. It is also worth noting that there were also examples of women as surgeons, some of whom were licenced by local guilds.[18] In some cases, through much of the medieval and early modern period, the surgeon was also a barber, hence the common term barber-surgeon. However, in England for much of the medieval period there were two distinct professions: the more-educated master surgeons and the less-formally-educated barber-surgeon, until the two were united by the Royal Charter of Henry VIII in 1540.[19] As the status of the profession increased in England and Scotland through the sixteenth century (the barber-surgeons achieved guild status in England in 1540 and in Edinburgh by 1505) and into the seventeenth century, the two aspects of the profession gradually split apart (a separation already observed in the College of Physicians and Surgeons of Glasgow, founded in 1519, which received Royal Charter in 1599, and which excluded barbers).[20] The schism between barbers and surgeons was finalised with the creation of the College of Surgeons in 1745 in England (granted the Royal Charter in 1800)[21] and The Royal College of Surgeons of the City of Edinburgh in 1778.[22] Within the London Company of Barber-Surgeons, during the mid-seventeenth century the two roles were quite distinct from each other, as shown by barbers and surgeons taking it in turns each year to be master of the Company of Barber-Surgeons.[23]

Unlike their physician peers, surgeons would not typically have been educated at University, but rather by apprenticeship to a senior practitioner, followed by an examination for obtaining a Guild licence, with the degree of challenge of that examination varying depending on the nature of the licence.[24] The surgeon was also required to be licenced by the Church, usually *via* the office of the local bishop.[25] Regarding military surgeons, each regiment would likely be allocated at least one surgeon (Gruber von Arni lists the names of the Surgeons noted for the regiments in Scotland (1651-9)[26]). The records of various 17th Century garrisons noted by Gruber Von Arni[27] in the Caribbean campaigns frequently note the presence of a Surgeon General, Master Surgeon, Surgeons, Surgeons and/or Surgeons' Mates; the latter being assistants and often apprentices or journeymen to the more senior practitioner(s). Being of lesser status, the civilian surgeon would have been paid less than the physician.[28] However, within the army, the pay of surgeons and physicians appears to have been relatively similar, although they also appear to have charged for individual services outside of their standard remit, which would suggest that they supplemented their income with private work, even when salaried by the army.[29]

Communication within the profession is evident.[30] Discussion of published works and papers took place within the professional bodies of surgeons, as evidenced by William Clowes, son of the eminent naval surgeon, who introduced a ruling to the London Company of Barber-Surgeons in 1641 that lectures on surgery were to be read by approved surgeons only.[31] Works by William Clowes and John Woodall were aimed specifically at training younger surgeons, suggesting a collegiate environment within the profession.[32] The establishment of guilds of surgeons therefore suggests that there was a good level of communication between practitioners and potentially central repositories for printed works, as well as the sharing of experiences and ideas. The guilds also regulated the practice of their members; the Barber-Surgeons of York were regulated by the 'Searchers', formal officers of the Guild who would inspect the practice of practitioners in the city; a similar approach was noted on the Continent.[33]

Another aspect of significance for surgeons in the mid-seventeenth century was the intellectual environment of the time, especially in England. The seventeenth century, as well as being a period of considerable social and religious upheaval, was also a century in which science and medical understanding flourished. Courtier, poet and scientist Sir Francis Bacon (d. 1626) is largely credited with setting up the foundations of the scientific revolution in the British Isles, foundations which were then built upon with the foundation of the Royal Society in 1660. Leading natural philosophers of the time, such as Johnson, Harvey, Hooke and Boyle in England, as well as Fabry and Descartes in mainland Europe, began to make significant breakthroughs in chemistry, biology, medicine and physiology. In particular, physiology (although not yet termed as such) was gaining in momentum, leading some to begin to challenge the supremacy of Galen's theories on the workings of the body.[34] For example, William Harvey's treatise on the circulatory system (*Exercitatio Anatomica de Motu Cordis et*

Sanguinis in Animalibus) was published in 1628, revolutionising the understanding of the human body, as did Francis Glisson's monograph on liver structure, *Anatomia hepatis*, published in 1654.

Anatomy too was fast becoming a mainstream science throughout the seventeenth century. Wholescale dissection of cadavers was formally authorised by Pope Clement VII in 1537, though it had been an occasional practice in key medical universities since the early fourteenth century and so may already have been accepted practice in England before the split from Rome. Cadaveric dissection rose in popularity across Europe after Vesalius's work was published in the mid-sixteenth century. Both physicians and surgeons were keen to learn from the dissection of corpses and the College of Physicians but the Company of Barber Surgeons being the only two bodies permitted to undertake cadaveric dissection.[35] The surgeons' study of anatomy by dissection was codified in the charter of Henry VIII which established the London Company of Barber-Surgeons, who were granted four bodies of criminals per year to anatomise.[36] Though the conveyance of the corpse to the anatomists was not always an easy one, and the crowd would on occasion remove the body before it could be transported away.[37]

By the mid-seventeenth century, dissective anatomy appears to have been accepted as commonplace for such practitioners. For example, the pages of 'The Printer to the Reader' immediately preceding the preface of the 1631 English extract by 'H. C.'[38] of Ambroise Paré's writings in *An Explanation of the Fashion and Use of Three and fifty instruments of chirurgery* describe the body of a monstrously misshapen convict executed in 1629 (ironically for the murder of the son of a Master Surgeon) brought to the College of Physicians to be 'Cut vp for an Anatomy'.[39] In a pamphlet reporting the unsuccessful execution of Anne Greene in Oxford 1651, it is mentioned in a matter-of-fact manner that her body was taken, once hanged, to 'the College of Physicians, where all the learned Doctors and Chyrurgions [Surgeons] met to anatomise her'.[40] The event was only noted because, much to the surprise of the would-be anatomists, when Anne's corpse was placed upon the anatomists' table she was found to be still alive and woke up! However, the casual manner in which the article refers to the fate of her body suggests that anatomical analysis by physicians and surgeons was common practice.

The level of anatomical knowledge evident in the various surgical treatises is significantly high, suggesting that the authors availed themselves of this learning opportunity, or had learned incidentally on-the-job. James Cooke's book, *The Marrow of Chirurgery*, contains an extensive, detailed and accurate section on human anatomy, whilst the translation of J. Berengarius's anatomical treatise *Μικροκοσμογραφια* [*Microcosmographia]: A description of the Body of Man* (published in English in 1664) was dedicated to the London Company of Barber-Surgeons, presumably to facilitate the training of their members.[41] Seminal works, such as those by Vesalius in his *De humani corporis fabrica*, whilst being far from cheap, had been available since the mid-sixteenth century (although there was no translation from the Latin of

Vesalius's work at the time).[42] The level of anatomical knowledge, such as the blood vessels within the body, the anatomy of ligaments, tendons and nerves, as well as the musculoskeletal system appear to be well-known to the authors of the surgical various texts.[43]

More significantly, understanding the roles of these structures, and how to treat damage to them, is also evident, such as the importance of avoiding trapping nerves or tendons during medical procedures[44] or of the significance of tendons and ligaments to the functioning of muscle and joints.[45] It is not unreasonable, therefore, to assume that many Surgeons, certainly in the mid- to latter-part of the seventeenth century, and especially in the major urban centres such as London and Edinburgh, would likely have been well-versed in anatomy, physiology and the workings of the human body in general.

Pioneering Surgeons of Note

This chapter will focus on the published works of several surgeons in the British Isles and mainland Europe as evidence for practice. In particular, there were a small number of highly influential individuals who published works of significance and longevity. Arguably the cornerstone of many surgical developments in this period was the works of Ambroise Paré (1510-1590), a French barber-surgeon active in the army during the mid-sixteenth century and surgeon to the kings of France from Henri II to Henri III.[46] Paré was highly respected, sufficiently so for Charles IX to reportedly have hidden him in a closet for safety during the St Bartholomew's Day massacre, for fear that his suspected Huguenot leanings would result in his murder.[47] Paré has been credited with several advances in surgery, pathology, orthopaedics and forensics, and several of his works were translated into other languages.[48] His *Three and fifty instruments of chirurgery* was published in London in 1631 and therefore may have had a significant impact on the practice of surgeons in the mid-seventeenth century British Isles. Another documented surgeon from the Continent was Johannes Scultetus (or Schultheiss, 1595–1645), one of the first known trained surgeons in the German region (originally from Ulm, trained at Padua) and a surgeon during the Thirty Years War. [49] Scultetus was an expert in cancer surgery and developed the 'Scultetus binder' or 'many-tailed binder', a method of binding the body after surgery (for example after a mastectomy or abdominal hernia) to relieve tension on the wound, a method which remains in clinical use today.[50] Scultetus's work, the *Armamentarium chirurgicum*, was published posthumously and translated into numerous languages. It remained popular for decades, having a major impact on the education of barber-surgeons in many regions.[51] Scultetus himself was a strong advocate of better training for surgeons and barber-surgeons.[52] The *Armamentarium chirurgicum* contains over 100 individual examples of patients treated, making his book highly evidence-based.

There were also very notable practitioners in the British Isles during the late sixteenth and early seventeenth centuries. Thomas Gale (1507–1567) was a surgeon in the armies of Henry VIII (1544) and later Phillip II (1557), and was elected master of the London Company of Barber-

Surgeons in 1561.[53] Gale was the author of *Certaine workes of chirurgie* (1563), the first printed surgical treatise to be written in English. Two surgeons of significant note in the latter part of the sixteenth and early seventeenth centuries were William Clowes (1543/4–1604) and John Woodall (1570–1643), each of whom had strong links to naval surgery, the former as part of Elizabeth I's navy (active during the Spanish Armada), the latter as Surgeon General of the East India Company.[54] Both developed ideas about treating scurvy and similar implications of long sea journeys and naval warfare. Clowes's *A Proved Practice for All Young Surgeons* was aimed at developing the skills of his peers, and he was a fierce proponent for better standards in the (what he claimed at the time was a poorly-trained and poorly-regulated) surgical profession. *The Surgions Mate*, published by Woodall in 1617, was targeted towards young naval surgeons and extremely influential.

There are there are two published surgeons from the Civil War period and beyond, who are of prime significance to this paper. James Cooke (d. 1693-4) was surgeon to Robert Greville, Lord Brooke, during the First Civil War (prior to Brooke's death in 1643) and of other notables in Warwick during and after the Civil Wars.[55] Cooke published several texts, *Mellficium chirurgiae, or the marrow of many good authors, wherein is handled the Art of Chirurgery* in 1648, *Mellficium chirurgiae, or the Marrow of Chirurgery* in 1655 and *Select observations on English bodies*. In 1657. The *Marrow of Chirurgery* was reprinted six times until 1717, showing the longevity of his works. Cooke's *Select observations on English Bodies* was based on the papers of the late Dr John Hall, purchased from Hall's widow (William Shakespeare's daughter Susannah) sometime between Hall's death in 1639 and her own in 1649.[56] This extensive collection of medical records is likely to have impacted on Cooke's own knowledge base and informed his own medical practice.

The final major contributor whose practice informs this analysis, is Richard Wiseman, surgeon to the prince of Wales during the Civil Wars, including the battle of Worcester in 1651, and sergeant surgeon to Charles as sing after the Restoration.[57] Wiseman's publications, *A Treatise of Wounds* in 1672 and his major work *Severall Chirurgicall Treatise*s in 1676 (later renamed *Eight Chirurgical Tre*atises in 1696) were of significant impact, the latter receiving five reprints 1734.[58] James Kirkup describes Wiseman as bridging 'the gap between military and naval wound surgeons of former generations and emergent civil surgeons'. [59] The key feature of Wiseman's work, as with that of Cooke (though to a much greater extent than Cooke), is the manner in which he uses case studies to evidence his practice, describing several hundred individual cases from his experience in the Civil Wars and in the Spanish navy. Not all of these case studies are clear successes, which makes Wiseman's approach particularly notable, as he is developing an evidence base for practice which does *not* work, as well as that which works effectively. It is approaches like Wiseman's and Cooke's that suggest that surgical practice in the mid-seventeenth century was not the poorly-evidenced and untrained charlatanry that its

popular reputation would imply but rather evidence-based medicine developed through a mixture of training, learning and trial-and-error.

It should be noted that the approach of this analysis is focused on a small number of practitioners only, and those who were fortunate, connected, or privileged enough to have positions of influence sufficient to enable their work to be published in print. It is likely that these individuals were unusual in their craft by being well-resourced and/or of sufficient skill to be noted by grandees sufficiently to be employed by them. Certainly there would have been a great many surgeons who did not share these fortunate circumstances and it is therefore difficult to generalise the findings presented here as applying to all practitioners of surgery, even those contemporary to the published surgeons. However, none of the authors of these treatises were men who hailed from particularly privileged backgrounds. Most do not appear to have had extensive (indeed any) formal medical education at university but rather learned their trade as apprentices and by experience. It is therefore not unreasonable to conclude that these individuals were not atypical of their peers, at least not to such an extent as to make this analysis invalid.

Key Early Modern Medical Concepts

At first glance, the terminology used by the early modern medical practitioner might seem arcane and their practices not based in any appropriate medical methodology. Whilst some of the superstitions of previous centuries were fading (though not completely lost), some traditional elements were still in evidence, such as the doctrine of signatures (which determined that herbal plants were likely to be shaped according to the part of the body they were designed to heal) and the Four Humours (blood, yellow bile, black bile and phlegm; the balance of which it was important to maintain for good health).[60] The reliance on the humours meant that cupping and blood-letting were still seen as effective medical practice (and remained so well into the nineteenth century). It also led to the terminology of blood flow as being referred to as 'heat' (restricted circulation, for example, leading to a lack of 'heat' to a body part). Similarly, there is some cognitive dissonance in understanding of medical and anatomical aspects. For example, despite an understanding of the nervous system, it was still understood that within the tooth resided a 'worm' (a misunderstood interpretation of the nerve) which was fundamental to tooth pain.[61] Many of the surgical treatises and books of physic of the period contain treatments and recipes for ointments and medicines that cannot have any foundation in evidence-based practice. Yet many methods do appear to be effective and not too dissimilar to contemporary medical practice.

Health and Hygiene for the Common Soldier

The circumstances of a military campaign are unlike those of civilian life but do have some parallels. Warfare in the mid-seventeenth century would have led to a high proportion of certain wounds: cuts and lacerations from swords, polearms and shrapnel; concussion damage from

blows to armour, blunt weapons and impact from explosions; penetrative wounds from pikes and polearms, and gunshot injuries from muskets, pistols and artillery fire. Each of these wound types will be discussed below but first an important focus is on the common health and hygiene of soldiers on campaign. Deaths of military personnel from disease were common, typically plague and water-borne diseases (such as typhoid, dysentery or cholera) in summer, typhus in winter. Malnutrition would also have been a concern for a mobile military unit, as well as vitamin or mineral-related diseases such as scurvy or rickets. These conditions and diseases were significant killers, although many could potentially be avoided.

Several treatises exist that advise simple cautionary approaches that householders and soldiers may take to avoid common camp diseases such as the 'bloody flux' (dysentary) and typhoid[62], diahorrea[63], scurvy[64], typhus[65], sexually-transmitted diseases[66] and even plague.[67] Many of these remedies or preventative measures have a solid basis in modern medical practice. Richard Elkes's publication, *Approved medicines of little cost*, published in 1651, advised soldiers to carry a piece of iron in their snapsacks, so that it may be heated to red hot in a fire and dropped into water or beer to purify it.[68] Clearly, Elkes knew nothing of the bacteria that boiling water would kill but by empirical observation, it had been recorded that this approach was effective. Boiling water or beer with oak leaves or bark which contains strong tannins and tannic acid as a cure for dysentery.[69] The medicinal properties of tannins and other plant secondary metabolites have shown positive medical potential in recent years.[70] A solid broth of porridge oats is suggested to aid against diahorrea.[71] Elkes claimed two ingredients are useful to help treat the flux: salt and oatmeal. Salt might replace lost electrolytes from the body during diahorrea, oatmeal might help solidify the patient's stool. Elkes also recommended three 'earth remedies', essentially whole or powdered clay, for treating an upset stomach: 'Terra Sigillata (Terra Lemina), Bolarmonicke and Chalke'.[72] *Terra Sigillata* was a clay exported as a medicinal ingredient from the Greek island of Lemnos, *Bolarmonicke* from Spain and chalk was to be found readily all over the British Isles. The calcium, magnesium and silicon in these clays might have helped settle the stomach, much like milk of magnesia today. The recommended use of chalk (calcium carbonate) powdered in a drink to settle the stomach is directly equivalent to modern treatments of indigestion or heartburn.

Another ingredient seems far-fetched at first: dragon's blood. However, this ingredient was actually a resin from various exotic species of tree.[73] Powdered, dragon's blood could be used both as a pigment and a medicine. Thaspine, a key component of dragon's blood resin from the tree species *Croton lechleri*, has been proven to have apoptotic properties (promotes cell death) in cancer tissue.[74] However, some of the recipes proposed do seem to be somewhat far-fetched. To protect against the plague, for example, Elkes recommended that one eats a small, walnut-sized amount each day of a paste made of powdered clay, walnuts, salt, figs, birthwort root, pimpernels, sorrel seed, purslane seeds and honey. None of these components have been suggested to have protective properties against *Yersinia pestis*, the bacterium that causes the

disease, when ingested in any quantity, let alone one so small. So whilst some of these general remedies have some basis in effective medical practice, they are by no means universally effective.

Antibacterial Agents

Even despite some of the more esoteric cures, many of the approaches suggested by these authors involve chemicals or processes that are mirrored today, where the bacterial cause of infection is known. This suggests that a large proportion of the remedies used were based on empirical evidence, rather than historical precedent and superstition. Principal among these are methods taken to either stem infection, or sterilise materials being used. Despite a lack of understanding of bacteria and the causative factors of infection and disease, it is commonplace to find the use of vinegar, red (and to a lesser extent white) wine, high-protein-level compounds (such as egg albumen) and other anti-bacterial compounds, such as poultices or honey.[75]

Vinegar has long been known as a cleaning and antiseptic agent, a 5% solution of acetic acid being an effective antibacterial agent. Vinegar was used in a diluted form either as oxycrate (vinegar/water mix) or as *posca* (an ancient vinegar/oxidised wine mix with water and herbs). The antibacterial properties of these acidic compounds is due to the reducing effect the acid has on bacterial enzymes and membranes.[76] No practitioners in the sixteenth or seventeenth centuries could have known this but clearly empirical evidence suggested that these agents were effective against infection, revealing a strong evidence base to their practice.

Alcohol is another effective antibacterial compound and alcoholic drinks were the preferred form of beverage for the very reason that it did not lead to disease. The use of wine, especially red wine, to soak bandages, 'tents' (rolled bandages used as separators in cut wounds) or swabs to clean wounds is so common in the writings that it suggests a near-ubiquitous usage. The use of red wine is far more common than white, possibly suggesting it was seen as more-effective. An explanation of this observation could possibly be due to the tannins in red wine, and also potentially due to the presence of resveratrol, an antibacterial and antifungal compound found in the skin of red grapes.[77]

Honey has been used as an antibacterial compound for millennia (there is evidence for its use in ancient Egypt) and has recently seen a resurgence in popularity due to the increase of antibiotic resistance.[78] The concentrated sugars in honey make bacterial survival impossible. Examples of the use of honey include boiling juice of Mullen in honey as a poultice to use on a wound after surgery for cancer, or in the treatment of 'great wounds'.[79] Similarly, high concentrations of protein (such as egg albumen) can have similar effects, and was frequently used as the basis for poultices.

Everyday compounds used in many of the treatments, therefore, did have effective properties and many are still in use today. It is likely that many of the other pharmacopeia and herbal remedies of the period had similarly effective properties, as the majority of modern pharmaceuticals are developed from plant-derived chemicals. Sufficient to say, that even though the practitioners of the time did not understand the mechanisms behind why these antimicrobial compounds worked, they were aware of their effectiveness and had an evidence base from which to base their continual use. The frequency in which they are referred to and their ubiquity across different practitioners suggests that their use was effective and commonplace, whilst also using many chemicals that are still utilised today.

Cuts and Lacerations

A common weapon in the British Civil Wars was the sword. Swords were issued to all soldiers, though it was debateable the extent to which the cheap, mass-produced blades issued to common soldiery would have been used effectively. Even low quality blades could cut deeply into unprotected bodies, with good quality blades cutting bone-deep or potentially severing limbs. This was particularly the case for cavalry blades, with the added momentum of the speed of the rider behind them. Such deep cuts would require significant medical procedures to close the wound and enable it to heal effectively.

Ligatures and Sutures

The texts have clear guidance for closing cut wounds. Two types of approaches are recommended: the use of ligatures and/or sutures. Ligature, a method of closing a wound by tying rather than stitching, was useful where an anatomical feature (such as a blood vessel or part of the body) required tying-off, or where stitching or suturing would not have been appropriate, possible or effective.[80] Ligatures could be either by a stout thread or a *rowler* (bandage). The basic ligature, the *Glutinative* or *Incarnative* ligature, used for 'simple, greene, and yet bloody wounds', used a bandage with either end wrapped around the body part, starting from the opposite side to the wound, crossing over the wound site, and then back again, secured again at the back to close the edges of the wound.[81] This is warned not to be too tight as to cause inflammation or pain, or so loose as to be ineffective. The second, the *Expulsive* ligature was designed to press out pus from an ulcer or infected wound, using a bandage that was wrapped initially loosely around the body, below the wound or ulcer but then ever tighter and tighter as it moved up over the limb or infected region, until it reached the infected area, thus providing pressure to expel the matter.[82] Finally, the *Retentive* ligature, used for wounds which could not be sutured or bound, or for areas such as the throat or belly, which was again a bandage, with pads beneath it, that pressed down upon the injured area.[83]

Where possible, a suture, or stitch, was used. Wiseman highlighted three types of suture: the *Incarnative*, the *Restringent* and the *Conserver*.[84] The *Incarnative* suture (termed the *Interpunctus* by Paré[85]), used for simple wounds, was a single or multiple whip-stitch, with the spacing of the sutures being the equivalent of a finger's width.[86]

> If the Wound be of two Fingers breadth, make one Stitch in the middle; if three fingers breadth, make two Stitches; if four fingers breadth, three Stitches; and so go on, making a Stitch less then the Wound is in number of fingers. Sometimes in declining Parts we make our Stitches at a little more distance. [87]

This was a quick and strong stitch, made with a needle that had a 'three square point' (much like a modern leather needle) for efficient piercing of the skin, and to prevent ripping.[88] The guidance to space stitches a minimum of a finger's breadth apart is in keeping with the material technology of the time, where making fine steel needles, such as are used today, was not possible. Sutures of one centimetre or more apart were therefore the closest that would be effective when sewing through skin and tissue.

The second stitch, the *Restringent* stitch, useful for removing sutures and for internal wounds such as those of the bowel, was the same as a glover's stitch[89] (indeed Paré referred to it directly as the glover's stitch).[90] This stitch enabled a backbone of thread to follow the line of the wound, making the sutures easier to remove and the scar less noticeable.

The final stitch, the *Conserver*, was used for deep wounds which otherwise would have been too extensive for the sutures to hold without tearing. The stitch was '… made by one or more needles, having threed in them, thrust through the wound, the threed being wrapped to and againe at the head and the point of the needle…'.[91] The stitch could also be used on areas where the flesh was thin or weak, such as cuts to the face or treating a hare lip.[92] The *Conserver* used needles, pins or hardened quills, inserted laterally through the wound. These then had thread tied around them in a figure-of-eight pattern, pulling against the pins to draw the wound closed, rather than the lips of the wound, which would tear if used to close an extensive cut wound. The torsion caused here would support the wound until the flesh began to knit and then the wound itself could be closed by another stitch after this initial stage of healing. Such approaches to healing deep wounds were used in the treatment of deep lacerating wounds in the First World War, in Vietnam and were still in use in more recent military conflicts, such as the First Gulf War. The practice of these early modern surgeons, therefore, was sufficiently effective to have been continued for centuries thereafter.

Paré also defined two additional suture types, the *Gastroraphia*, used for deep belly wounds, and the dry suture, used primarily for cuts to the face.[93] The *Gastrographia* involved extensive packing of the wound as well as suture. The dry suture entailed two strips of linen or buckram glued to the skin on either side of the cut, with the sutures sewn through the cloth rather than through the skin, thus joining the two halves of the wound without leaving a disfiguring scar. The surgeons were therefore able to adapt to the fact that their needles were not of fine quality by contemporary standards.

Another type of suture is also mentioned by Paré, who referred to it as the *Seton.*[94] In this treatment, a hole is pierced through the flesh using a red-hot needle or probe. This approach causes an eschar (a form of livid scar tissue) to line the hole, through which thread can be passed to hold the tissue together more-firmly. The *Seton* could then be threaded with a thick thread, linen or wool, in order to drain fluid from the affected area. The *Seton* has a direct modern equivalent in the form of the *shunt*, a fluid drainage tube used in the treatment of swelling, hydrocephalus and even in the treatment of cardiac disease.[95]

An interesting omission in many descriptions of practice is the use of cauterisation: the application of a red-hot cautery (cauterising iron) to sear and seal a wound or a vessel. Common in mediaeval surgery, the use of a cautery is only suggested to be used as a last resort.[96] Even in the repair of blood vessels, a glover's stitch is advised and cauterisation is only used when sutures or plugging the vessel is ineffective or insufficient.[97] Wiseman and Paré are similarly disdainful of the use of hot oil for cauterisation.[98] Indeed, Paré recounted how he accidentally identified that a mixture of egg yolk, rose oil and turpentine was a better means of treating a gunshot wound than boiling oil for cauterisation because he had run out of oil and had to improvise instead.[99] It appears that in the seventeenth century, cauterisation was used only when there was no alternative.

Delayed Primary Closure

One interesting procedure for the treatment of cut wounds appears, at first sight, rather confusing. At first, Wiseman advised, one should clean the wound and let it bleed:

> The weapon thus drawn out, cleanse it from Rags or ought else, and permit the wound to bleed, according to your judgement shall think fit, still having respect to the Constitution and Habit of the body, that what is in the small veins cut asunder may flow out, as well as to hinder inflammation, as the generation of much matter.[100]

By allowing the wound to bleed, potential infectious agents could be removed from the wound site, although this would not be a certain method of removing all risk of infection.

Subsequently, the advice was not to close the wound but instead, to keep it open to the air. A 'tent' (a small rolled-up bandage) could be used to keep the sides of the wound apart until such a time as the surgeon deemed it fit to close the wound.[101] Wiseman advised that the wound be left open until it has the appearance of 'flesh long hang'd in the air'.[102] Paré also advised not to close the wound too soon.[103] Yet, interestingly, Cooke and other treatises did not advise this approach, so it may be that the practice was not universal and that certain military surgeons of the seventeenth century were perhaps pioneers in this practice.

The reason for keeping the wound open is to encourage 'proper digestion' of the wound. In other words, that it should produce pus and otherwise cleanse itself. By leaving the wound

open, it encouraged the accumulation of lymph at the wound site and with it, the necessary white blood cells of the immune system to help fight infection. Closing the wound would merely trap the infection within the wound space and lead to sepsis. This approach of 'delayed primary closure' (also known as 'delayed primary suture') therefore accommodated for the lack of antibiotics in the fight against wound infection and was an approach that has remained in evidence ever since. In the Crimean War, George Husband Baird MacLeod recommended that wounds should be left open until 'all oozing has ceased from the cut surfaces'.[104] In the First World War, the approach for healing deep and infected wounds was to place the patient on a mattress that had been covered with a rubber sheet, then to drip sterile saline solution, or Dakin's Solution[105], through the wound, drawn out by a muslin 'wick' on the lower side of the wound, much to the same effect.[106] Similar approaches were used in the Second World War. In his surgical manual, W. H. Ogilvie also advised that the wound be cleaned and packed with dressing/gauze soaked with 1/1000 flavine solution, then covered for 48-72 hours until it was 'pale and picked, like salt beef'.[107] Ogilvie even goes so far as to name premature closure of the wound by suturing as the first of his '7 deadly sins of field surgery'.[108] Delayed primary closure has continued to be used even long after the development of antibiotics as a means to deal with wound infection, in Korea, Vietnam, in the Gulf and in civilian surgery, such as treating compartment syndrome and appendicitis.[109]

The use of delayed primary closure not only displays the competence of the seventeenth century practitioners but also highlights their understanding of the progress and impact of infection. It was to be another two centuries before bacteria were first identified as the causative agents of infection by Koch and others. Yet, the importance of cleansing the wound, or allowing it to cleanse itself, was clearly evident. The frequent advice for the use of 'rowlers' (bandages) that had been soaked in red wine or vinegar also shows that the authors understood the significance of antiseptic agents, though without any knowledge of the biochemical nature of their effects. The knowledge base of these practitioners, therefore, was far from basic when it came to wound treatment and aftercare. In the absence of a proper understanding of the causes of infection, or access to antimicrobial drugs, their approaches are quite remarkable and were probably highly effective. The need to cleanse the wound and to remove all foreign (and therefore potentially infectious) material from it was also highlighted in the other major wound form of the Civil Wars: gunshot wounds.

Gunshot Wounds

One of the characteristics of the Civil Wars, in contrast to most previous major conflicts within the British Isles, was the prevalence of small arms fire from muskets. Naval surgeons had needed to combat injuries sustained from firearms for well over a century, and evidence for this is found in the collection of surgical implements found on the Mary Rose, which include probes and bullet extractors.[110] However, to most surgeons at the start of the Civil Wars, and

to most civilian-trained surgeons, firearm wounds were unusual and they had little experience in their treatment. Pare offered insights into the diagnosis of a gunshot wound:

> In the beginning of the Curation, you ought first to know whether the wounds was made by Gun-shot or no; which is easie to be seene if the figure of the wound be round and livid in colour, and the naturall colour of the part is chaunged, that is to say, yellow, azure, liuid, or blacke. Al|so at the same instant that the patient receyved the blow, if he say that he felt an agravating pain, as if he had beene strooke with a great stone, or with a club, or as if a great burthen had falne upon the wounded part.[111]

Wiseman warned of the dangers of leaving inexperienced civilian surgeons to treat gunshot wounds, as they are easily mis-diagnosed. Wiseman observed that 'Where the bullet pierceth, it extinguishes the natural heat, and the lips of the wound are livid and blackish'.[112] This effect of a 'gunpowder tattoo' is indicative of a bullet wound.[113] Wiseman warned that a civilian surgeon, or one with no experience of gunshot wounds, would be likely to misdiagnose the blackened nature of the wound as gangrene and to try to treat the wound by 'inserting a pea and a poultice' into the wound, rather than investigating the wound appropriately.

The approaches displayed in the published writings were both effective and efficient. The main foci were on finding the bullet, and material it had taken in with it, removing it without causing further damage, and how to treat the bullet hole afterwards. The musket ball used in the Civil Wars was spherical, made of lead, and typically fifteen to twenty millimetres in diameter (12-bore, the equivalent of 1/12thlb or 38g in weight; although 10-bore (1/10 lb) was also not uncommon).[114] Fired by loose-grain black powder, the musket ball trajectory was typically of a low velocity (400-500 m/sec, compared to a modern rifle velocity of 1200-1700m/sec) with maximum range of up to 180 metres, the force of impact lessening with distance, so the *effective* range of the weapon was significantly less.[115] The low velocity, bullet shape, and the fact that lead in seventeenth century was softer than contemporary lead (which is now typically hardened with antimony), meant that the bullet was often lodged within the body after entry. A bullet will cause significant damage to the body as it travels through tissue, from the 'permanent cavity' (the tissue carved out by the passage of the bullet).[116] A modern conical bullet will typically yaw from side to side and in some cases flipping backwards as it travels within the body but with most high-velocity bullets, the trajectory of the projectile within the body is quite direct. A bullet will also induce a high degree of compression-related damage *via* the 'temporary cavity', due to the shockwave through the body caused by the displacement of tissue and momentum of the bullet.[117] A low-velocity bullet, such as a musket ball, is more prone to cause a wider secondary cavity and also to be affected by the varying densities of tissues within the body. When it strikes tissue of varying densities, ball will likely veer off course, making it challenging to identify the pathway of the projectile; 'It being wonderful to consider how these Shots do twirl about' as Wiseman warned.[118]

An example of the variable trajectory of the musket ball can be seen in the wound received by Sergeant-Major-General Phillip Skippon of the parliamentarian Army at the battle of Naseby, 1645. The bullet pierced his armour and entered his body on the right side of his breast, about six inches below the dorsal side of the armpit, and eventually excited in the small of the back, near the spine.[119] Similarly, a theoretical analysis of the symptoms of Admiral Lord Nelson, after he was shot at the Battle of Trafalgar, suggests that the bullet entered his body at the shoulder, lacerated the pulmonary artery, damaged the lungs and other internal organs, before lodging in the lower spine.[120] Whilst this case was 150 years after the Civil Wars, the shot was from a round lead ball from a smooth-bore musket and so would not have been dissimilar. The random path of the ball therefore posed considerable challenges for the surgeon.

Modern firearms typically have an exit wound which is usually larger, effusive and more-livid than the entry wound. However, this was not always the case with musket shot. Wiseman does describe an exit wound as being different to the entry wound,

> The figure of these wounds is always round. The Bullet forces the Flesh in with it, and the place by which it enters presently contracts closer; but its going out is more lax.[121]

However, frequently the musket ball would not pass through and so would need to be extracted from the body. Key to the process of extraction was locating the bullet, a procedure made challenging by the behaviour of the bullet within the human body. Contemporary accounts of bullet wounds support this observation. Either the surgeon's finger, or a long metal probe (with either a barrel or ball end) would be used to find the bullet, the latter relying on the difference in feel of metal striking bone or tissue, versus striking other metal.[122] The design of such probes (essentially a long metal rod of eight to twelve inches) had not changed since the early sixteenth century and remained largely unchanged until the turn of the twentieth century. The only alteration was that the improvement in material technology meant that the probe could be made lighter and more delicate in later years, as can be seen from extant examples as well as illustrations in later military surgical manuals of the eighteenth and nineteenth centuries.[123] Interestingly, Wiseman suggested that when searching for the bullet, the surgeon,

> … may guess by view of the wound the largeness of the bullet; and by comparing the one with the other make a choice of fit instrument for extraction…
> Your main care in this work must be to find the bullet: But if you fail of it by searching into the wound with the probe then try if you can feel it by handling the parts about.[124]

This advice suggests that the initial approach should be to use an implement, rather than one's own fingers, which would be considerably more sensitive and tactile. Although Wiseman does not state his reasons, it is tempting to suggest that the main reason why one might use a probe,

where a finger would otherwise be a more-sensitive alternative, would be because a probe might be less prone to carry infection into the wound. If the bullet could not be found immediately, then often leaving it in place would lead to sufficient inflammation that its location became obvious.[125]

Once found, the bullet needed to be removed. The device used for bullet extraction could take two forms. A bullet extractor, or *Tirefond,* was a long metal tube containing a bore within it, with a screw-head at one end, which would be used to screw into the bullet, facilitating its removal.[126] Alternatively, tongs could be used, which were long and slender scissor-like implements, usually with either serrated or cupped ends, to clamp the ball. Various versions of these extractors existed, each with their own colourful and descriptive name, such as the 'Crowe's Bill' (with short, toothed fronds), 'Crane's Bill' (with longer, angles fronds), the 'Drake's Bill' (a long device with hollowed-out rounded ends operated by an internal baffle), the 'Parrot's Bill' (a long thin clamp, with a vice-like end operated by a screw) and the Swan's Beake' (which applies outwards pressure, like a modern rib spreader or Finochietto retractor).[127] Several of these implements remained fundamentally the same through the next several centuries but again, improved metallurgical technology leading to more delicate and precise instruments.[128] In removing the bullet, care was often advised not to clamp or pull either tendons or nerves, which hints at the high level of anatomical understanding which underpinned many of these procedures.[129]

Of fundamental importance in the treatments of gunshot wounds was the removal of any foreign matter that may have been taken in with the bullet. This may include dirt, hair and (most importantly) fragments of clothing. A soldier would have worn a shirt, a doublet and a coat, none of which would be particularly clean, and fragments of this cloth, if left inside the body, would hinder wound healing at best, cause septicaemia, fever and possibly death at worst.[130] Removal of 'Rags' seems to have been a fundamental priority in the advised procedures: 'Nay, while any of the Rags remain in the Wound, it will never cure, but the extraneous bodies drawn out, there is little difficulty in healing these Wounds if drest rationally', as Wiseman put it.[131] This was even more important than the removal of the bullet itself, which could sometimes be left within the body without causing too much further damage:

> Yet by the confession of those that allow Fire and Poison in it, the bullet may lie long there, and do little harm. Nay, I suppose there are not many but have heard of or seen bullets that, without grievance to the Patient, have continued lying long in the Fleshy parts of wounded men. Conceive this spoken of Leaden bullets; for Iron or Brass cannot (by reason of their aptness to rust) remain without doing harm.[132]

This obsession with the removal of rags and foreign matter shows the extent to which the surgeons could link cause and effect to the causation of infection and sepsis. The high degree

of prominence of it within the advice given in the texts similarly shows the degree of certainty with which this association was made. The understanding would have come primarily from observation, or from advice from older or more senior surgeons, which is a clear example of evidence-based medicine within these practitioners.

Fractures

Aside from cuts and penetrative wounds, another major wound type on a Civil War battleground would have been a fracture. Whilst the use of blunt weapons such as hammers or pollaxes was far less common than in previous centuries, musketeers would typically fight in close-quarters by using the iron-bound butts of their muskets, rather than swords. Therefore, cranial injuries, broken limbs and ribs would have been commonplace: 'Besides which there were various Fissures, Sedes, and some Fractures, with Depression, made by Sword, Musket-stock, &c.'.[133] Blunt force trauma could also be caused by edged weaponry striking armoured body parts, concussion from explosions, striking by shrapnel from mortar shells, by falls from horses or accidental damage.

Setting of a limb was a straightforward affair, despite not having access to plaster (such as is common for treating fractures today). Instead, setting the bone required splinting, using a leather cast, or wooden or metal splints, held in place with strapping or rowlers, and possibly a stiffened plaster equivalent made from egg white and resin.[134] Wiseman noted that it was important to ensure that the splint does not cause more damage to the limb by rubbing or cutting off circulation or 'heat' to the limb, whilst Paré warned 'it may cause the member to become Atrophied or withered thorough the too long continuation of the said Rollers', which both display a practical understanding of the causes of sores and the implications of restricting circulation to extremities.[135]

A common cause of fractures was the secondary effect of gunshot wounds[136]. Low-velocity bullet wounds, such as those from black-powder weapons, when striking limbs could either cause severe bruising (easily mistaken for gangrene by naïve surgeons) or subcutaneous fractures[137]or if it penetrated, be stopped by the bone and cause a cross-ways fracture in a diagonal cross shape from the strike point.[138] This diagonal fracture is a combination of the energy from the impact trying to find the fastest exit from the bone and also following the grain of the bone. The flake-like fracture that results from such wounds are described as being flake-like, or similar to fish scales, which could only be understood by extensive investigation and frequent experience of such injuries.[139] These fracture patterns were also found in later wars and even recognised up to the Second World War, although by the later twentieth century, the impact of the bullet was likely to cause more shattering of the bone than cross-hair fractures.[140] The treatment of shatter fractures from gunshots remained largely unchanged for many years, until resection of the bone became possible in the mid-nineteenth century, which enabled the

shattered part of the bone to be removed and the bone to be reset as a shorter (but more stable and potentially-recoverable) limb.[141]

The major challenge with projectile-derived fractures is that the shattered nature of the bone is problematic to repair. The fact that there was an open wound, and potentially a projectile remaining in the wound site or the bone itself, was also a challenge for the surgeon. Wiseman advised that it is important to remove the bullet and repair the shattered limb before closure of the wound.[142]

Of importance to the treatment of a projectile-derived fracture, or a compound fracture where the bone has pierced the skin, is the need to dress or otherwise treat the wound whilst also maintaining traction on the limb. In Vietnam and more-recently, this was achieved by using an inflatable cast (a strip of inflatable sleeves which could wrap around and support the limb).[143] In earlier twentieth-century military surgery, this was enabled by the use of the Liston, Thomas and later the Tobruk splint, a personal traction device which held the limb at the top and bottom (e.g. the hip and the ankle) and then joined the two using steel or aluminium brackets, which could be slid apart from one another, then held in place with bolts to provide the traction.[144] The limb could then be supported by using a leather or similar sleeve for rigidity, whilst also providing access to the wound site when required. There is a direct equivalent suggested for similar wounds in the early modern period. The limb is supported inside either a leather or brass sleeve, or item of arm/leg armour, to which is attached long pins, with screws that enable them to be jacked apart to provide tractive force. This model is seen in writings from the 1530s through to 1640s.[145] Aside from the materials involved, the structure of these precursors of the Thomas and Tobruk Splint is identical to that used subsequently, which leads to the suggestion that either the later practitioners may have been building on innovations introduced by the seventeenth-century pioneers, or the seventeenth-century practitioners were utilising good medical practice which was also developed independently by later surgeons.

Amputation

If the limb, or part thereof, was too damaged or infected to be saved, then it needed to be removed in order not to damage the remainder of the body. The removal of body parts through amputation was possibly the most feared and misunderstood of all operations undertaken by the surgeon. James Cooke highlights this in the first sentence of his chapter on amputation: 'Dismembering is a dreadful Operation; yet necessary, that the dead part may not injure the living, nor procure death. *Sphacelus* [Gangrene] is the perfect *Mortification* of any part, invading not only the soft parts, but also the bones'.[146] He further goes on to show a good understanding of the diagnosis of affected parts:

> The part is senseless, tough cut, if unseen by the party [patient]: the flesh is cold, flaggy, black, smells like a dead Carcass, the skin may be separated from the flesh, and flows

> therefrom viscid, green and blackish matter. There may be motion, the heads of the muscles being not affected, yet the work is not to be delayed. It may be taken off, either in the *sound* or *corrupt* part. The first is most use, and more secure.[147]

Quite apart from the common folk myth of the surgeon hacking off a limb with casual abandon, Cooke describes meticulous preparations for the operation, which include bolstering the patient's ability to recover from the operation by providing high calorie diet (including egg yolks and sweet wine) and purgatives before operation.[148] Care is also taken to ensure a sterile operation site, with a requirement for a large bowl of ashes (a source of alkali such as lye, or sodium/potassium hydroxide), water and vinegar to clean the wounded area before and after, and bladders to cover the stump to keep it clean after the operation. Every precaution is also made to ensure that the operation is rapid and there are no unnecessary hiatuses in the procedure. Two bone saws are recommended (a spare therefore being immediately to hand in case of breakage), three needles (ideally ones which had not yet been used for any other purpose, and therefore sharp), several bandages of various kinds, and cloth buttons of various sizes that could be used to plug the ends of blood vessels.[149]

After applying a secure tourniquet (especially important is the limb contains large arteries), the flesh would be cut through to the bone with a dismembering or paring knife (a curved blade with the sharpened edge on the inside of the curve), which, Cooke suggests, some surgeons used red-hot.[150] The bone could then be cut using the saw, as close to the cut flesh site as possible. An eschar would be encouraged to develop by treating the cut site of the stump with a mixture of umber and lime, powdered and made into a paste using egg whites and ground hair (presumably the latter was to encourage aggregation of the poultice). The blood vessels would be plugged with cloth buttons made of tow (strong linen) dipped in *posca*. Alternatively, cauterising or suturing could be used (although the latter was less ideal due to the pressures exerted upon the sutured vessel, leading to rupture and haemorrhage within the stump). Bandaging the wound afterwards was done using rowlers dipped in oxycrate, the dressing kept unchanged for two to three days, then removed, cleansed of clotted blood and replaced with a second set of bandages, this time dipped in white wine. With each successive dressing, the aim was to try, ideally using dry stitches, to draw the edges of the stump together over the bone, after which, when the gap was sufficiently small, the tip of the stump could be stitched. Stitching of the stump was therefore not immediate.[151]

This procedure is remarkable in its attention to detail, hygiene, control of bleeding and the speed at which it should be performed. Management of infection, both of the flesh (which would cause septicaemia) or of the bone (which would cause osteomyelitis), are recognised as important considerations. The understanding of the latter affect, of infecting the bone, is quite remarkable as it reveals an extensive understanding of different entry routes for infections, of which bone-born infections are not obvious. Use of antibacterial compounds (alkali, vinegar or alcohol) also shows a deep understanding of the way in which infection could be controlled (as

does the use of a red-hot dismembering knife), even though bacteria, as causative agents of infection, had not yet been identified. The emphasis on speed of the operation and then on quite intricate aftercare, also reveals a sophisticated approach which belies the butcher-like reputation that is characteristic of popular views of the profession. The emphasis on redundancy of equipment in the preparation is also significant and reflects on the concerns of contemporary military surgeons in Vietnam and the Gulf Wars, who expressed concerns about the fragility of their surgical saws.

The amputatory procedure, whilst undoubtedly being a terrifying and dangerous procedure, especially in the absence of anaesthetics, was nevertheless as controlled as it could realistically be expected to be. Whilst the surgeons did not understand the basis of infection, they did clearly understand how best to control it and limit its impact. The amputation procedure in the seventeenth century was considerably more delicate than that in previous periods (where cauterisation of the stump was commonplace[152]) and indeed, the procedure remained largely unchanged after the development at the end of the seventeenth century of the 'flap amputation' method, using angled cuts through the flesh, rather than transverse ones, to produce flaps of skin that could easier be sewn together over the stump.[153] Many of the precautions established in seventeenth century practice were unchanged until the mid to late nineteenth century and the introduction of anaesthetics and rubbing alcohol or iodine for sterilisation, and the use of anaesthetics to calm the patient (which facilitated more rapid and effective procedures, as there was not also the need to hold the patient down during the operation).

Competence and effect

A key issue, and a problem when assessing the competence of early modern surgeons, is the lack of reliable medical records or specific data on patients. While some records of medical practitioners remain, such as the 1633-1663 casebook of London Surgeon Joseph Binns, the majority of references available regarding the efficacy practice are primarily eye witness accounts of survivors.[154] Such observations may themselves be naïve or unreliable, being either written by lay observers rather than medical professionals and often being embellished for political purposes (such as the detailed accounts of the wounding, treatment and recovery of Skippon in the popular press[155]). The other source of information is the writings of the surgeons themselves, which are subject to reporter bias and were often written many years after the events. Furthermore, it is impossible to determine which of those soldiers who died of their wounds did so because of poor or ineffective practice, or treatment arriving too late, or because the wounds themselves were beyond repair. Wiseman observes that thoracic wounds, and many abdominal wounds, are rarely able to be healed.[156] In this instance, it was a priority for the surgeon to make the patient as comfortable as possible, in order to make his remaining time alive more bearable.

However, one source of information can hint at the extent to which surgery was effective and that is to survey the extent of injuries which appeared to be survivable. Accounts of the recovery of notable figures, such as the well-documented injury and recovery of Skippon or the wounding of Sir Thomas Fairfax in the wrist at Adwalton Moor,[157] can identify injuries which were treated by medical professionals but which were not fatal. Similarly, the survivability of injuries can be inferred by assessing the range of injuries reported by maimed soldiers seeking pensions after the war. Data compiled by Hannah Worthen from Kent County Court records suggests a prevalence of injuries to either the limbs, the extremities (hands and feet) or the eyes.[158] Several petitioners are recorded as having sustained 'many dangerous wounds', suggesting that severe injury could be sustained without certain loss of life. A petition on behalf of John Tinkler of Durham, a gunner at Hartlepool, reveals that he survived blinding and the loss of both his arms.[159] Data summarised by Gruber Von Arni from the records of the admissions to the Chelsea Hospital in the early eighteenth century (1715-32) reveals survivors with injuries to the limbs (often several limbs simultaneously), damage to the head, back, abdomen, clavicle, groin and even removal of part of the peritoneum.[160] What is interesting about these last records is that of the fourteen cases, all of the patients sustained multiple injuries and all but four of them gained those injuries in different engagements, often over several years, showing that they had recovered sufficiently to continue serving in an active military capacity. The treatments these men had received clearly were effective, although it is perhaps telling that the majority of wounds presented by maimed soldiers seem to be damage to the limbs, which perhaps reinforces Wiseman's commentary that thoracic and abdominal wounds were difficult to treat and would most likely be fatal.

Early Modern Surgeons in Context

One characteristic which makes several of the published practitioners (especially Wiseman, and the German surgeon Johannes Scultetus[161]) particularly notable is their approach to describing their many treatments, providing clear evidence of the impact on specific patients. These descriptions are remarkable in that they often state that the approach taken did not produce the desired results. This approach is clearly one of 'evidence-based medicine'. This evidence-based approach is also characteristic of the scientific approaches adopted in the Enlightenment, first developed by Sir Francis Bacon and which are still in evidence in scientific endeavour today. As such, one can view these early surgical pioneers as pioneers of contemporary medical and scientific practice as well.

There are many instances of medical practice in these volumes that do not reflect procedures with a sound basis in science. The question, therefore, is why these practices were still adopted by reflective practitioners who were using an evidence base for their practice. It is notable that case studies are rarely given for any examples of practice that are *not* valid approaches, which leads one to tentatively suggest that in cases where an approach could not be proven by experience, then the traditional medicines or methods were applied by default. It is entirely

possible that some of these treatments, recipes and poultices contained some element of pharmacologically-active ingredients but there are few obvious candidates for most. For example, Wiseman, as well as others, recommend the use of fat rendered from newly born puppies, which may have pharmaco-active properties, but this is highly unlikely.[162] In many cases, it is likely that what was at work was not an active ingredient in the medicine but rather the 'placebo effect' and the body actually self-healing. The placebo effect has been well documented, and evidence suggests that the more-interventionist the therapy, the stronger the placebo effect becomes.[163] It is entirely possible that for some less-serious complaints, the treatment itself was entirely incidental but were assumed to be effective on a *post hoc ergo proper hoc* basis, rather than by empirical proof.

Certainly the surgeons of the early modern period were still wedded to many of the ancient traditions of medicine, especially the concept of the four humours within the body, although there is a tentative sign that these more superstitious concepts were being explained through more rational observations, such as the access of blood to a wound providing heat and cleansing properties. Certainly they were not averse to challenging accepted dogma in the medical profession and, along with the scientific revolution of which they were a part, they were establishing new methodologies of their own and identifying (and sharing) novel practices based on experience. In this, the military surgeon was ideally-situated to refine his practice, as he was provided with ample numbers of patients on whom to observe his effectiveness and the frequency of repetition of certain key injuries to be able to gather replicate observations of different patients.

It is, of course, dangerous to generalise and suggest that all practitioners in the seventeenth century were of equal capacity and training to those described here. Certainly Clowes and Gale seemed to consider their peers to be generally lacking in skill and Wiseman was quite dismissive of the skills of some civilian colleagues. It is also impossible to verify the claims of the surgeons against data or independent medical records. No patient records were kept, certainly not in a systematic manner, so it is impossible to follow individual treatments for all except the most celebrated of patients, such as Skippon.[164] Although Wiseman describes the treatment of his patients clearly, the accounts are, in many cases, twenty to thirty years after the event and so it is questionable whether all of the accounts are entirely accurate (though Wiseman is particularly vociferous that his memory can be trusted)[165]. It is also possible that the reason the practitioners were published was because they were exceptionally-competent enough to have been noted by, and patronised by, grandees (Wiseman was surgeon to the prince of Wales and later to him as Charles II, Paré was surgeon to the French royal family, Gale was close to two royal courts and Cooke was surgeon to Lord Brooke, earl of Warwick). It is therefore highly likely that the majority of surgeons were less capable and/or less well-trained. Certainly no printed work would detail examples of gross incompetence and so the published accounts and guides are not likely to be a true reflection of the profession as a whole.

However, the published writings do evidence practice which is not seen in earlier texts, and practice that is repeated and maintained for several centuries thereafter, albeit with occasional developments and refinements. As such, it is appropriate to see early modern surgeons of the mid-sixteenth to mid-seventeenth centuries as pioneers in their field, military surgeons especially so. For the following 200 years, their techniques were retained, largely unaltered, from their original methodologies. It was only the refinement of material technology that improved the surgical practices, with finer steel-working enabling needles, probes, knives, forceps and saws to be of finer quality or more delicate and precise in nature. The fundamental usage of these instruments, however, was not changed significantly, which evidences the longevity of these practitioners' approaches. Far from being quacks, charlatans or dangerous amateurs, these individuals laid the foundations for surgery as a respected and effective medical profession.

[1] R. B. Haynes, P. J. Devereaux and G. H. Guyatt, 'Clinical expertise in the era of evidence-based medicine and patient choice', *EBM Notebook*, 7 (2002), pp. 36-8.

[2] G. Guyatt *et al*., 'Evidence-Based Medicine: A New Approach to Teaching the Practice of Medicine', *Journal of the American Medical Association*, 268 (1992), pp. 2420-5.

[3] R. A. Gabriel, *Between Flesh and Steel: A history of military medicine from the middle ages to the war in Afghanistan* (Washington D.C., Potomac Books: 2013), pp. 65-85.

[4] P. B. Adamson, 'The military surgeon: his place in history', *Journal of the Royal Army Medical Corps*, 128 (1982), pp. 43-50; N. M. Rich, 'Military Surgeons and Surgeons in the Military', *Journal of the American College of Surgeons*, 220 (2015), pp. 127-35; B. A. Pruitt, 'Combat Casualty Care and Surgical Progress'. *Annals of Surgery*, 243 (2006), pp. 715-29.

[5] Ibid., pp. 715-29; D. Dobanovački *et al.*, 'Surgery Before Common Era', *History of Medicine*, 20 (2012), pp. 28-35; P. D. Mitchell, *Medicine in the Crusades* (Cambridge, Cambridge University Press: 2004) pp. 31-40.

[6] Gabriel, *Between Flesh and Steel*, pp. 133-7; M. M. Manring, A. Hawk, J. H. Calhoun and R. C. Andersen, 'Treatment of War Wounds, A historical review', *Clinical Orthopaedics and Related Research*, 467 (2009), pp. 2168-91; J. Laffin, *Combat Surgeons* (Stroud, Sutton: 1999), pp. 177-9; B. A. Pruitt, 'Combat Casualty Care and Surgical Progress', pp. 722-3.

[7] R. M. Hardaway, '200 Years of military surgery', *Injury*, 30 (1999), pp. 387-97; T. Scotland and S. Heyes, *War Surgery 1914-18* (Solihull, Helion: 2012), pp. 101-13; B. Pichel, 'Broken faces: reconstructive surgery during and after the Great War', *Endeavour*, 34 (2010), pp. 25-9; L. G. Stansbury and J. R. Hess, 'Blood Transfusion in World War I: The Roles of Lawrence Bruce Robertson and Oswald Hope Robertson in the "Most Important Medical Advance of the War"', *Transfusion Medicine Reviews*, 23 (2009), pp. 232-6; D. B. Hoyt, 'Blood and War – lest we forget', *Journal of the American College of Surgeons*, 209 (2009), pp. 681-6; M. M. Manring, A. Hawk, J. H. Calhoun and R. C. Andersen, 'Treatment of War Wounds, A historical review', *Clinical Orthopaedics and Related Research*, 467 (2009), pp. 2168-91; P. H. Pinkerton, 'Canadian Surgeons and the Introduction of Blood Transfusion in War Surgery', *Transfusion Medicine Reviews*, 22 (2008), pp. 77-86; Laffin, 'Combat Surgeons', pp. 197-208.

[8] B. A. Pruitt and T. E. Rasmussen, 'Vietnam (1972) to Afghanistan (2014): The state of military trauma care and research, past to present.', *Journal of Trauma and Acute Care Surg*ery, 77 (2014), pp. S57-S65; Scotland and Heyes, *War Surgery*, pp. 51-82; Gabriel, *Between Flesh and Steel*, pp. 235-6; S. P. Cohen, C. Brown, C. Kurihara, A. Plunkett, C. Nguyen and S. A. Strassels, 'Diagnoses and factors associated with medical evacuation and return to duty for service members participating in Operation Iraqi Freedom or Operation

Enduring Freedom: a prospective cohort study', *Lancet*, 375 (2010), pp. 301–9; D. Trunkey, 'Changes in Combat Casualty Care', *Journal of the American College of Surgeons*, 214 (2012), 879-91; A. Ramasamy, D. E. Hinsley, D. S. Edwards, M. P. M. Stewart, M. Midwinter, P. J. Parker, 'Skill sets and competencies for the modern military surgeon: Lessons from UK military operations in Southern Afghanistan.', *Injury*, 41 (2010), pp. 453–9.

[9] I. Gentles, *The English Revolution and the Wars in the Three Kingdoms, 1638-1652* (London, Routledge: 2007); C. Carlton, cited in E. Gruber von Arni, *Justice for the Maimed Soldier* (Aldershot, Ashgate: 2001), p. 10.

[10] A. Williams, D. Edge and T. Atkins, 'Bullet dents – "Proof Marks" or battle damage?' *Gladius*, 26 (2006), pp.175-206, at p.176 ; V. Florato, A. Boylston and C. Knüsel, eds, *Blood Red Roses: The archaeology of a mass grave from the Battle of Towton AD 1461* (Oxford, Oxbow Books: 2007), pp. 91-2.

[11] R. Wiseman, *Severall Chirurgical Treatises* (London: 1676), p. 400.

[12] Gruber von Arni, *Justice for the Maimed Soldier*, pp. 8 and 27.

[13] A. W. Sloan, *English Medicine in the Seventeenth Century* (Oreston, Carnegie: 1996), pp. 2-8.

[14] Gruber von Arni, *Justice for the Maimed Soldier*, p.103-4 and 148-51.

[15] Sloan, *English Medicine*, pp. 4-6 and 92-6; R. Jütte, 'A Seventeenth-Century German Barber-surgeon and his Patients', *Medical History*, 33 (1989), pp. 184-98, at p. 189.

[16] L. McCray Beier, *Sufferers and Healers: The experience of illness in seventeenth-century England* (London, Routledge: 1987), pp. 12-13; A. L. Wyman, 'The surgeoness: the female practitioner of surgery 1400–1800', *Medical History*, 28 (1984), pp. 22-41, at p.29. J. Cooke, *Mellificium Chirurgiae, or the Marrow of Chirurgery much enlarged, to which is added Anatomy* (London: 1676), p. 73.

[17] Ibid., p. 12. Indeed the Company of Barber-Surgeons petitioned Parliament in 1624 for the right to be able to practice internal medicine, despite the monopoly the physicians had on that branch of medical practice: Anon, *To the most Honourable House of Commons, commonly called, the Lower House of Parliament. The humble petition of the masters or gouernors of the mysterie and comminaltie of barbers and chirurgions of London* (London: 1624).

[18] Wyman, 'The surgeoness: the female practitioner of surgery 1400–1800', *Medical History*, 28 (1984), pp. 22-41.

[19] J. Dobson, 'Barber into surgeon', *Annals of the Royal College of Surgeons of England*, 54 (1974), pp. 84-91, at pp. 84-85.

[20] J. O. Robinson, 'The barber-surgeons of London', *Archives of Surg*ery, 119 (1984), pp. 1171-5; I. MacLaren, 'A Brief History of the Royal College of Surgeons of Edinburgh', *Res Medica*, 268 (2005), pp. 55-56; J. Geyer-Kordesch and F. Macdonald, *The History of the Royal College of Physicians and Surgeons of Glasgow: Physicians and Surgeons in Glasgow, 1599-1858* (London, Hambledon Press: 1999), pp. ix-x.

[21] Dobson, 'Barber into surgeon', p. 91.

[22] MacLaren, 'Brief History', p. 56.

[23] A. Griffin, 'Clowes, William, (1582–1648)', *Oxford Dictionary of National Biography* (Oxford, Oxford University Press: 2008), online edn, http://www.oxforddnb.com/view/article/5717.

[24] McCray Beier, *Sufferers and Healers*, p. 12; Dobson, 'Barber into surgeon', p. 85; R. Magee, 'Medical practice and medical education 1500–2001: An overview', *Australia and New Zealand Journal of Surgery*, 74 (2004), pp. 272–6, at p. 275.

[25] Dobson, 'Barber into surgeon', p. 85; McCray Beier, *Sufferers and Healers*, pp. 12-13.

[26] Gruber von Arni, *Justice for the Maimed Soldier*, p. 228-31.

[27] Ibid., pp. 8 and 34; E. Gruber Von Arni, *Justice to the Maimed Soldier, Vol. 2* (Nottingham, Caliver: 2015), pp. 22 and 62.

[28] Ibid., p. 22-23; Jütte, 'A Seventeenth-Century German Barber-surgeon and his Patients', p. 189.

[29] Gruber von Arni, *Justice for the Maimed Soldier*, pp. 8 and 54.

[30] M. McVaugh, 'Richard Wiseman and the Medical Practitioners of Restoration London', *Journal of the History of Medicine*, 62 (2007), pp. 125-140, at pp. 129, 131-2.

[31] A. Griffin, 'Clowes, William, (1582–1648)', *Oxford Dictionary of National Biography* (Oxford, Oxford University Press: 2008), online edn, http://www.oxforddnb.com/view/article/5717.

[32] As noted on the Prefaces of: A. Paré (transl. W. Hammond), *The Method of Curing Wounds made by Gun-shot. Also by Arrowes and Darts, with their Accidents* (London; 1617); H. C., *An Explanation of the Fashion and use of Three and fifty instruments of chirurgery* (London, 1631); H. Crooke (transl.), 'Μικροκοσμογραφια: A description of the Body of Man, together with the controversies thereto belonging' (London: 1631).

[33] M. C. Barnett, 'The Barber-Surgeons of York', *Medical Hist*ory, 12 (1968), pp. 19-30, at pp. 21-2, 26, 30; Jütte, 'A Seventeenth-Century German Barber-surgeon and his Patients', pp. 188, 194-5.

[34] T. Gale, *Certain works of Galens, called Methodus Medendi* (London: 1586).

[35] S. B. Ghosh, 'Human cadaveric dissection: a historical account from ancient Greece to the modern era', *Anatomy and Cell Biology*, 48 (2015), pp. 153-69, at p. 158.

[36] J. O. Robinson, 'The barber-surgeons of London', *Archives of Surgery*, 119 (1984), pp. 1171-5, at p. 1174; R. M. Ward, 'The Criminal Corpse, Anatomists and the Criminal Law: Parliamentary Attempts to Extend the Dissection of Offenders in Late Eighteenth-Century England', *Journal of British Studies*, 54 (2015), pp. 63–87, at p. 64; Ghosh, 'Human cadaveric dissection: a historical account from ancient Greece to the modern era', p. 159;

[37] Dobson, 'Barber into surgeon', pp. 88-9.

[38] 'H. C.' is Helkiah Crooke, Doctor of Physick, who translated several other surgical and anatomical texts of the period, such as *Μικροκοσμογραφια: A description of the Body of Man, together with the controversies thereto belonging* (London: 1631), a combination of the works of several authors but especially Gasper Bauinus and Andréas Laurentius, and '*σοματογραφια ανθροπινε [somatograpia anthropine]. Or A description of the body of man With the practise of chirurgery, and the use of three and fifty instruments. By artificiall figures representing the members, and fit termes expressing the same. Set forth either to pleasure or to profit those who are addicted to this study* (London: 1634).

[39] H. C., *Explanation of the Fashion*, 'The Printer to the Reader'.

[40] Anon., *A declaration from Oxford, of Anne Green a young woman that was lately, and unjustly hanged in the Castle-yard* (London: 1651), title page.

[41] J. Cooke, *Mellificium Chirurgiae, or the Marrow of Chirurgery much enlarged, to which is added Anatomy* (London: 1676), pp. 305-48 and 377-442; Crooke, 'Μικροκοσμογραφια, pp. 95-156.

[42] The first edition was published in 1543, the second edition in 1555.

[43] For example, a detailed description of the musculoskeletal system and circulatory system is included in Cooke, *Mellificium Chirurgiae*, pp. 424 and 411, respectively; Crooke, *Μικροκοσμογραφια*, pp. 96-160; H. Crooke (transl.), *σοματογραφια ανθροπινε [somatograpia anthropine]. Or A description of the body of man With the practise of chirurgery, and the use of three and fifty instruments. By artificiall figures representing the members, and fit termes expressing the same. Set forth either to pleasure or to profit those who are addicted to this study* (London: 1634), pp. 1-105; T. Johnson (transl.), *The workes of that famous chirurgion Ambrose Parey translated out of the Latine and compared with the French* (London: 1634), pp. 60-194.

[44] 'In the work of Extraction, take great care you lay not hold of some Nerve or Tendon, and so pluck them along with the Bullet': Wiseman, *Severall Chirurgical Treatises*, p. 412.

[45] Wiseman, *Severall Chirurgical Treatises*, pp. 357-61; Cooke, *Mellificium Chirurgiae*, p. 434; Crooke, *Μικροκοσμογραφια*, pp. 907-25.

[46] C. B. Drucker, 'Ambroise Paré and the Birth of the Gentle Art of Surgery', *Yale Journal of Biology and Medicine,* 81 (2008), pp. 199-202; P. K. Goya and A. N. Williams, '"To illustrate and increase Chyrurgerie": Ambroise Paré (1510-1590)', *Journal of Pediatric Surgery*, 45 (2010), pp. 2108-14.

[47] According to Maximilien de Béthune, 1st Duke of Sully, Henri IV's Prime Minister; cited in P. Hernigou, 'Ambroise Paré's life (1510–1590): part I', *International Orthopaedics*, 37 (2013), pp. 543–7, at p.546.

[48] P. Hernigou, 'Ambroise Paré III: Paré's contributions to surgical instruments and surgical instruments at the time of Ambroise Paré', *International Orthopaedics*, 37 (2013), pp. 975-80.

[49] A. H. Scultetus, J. L. Villavicencio and N. M. Rich, 'The Life and Work of the German Physician Johannes Scultetus (1595–1645)', *Journal of the American College of Surgeons,* 196 (2003), pp. 130-9.

[50] Ibid., pp. 136, 137-8.

[51] D. Schultheiss and U. Jonas, 'Johannes Scultetus (1595-1645). Urologic aspects in the 'Armamentarium chirurgicum'', *European Urology*, 34 (1998), pp. 520-5.

[52] Scultetus, Villavicencio and Rich, 'Life and Work', pp. 132.

[53] M. Satchell, 'Gale, Thomas (c.1507-1567)', *Oxford Dictionary of National Biography* (Oxford, Oxford University Press: 2008), online edn, http://www.oxforddnb.com/view/article/10297.

[54] I. G. Murray, 'Clowes, William (1543/4–1604)', *Oxford Dictionary of National Biography* (Oxford, Oxford University Press: 2008), online edn, http://www.oxforddnb.com/view/article/5716; J. H. Appleby, 'Woodall, John (1570–1643)', *Oxford Dictionary of National Biography* (Oxford, Oxford University Press: 2008), online edn, http://www.oxforddnb.com/view/article/29902.

[55] S. Wright, 'Cook, James (1571/2–1610)', *Oxford Dictionary of National Biography* (Oxford, Oxford University Press: 2004) online edn, http://www.oxforddnb.com/view/article/6139.

[56] R. A. Cohen, 'Documents concerning James Cooke, surgeon, of Warwick', *Medical History*, 1 (1957), pp. 168-73, at p. 168.

[57] T. Longmore, *Richard Wisman: Surgeon and Sergeant Surgeon to Charles II* (London, Longmans, Green & Co: 1891); J. Kirkup, 'Wiseman, Richard (bap. 1620?, d. 1676)', *Oxford Dictionary of National Biography* (Oxford, Oxford University Press: 2008), online edn, http://www.oxforddnb.com/view/article/29792; L. Bakay, 'Richard Wiseman, a Royalist Surgeon of the English Civil War', *Surgical Neuroscience*, 27 (1987), pp. 415-18; M. McVaugh, 'Richard Wiseman and the Medical Practitioners of Restoration London', *Journal of the History of Medicine,* 62 (2007), pp. 125-40; A. D. Smith, 'Richard Wiseman: His Contributions to English Surgery', *Bulletin of New York Academy of Medicine*, 46 (1970), pp. 167-82.

[58] J. Kirkup, 'Wiseman, Richard (bap. 1620?, d. 1676)', *Oxford Dictionary of National Biography* (Oxford, Oxford University Press: 2008), online edn, http://www.oxforddnb.com/view/article/29792.

[59] Ibid.

[60] Sloan, *English Medicine*, pp. 25-6.

[61] Greenspan, *Medicine: Perspectives in History and Art*, pp. 456-8.

[62] B. A., '*A sick man's rare jewell*' (London, 1674), pp. 153-5; R. Elkes, *Approved Medicines of Little Cost, to preserve health and also to cure those that are sick*, pp. 21-23; G. Markham, *Countrey Contentments, or The English Huswife, containing The inward and outward Vertues which ought to be in a compleate Woman* (London: 1623), pp. 30-2; K. Digby, *Choice and Experimented Receipts in Physick and Chirurgery* (London: 1675), pp. 9-10, 13; J. Cooke, *Supplementum Chirurgiae, or the supplement to the Marrow of Chyrurgerie*, (London: 1655), pp. 248, 337; Cooke, *Mellificium Chirurgiae, or the Marrow of Chirurgery much enlarged*, (1676) p. 311; A. M., *A Rich Closet of Physical Secrets* (London: 1652), pp. 46-7.

[63] Cooke, *Mellificium Chirurgiae, or the Marrow of Chirurgery much enlarged* (1676), p. 314; B. A., '*A sick man's rare jewell*' (London, 1674), pp. 156-9; A. M., *A Rich Closet of Physical Secrets* (London: 1652), pp. 44-5.

[64] Elkes, *Approved Medicines of Little Cost,* pp. 19-21; B. A., '*A sick man's rare jewell*', pp. 46-50, 68-81; Digby, *Choice and Experimented Receipts in Physick and Chirurgery*, pp. 23-4; Cooke, *Supplementum Chirurgiae, or the supplement to the Marrow of Chyrurgerie*, pp. 343-4, 350, 352, 359; A. M., *A Rich Closet of Physical Secrets* (London: 1652), p. 69.

[65] Elkes, *Approved Medicines of Little Cost,* pp. 25-6; Markham, *Countrey Contentments, or The English Huswife*, p. 9;

[66] Generic term: Lue venerea; Primarily Syphalis, generally referred to as the 'Neopolitan [or Neapolitan] disease', 'French Pox' or 'Spanish Pox'; or Gonorrhea, also referred to as 'The Clap' or 'Running the Reins'. B. A., '*A sick man's rare jewell*' (London, 1674), pp. 97-118; Cooke, *Mellificium Chirurgiae, or the Marrow of Chirurgery much enlarged* (1676), pp. 759-69 and 769-72; B. A., '*A sick man's rare jewell*', pp. 116; Markham, *Countrey Contentments, or The English Huswife*, p. 50; Johnson (transl.), *The workes of that famous chirurgion Ambrose Parey translated out of the Latine and compared with the French* (1634), pp. 464-481; A. M., *A Rich Closet of Physical Secrets*, pp. 58-9.

[67] Elkes, *Approved Medicines of Little Cost,* pp. 11-15; J. Woodall, *The cure of the plague by an antidote called Aurum Vitae*, (London: 1640); Anon., 'A treatise concerning the plague and the pox', in A. M., *A rich Closet of Physical Secrets* (London: 1652), pp. 1-113; Markham, *Countrey Contentments*, p. 9; Digby, *Choice and Experimented Receipts in Physick and Chirurgery*, pp. 40-3; Cooke, *Supplementum Chirurgiae, or the supplement to the Marrow of Chyrurgerie*, pp. 162-4, 192 and 283-412; Cooke, *Mellificium Chirurgiae, or the Marrow of Chirurgery much enlarged*, (1676) pp. 268, 277; Johnson (transl.), *The workes of that famous chirurgion Ambrose Parey translated out of the Latine and compared with the French* (1634), pp. 535-75.

[68] Elkes, *Approved Medicines of Little Cost,* p. 2.

[69] Ibid., pp. 2-3.

[70] K. T. Chung, T. Y. Wong, C.-I. Wei, Y. W. Huang and Y. Lin, 'Tannins and human health: a review', *Critical Reviews of Food Science and Nutrition*, 38 (1998), pp. 421-64.

[71] Elkes, *Approved Medicines of Little Cost*, p. 2.

[72] Ibid., p. 3.

[73] The rather fanciful name refers to the bright scarlet-crimson hues of the resin, which could be used as a pigment as well as a medicine.

[74] W. Fayad, M. Fryknäs, S. Brnjic, M. H. Olofsson, R. Larsson, S. Linder, 'Identification of a novel topoisomerase inhibitor effective in cells overexpressing drug efflux transporters', *PLoS ONE*, 4 (2009), e7238.

[75] Wiseman, *Severall Chirurgical Treatises*, p. 341.

[76] B. S. Nagoba, S. P. Selkar, B. J Wadher and R. C. Gandhi, 'Acetic acid treatment of Pseudomonal wound infections--a review', *Journal of Infection & Public Health*, 6 (2013), pp. 410-15.

[77] L. Frémont, 'Biological effects of Resveratrol', *Life Sciences*, 66 (2000), pp. 663-73; N. B. Bottaria *et al*., 'Synergistic effects of resveratrol (free and inclusion complex) and sulfamethoxazole-trimetropim treatment on pathology, oxidant/antioxidant status and behavior of mice infected with *Toxoplasma gondii*, *Microbial Pathogenesis*, 95 (2016), pp. 166–74.

[78] P. H. Kwakman, A. A. Te Velde, L. de Boer, C. M. Vandenbroucke-Grauls, S. A. Zaat, 'Two major medicinal honeys have different mechanisms of bactericidal activity', *PLoS ONE*, 6 (2011), e17709; M. D. Mandal and S. Mandal, 'Honey: its medicinal property and antibacterial activity', *Asian Pacific Journal of Tropical Biomedicine*, 1 (2011), pp. 154–60; N. J. Basson and S. R. Grobler, 'Antimicrobial activity of two South African honeys produced from indigenous Leucospermum cordifolium and Erica species on selected micro-organisms', *BMC Complementary and Alternative Medicine*, 8 (2008) pp. 41-4.

[79] Wiseman, *Severall Chirurgical Treatises*, pp. 104 and 347.

[80] G. Keynes, ed., *The Apologie and Treatise of Ambroise Paré, 1585* (Chicago, University of Chicago Press: 1952), pp. 124-5; Wiseman, *Severall Chirurgical Treatises*, pp. 343-4.

[81] Keynes, *Apologie and Treatise of Ambroise Paré*, p. 124.

[82] Ibid., pp. 124-5.

[83] Ibid., p. 125.

[84] Wiseman, *Severall Chirurgical Treatises*, pp. 343-5.

[85] H. C., 'Explanation of the Fashion', p12; Keynes, *Apologie and Treatise of Ambroise Paré*, pp. 128-9.

[86] Cooke, *Mellificium Chirurgiae*, p. 433; H. C., 'Explanation of the Fashion', pp. 12-13.

[87] Wiseman, *Severall Chirurgical Treatises*, p. 344.

[88] H. C., 'Explanation of the Fashion', pp. 12-14; Keynes, *Apologie and Treatise of Ambroise Paré*, pp. 127-129.

[89] The equivalent of a modern 'blanket stitch'.

[90] Keynes, *Apologie and Treatise of Ambroise Paré*, pp. 129; H. C., 'Explanation of the Fashion', p. 12.

[91] Keynes, *Apologie and Treatise of Ambroise Paré*, p. 129.

[92] Cooke, *Mellificium Chirurgiae*, p. 715; H. C., 'Explanation of the Fashion', p.13.

[93] Keynes, *Apologie and Treatise of Ambroise Paré*, pp. 129; H. C., 'Explanation of the Fashion', pp. 13-14.

[94] Ibid., pp.14-15; Paré, *Method of Curing Wounds*, pp. 52-3.

[95] A. K. Toma, M. C. Papadopoulos, S. Stapleton, N. D. Kitchen and L. D. Watkins, 'Systematic review of the outcome of shunt surgery in idiopathic normal-pressure hydrocephalus', *Acta Neurochirurgica*, 155 (2013), pp. 1977-80; S. M. Gifford *et al*., 'Effect of temporary shunting on extremity vascular injury: An outcome analysis from the Global War on Terror vascular injury initiative', *Journal of Vascular Surgery*, 50 (2009), pp. 549-56.

[96] Mitchell, *Medicine in the Crusades*, p. 116; Keynes, *Apologie and Treatise of Ambroise Paré*, p. 137; Cooke, *Mellificium Chirurgiae*, p. 433.

[97] Wiseman, *Severall Chirurgical Treatises*, pp. 359 and 409.

[98] Ibid., p. 359; Keynes, *Apologie and Treatise of Ambroise Paré*, p. 137.

[99] Paré, *Method of Curing Wounds*, pp. 5-6.

[100] Wiseman, *Severall Chirurgical Treatises*, p. 341.

[101] Paré, *Method of Curing Wounds*, p. 63.

[102] Wiseman, *Severall Chirurgical Treatises*, p. 349

[103] Keynes, *Apologie and Treatise of Ambroise Paré*, pp. 124-5; Wiseman, *Severall Chirurgical Treatises*, p. 325.

[104] G. H. B. MacLeod, *Notes in the Surgery of the War in the Crimea; with remarks on the treatment of gunshot wounds* (London, Churchill: 1858), pp. 392 (see also pp. 322 and 352).

[105] Dakin's solution, also known as 'Carrel–Dakin fluid', was a dilute solution of sodium hypochlorite (bleach; 0.4 - 0.5% v/v) and boric acid (4% v/v); Gabriel, *Between Flesh and Steel: A history of military medicine from the middle ages to the war in Afghanistan*, p. p217.

[106] Scotland and Heyes, *War Surgery*, p. 68; D. P. Penhallow, *Military Surgery* (London, Oxford University Press: 1916), p. 73.

[107] W. H. Ogilvie, *Forward Surgery in Modern War* (London, Butterworth: 1944), p. 26.

[108] Ibid. p. 32.

[109] T. E. Rasmussen and R. M. Tai, *Rich's Vascular Surgery* (London, Elsevier Life Sciences: 2016), p. 9; V. E. Burkhalter, B. Butler, W. Metz, and G. Omer, 'Experiences with Delayed Primary Closure of War Wounds of the Hand in Viet Nam', *Journal of Bone and Joint Surgery*, 50A (1968), pp. 945-54; B. E. Leininger, T. E. Rasmussen, D. L. Smith, D. Jenkins and C. Coppola, 'Experience with Wound VAC and Delayed Primary Closure of Contaminated Soft Tissue Injuries in Iraq', *Journal of Trauma Injury, Infection, and Critical Care*, 61 (2006), pp. 1207-11; N. Chiverton and J. F. Redden, 'A new technique for delayed primary closure of fasciotomy wounds'. *Injury*, 31 (2000), pp. 21-4; J. Harrah, R. Gates, J. Carl and J. D. Harrah, 'A Simpler, Less Expensive Technique for Delayed Primary Closure of Fasciotomies', *American Journal of Surgery*, 180 (2000), pp. 55-7; F. J. Verdam *et al.*, 'Delayed Primary Closure of the Septic Open Abdomen with a Dynamic Closure System', *World Journal of Surgery*, 35 (2011), pp. 2348–55; B. Siribumrungwong, K. Srikuea and A. Thakkinstian, 'Comparison of superficial surgical site infection between delayed primary and primary wound closures in ruptured appendicitis', *Asian Journal of Surgery*, 37 (2014), pp. 120-4. M. C. Eliya-Masamba and G. W. Banda, 'Primary closure versus delayed closure for non bite traumatic wounds within 24 hours post injury', *Cochrane Database of Systematic Reviews*, 10 (2013), pp. 1-22.

[110] J. Gardiner, ed., *Before The Mast: The Archaeology of the Mary Rose* (Trowbridge, Cromwell Press: 2005), pp. 189 and 220-5.

[111] Paré, *Method of Curing Wounds*, pp. 41-2.

[112] Wiseman, *Severall Chirurgical Treatises*, p. 407.

[113] M. Tokdemir, H. Kafadar, A. Turkoglu and T. Bork, 'Forensic value of gunpowder tattooing in identification of multiple entrance wounds from one bullet', *Legal Medicine*, 9 (2007), pp. 147-50.

[114] V. Eyers, 'Ballistics of Matchlock Muskets', Unpublished MSc Thesis, Cranfield University, 2006. pp. 9, 12-13, 54; D. J. Blackmore, *Destructive and Formidable: British Infantry Firepower 1642 – 1765* (Croydon, Frontline, 2015), pp. 9-10.

[115] Ibid. pp. 27-33, 41-42.

[116] A. C. Szul, ed., *Emergency War Surgery: NATO Handbook, US revision 3* (Washington D. C., Unites States Government Printing Office: 2004); M. L. Fackler, 'Gunshot wound review', *Annals of Emergency Medicine*, 28 (1996), pp. 194-203; R. A. Santucci and Y.-J. Chang, 'Ballistics for Physicians: Myths about wound ballistics and gunshot injuries', *Journal of Urology*, 171 (2004), pp. 1408–14.

[117] Ibid., pp. 1408-14.

[118] Wiseman, *Severall Chirurgical Treatises*, p. 411.

[119] Gruber von Arni, *Justice for the Maimed Soldier'*, p. 179; I. Pells, 'Stout Skippon Hath a wound: the medical treatment of parliament's infantry commander following the battle of Naseby', conference paper given at 'Mortality, Care and Military Welfare during the British Civil Wars', National Civil War Centre, Newark, 7-8 August 2015.

[120] D. Wang, W. S. El-Masry, M. Crumplin, S. Eisenstein, R. J. Pusey and T. Meagher, 'Admiral Lord Nelson's death: known and unknown – A historical review of the anatomy*', Spinal Cord,* 43 (2005), pp. 573–6.

[121] Ibid., pp. 573-6.

[122] R. Wiseman, 'Severall Chirurgical Treatises'. (Norton and Maycock, London, 1676), p. 411.

[123] Gross, *manual of Military Surgery*, p. 70; F. H. Hamilton, *A Practical Treatise on Military Surgery* (New York, Balliere Brothers: 1861), p. 139.

[124] Wiseman, *Severall Chirurgical Treatises*, p. 411.

[125] Ibid., p. 411.

[126] Paré, *Method of Curing Wounds*, pp. 50-1.

[127] Ibid., pp. 45-50; H. C., *Explanation of the Fashion*, pp. 41-3.

[128] Gross, *manual of Military Surgery*, p. 70; Hamilton, *Practical Treatise*, pp. 139-40.

[129] Wiseman, *Severall Chirurgical Treatises*, p. 412.

[130] Paré, *Method of Curing Wounds*, pp. 51-52.

[131] Wiseman, *Severall Chirurgical Treatises*, pp. 410-11

[132] Ibid., p. 410.

[133] Ibid., p. 400.

[134] T. Gale, *Certain works of chirurgery, newly compiled*, (London: 1563), p. 58; Cooke, *Mellificium Chirurgiae*, p. 452; Keynes, *Apologie and Treatise of Ambroise Paré*, p. 168.

[135] Wiseman, *Severall Chirurgical Treatises*, p. 443; Paré, *Method of Curing Wounds*, p. 66.

[136] Paré (transl. Hammond), *The Method of Curing Wounds made by Gun-shot.* p.9

[137] Paré (transl. Hammond), *The Method of Curing Wounds made by Gun-shot.* p.26, 79.

[138] G. J. Ordog, J. Wasserberger and S. Balasubramanium, 'Wound Ballistics: Theory and Practice', *Annals of Emergency Medicine*, 13 (1984), pp. 1113-22; Penhallow, *Military Surgery*, p. 163.

[139] Wiseman, *Severall Chirurgical Treatises*, p. 419.

[140] Penhallow, *Military Surgery*, p. 163; Szul, *Emergency War Surgery*; Santucci and Chang, 'Ballistics for Physicians', pp. 1408–14.

[141] Gross, *manual of Military Surgery*, pp. 87-8.

[142] Wiseman, *Severall Chirurgical Treatises*, p. 421.

[143] J. C. Clasper, 'Limb Injuries', in P. Mahoney *et al*, eds, *Ballistic Trauma* (London, Arnold: 1997), pp. 356-80.

[144] Scotland and Heyes, *War Surgery*, pp. 154-5; Penhallow, *Military Surgery*, pp. 171-9; Ogilvie, *Forward Surgery*, p. 37.

[145] W. Fabry (transl. J. Steer), *Gulielm Fabricus Hildamis, his experiments in Chyrurgerie* (London: 1643), pp. 57-64.

[146] Cooke, *Mellificium Chirurgiae*, pp. 722-7.

[147] Ibid., p. 722.

[148] Ibid., pp. 722-3.

[149] Ibid., p. 724.

[150] Ibid. p. 723.

[151] Ibid. pp. 724-5.

[152] Mitchell, *Medicine in the Crusades*, pp. 116, 150, 192.

[153] Two and three cut amputations, which used angled cuts rather than a single circular cut, were developed in 1715 and 1773 respectively. The approach of transverse cuts through the skin before removal of the muscle and bone, so that a soft-tissue flap covered the stump and there was therefore no skin tension over the amputated region ('flap amputation'), was developed by Lowdham in 1679, Verduyn in 1696, and later by Langenbeck in 1810 - see M. Sachs, J. Bojunga and A. Encke, 'Historical evolution of limb amputation' *World Journal of Surgery*, 23 (1999), pp. 1088-93.

[154] McCray Beier, *Sufferers and Healers*, pp. 51-96.

[155] I. Pells, 'Stout Skippon Hath a wound: the medical treatment of parliament's infantry commander following the battle of Naseby', conference paper given at 'Mortality, Care and Military Welfare during the British Civil Wars', National Civil War Centre, Newark, 7-8 August 2015.

[156] Wiseman, *Severall Chirurgical Treatises*, pp. 366-73.

[157] A. Hopper, *'Black Tom': Sir Thomas Fairfax and the English Revolution* (Manchester, Manchester University Press: 2007), p. 228; I. J. Gentles, 'Fairfax, Thomas, third Lord Fairfax of Cameron (1612–1671)', *Oxford Dictionary of National Biography* (Oxford, Oxford University Press: 2008), online edn, http://www.oxforddnb.com/view/article/9092.

[158] H. Worthen, 'The administration of war relief in Kent', conference paper given at 'Mortality, Care and Military Welfare during the British Civil Wars', National Civil War Centre, Newark, 7-8 August 2015.

[159] Durham County Record Office, Q/S/OB 5 (Microfilm M7/2), Quarter Sessions Order Book, 1660-1668, fol. 72, ('The petition of John Tinckler of the city of Durham, 3 October 1660').

[160] Gruber Von Arni, *Justice to the Maimed Soldier, Vol. 2*, pp. 198-9.

[161] Scultetus, Villavicencio and Rich, 'Life and Work', pp. 135.

[162] Wiseman, *Severall Chirurgical Treatises*, p. 413.

[163] M. Fässler, M. Gnädinger, T. Rosemann and N. Biller-Andorno, 'Placebo interventions in practice: a questionnaire survey on the attitudes of patients and physicians', *British Journal of General Practice*, 61 (2011), pp. 101–7, at p. 105; A. Hróbjartsson, M. Norup, 'The use of placebo interventions in medical practice - a national questionnaire survey of Danish clinicians', *Evaluation and the Health Professions*, 26 (2003), pp. 153–65, at p. 162.

[164] Detailed patient notes were a key innovation of the Crimean War, enabling different army surgeons to follow the ongoing treatments of an individual, enacted previously by their peers.

[165] McVaugh, 'Richard Wiseman', pp. 136.