3. A new kind of surgery for a new kind of war: gunshot wounds in the British Civil Wars, and how to treat them

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Early modern surgeons have a generally poor public image in current popular culture as unskilled and primitive butchers, whose horrifying and unsanitary procedures, undertaken whilst the patient was still conscious, were just as likely to kill as cure.[1] However, texts published by surgeons of this period reveal a high level of understanding of physiology, anatomy, hygiene and medical practice. These medical texts remained in active use for many decades after they were written, and many techniques described by these authors did not change substantially for centuries thereafter. Indeed many early modern surgical procedures are still practiced in surgery today.

Some of the most significant advances in surgical practice in the early modern period appear to have been made by military surgeons. The cliché that war drives innovation was certainly true of the British Civil Wars regarding medical practice. These advancements were likely driven by necessity, from the high numbers of casualties, and facilitated by the repetitive nature of the battlefield wound-types themselves. Wounds that would be generally unknown to the civilian surgeon would be commonplace for the military surgeon. In particular, military surgeons would be afforded the opportunity to compare their treatments between patients, and trial new approaches. They could therefore develop their practice constantly, and the published writings of the former military surgeons from this period demonstrate the abundant use of an evidence-base for their medical methods. The approach exemplified by some of the authors of medical texts from the period show clear parallels to present-day 'evidence-based medicine',[2] the basing of medical practice on observed positive outcomes and research. Through developing an evidence base, and presenting cases that were both effective and less-so, the approach of these surgeons is directly analogous to modern day medical practice.

This chapter will highlight some of the surgical procedures used during the civil wars, evaluate their biomedical validity and situate early modern military surgeons in context with the ongoing development of military surgical practice. The sudden and considerable increase in the use of firearms in infantry warfare in this period would have shaped military surgeons' practice and required effective remedies; therefore this chapter will focus primarily on the methods used to treat injuries caused by firearms.

The surgeon

Alongside the physician and apothecary, the surgeon (or barber-surgeon) was one of the recognised medical professions in the seventeenth century.[3] Physicians (doctors) were well-educated, and attended to 'physic', the science of maintaining the body's homeostatic balance. Apothecaries purveyed chemicals and medicines, usually as prescribed by the physician. Apothecaries also provided their own medical advice supplying a cheaper alternative for medical care than the physician. Surgeons focused on the treatment of injuries and any operation which involved cutting the patient open or spilling blood (amputation, surgery or blood-letting); also setting limbs, dentistry and curing injury-related conditions, such as gangrene, septicaemia or sepsis. The surgeon's role was traditionally associated with the barber, and in many societies across Europe, the combined role of barber-surgeon was the norm. However in England and Scotland, despite often being joined administratively by a single guild, it was common for the roles of barber and surgeon to be separate.[4] By the 1640s, barbers and surgeons had enjoyed Royal Guild status for a century in a regulated profession.[5] Military surgeons were attached to regiments or garrisons,[6] and were a mixture of civilian and professional military surgeons.[7]

Surgeons usually learned their trade through apprenticeship, and accounts by surgeons refer to subordinates and surgeons' mates who assisted the author, and many subsequently moved on to their own independent practice.[8] Although eminent sixteenth-century surgeons,

Thomas Gale, William Clowes, and John Woodall each lamented the poor state of education among young surgeons, the training of surgeons does appear to have been extensive, supported by the circulation of texts and study of anatomy. The study of anatomy through cadaveric dissection was a commonly-accepted practice for medical practitioners.[9] The exceptional accuracy of engravings in mid-seventeenth-century surgical texts showing musculoskeletal, circulatory and nervous system anatomy could only have been gained through observing cadaveric dissections. Surgeons were potentially well-trained professionals, and although there were clearly some in the profession with poor or dangerous practices, there was a self-regulating professional infrastructure to promote good practice within the profession.

Although there were several surgeons of note during the British Civil Wars, the two of most relevance to this analysis each authored printed texts of significant longevity: James Cooke and Richard Wiseman.

James Cooke (d. 1693–4) was surgeon to the Greville family, Warwick, from 1638, and served Robert, second Baron Brooke until Brooke's death in 1643[10]. Cooke served as a surgeon throughout the wars, becoming a Baptist minister in later years. He published *Mellficium chirurgiae, or the marrow of many good authors* in 1648, and his *Mellficium chirurgiae, or the Marrow of Chirurgery* (1655) was reprinted six times until 1717. Cooke referenced several patient cases, and his *Select Observations on English Bodies* (1657), a translation of the work of the late Dr John Hall of Stratford upon Avon,[11] was based on over a thousand recorded cases.

Richard Wiseman (c.1620–1676) became the wartime surgeon to Charles, Prince of Wales, and was present at the Battle of Worcester.[12] Wiseman was appointed Sergeant Surgeon to the King in 1660, continuing until his death in 1676, and appears to have been financially successful.[13] Wiseman also appears to have worked collaboratively with many other contemporary surgeons.[14] Wiseman published two major works, *A Treatise of Wounds* (1672) and *Severall Chirurgicall Treatises* (1676, renamed *Eight Chirurgical Treatises*, 1696). Like

Cooke's works, these were also of significant impact (the latter receiving five reprints, up to 1734). For example, Ballingall's *Outlines of Military Surgery* (1844) referenced Wiseman as its principal authority on gunshot wounds.[15] Wiseman's texts also contain very many examples of patients treated. What makes Wiseman of particular note is his reference to cases that did not have positive outcomes, and his suggestions of why they failed. This evidence-based approach identifies Wiseman as a reflective practitioner, rather than a passive employer of traditional practices.

Another English author of particular note to this chapter is John Browne (1642–1702) who was not active during the civil wars, but whose works reference several examples of cases from the period. Also, continental European surgeons were of particular impact: French military surgeon, Ambroise Paré, revolutionised surgery during the latter sixteenth century.[16] Although Paré died in 1590, his pioneering works were published in English during the early-mid 1600s, so would have impacted directly on English practitioners. Wiseman frequently describes Paré's procedures, suggesting a strong influence. Wilhelm Fabry (1560–1634; also known as *Guilelmus Fabricius Hildanus*),[17] and Johannes Scultetus (1595–1645)[18] were German surgeons who each made significant advances in surgical practice that are still used today. Each of these had works translated into English and are referenced in writings by former civil-war surgeons. These authors also refer extensively to examples of patient cases.[19]

Core medical understanding

Contemporary medical practitioners were still strongly wedded to many traditional theories, such as those of Galen or Aristotle. In particular, physic rested heavily on the four humours (blood, yellow bile, black bile and phlegm), whose natural balance was the key to health. Practices such as bleeding and cupping were still taken as effective methodologies, and belief in these approaches continued well into the nineteenth century. However, the writing of many seventeenth-century authors displays a critical stance on numerous traditional practices, and

disagree with established authorities. This more-critical approach is unsurprising, given the context of the intellectual developments in natural science during the period, to which these practitioners – certainly Wiseman at the court of Charles II – would have been exposed. The level of understanding of physiology and anatomy in the printed surgical texts is extensive and generally accurate. Understanding of physiology is often couched within terms the authors could relate to. For example the importance of blood flow was referred to as maintaining 'heat', as the significance of oxygenated blood was not understood.

Gangrene, and its more-severe form, *sphacelus,* were recognised and their causes understood, despite a lack of knowledge of the physiological causes. Both involved the restriction of 'heat' (blood flow) to the affected part of the body, either by the over-tight torsion of a bandage, tournequet or ligature[20], frostbite, sepsis from foreign matter in a gunshot wound, damage from a wound or concussion. [21] Over-tightening of bandages was identified as a particular danger when affixing a splint to a broken limb. Gangrene was easily recognised by the body part going pale (as if it had been scalded) and then black. The remedy for the condition was to try to encourage blood flow by scarification of the tissue, and to cut away the dead matter. By the rate of blood flow and the nature of the blood being released, the surgeon would be able to ascertain the progression of the gangrene.[22] Left untreated, gangrene and the ensuing *sphacelus*, were fatal, and that death would be a painful one. Wiseman wrote of one patient he had attended too late: 'he died howling'.[23]

Seventeenth-century surgeons understood the impact of infection, although the role of pus was misunderstood. 'Laudable pus'[24] was seen as a means of cleansing the wound, referred to as 'digestion', rather than as a discharge of waste matter. Despite this, and without knowledge of the bacterial cause of infection, they did appreciate the impact of antiseptic agents on reducing infection rates and accelerating healing. The use of alcohol, either red or white wine, or a water-alcohol mix, *aqua vitae,* was frequently recommended for cleaning wounds and soaking bandages and dressings. Vinegar was also frequently used, usually as a

vinegar-water mix, oxycrate, or *posca* (an ancient Roman water-vinegar drink). Similarly, terpentine (‘*terebinth’*) was commonly used in either operative treatment or post-operative wound care.

Concentrated sugars, such as honey or treacle, were also used in dressings to reduce infection, approaches which are still used today, especially in veterinary medicine. The recommendation to treat burns using a poultice of garlic, onions or leeks with salt[25] is also a potentially viable approach to limit infection. These members of the *Allium* contain organosulphur compounds, such as Allicin, which have antimicrobial properties.[26] Powders, such as chalk or various mineral clays, or resins, such as ‘Dragon’s Blood’ or mastic gum, were also effective at impeding bacterial growth. Dragon’s Blood was a resin from the South American tree, *Croton lechleri* which has been used as a coagulant in South American traditional medicine for many centuries. The active component of Dragon’s Blood, Taspine, has been suggested to have anti-inflammatory and anti-viral properties and to promote cell death in cancer tissue.[27]

None of these remedies were understood from a mechanistic point of view, but clearly experience, trial and error showed the practitioners that they worked. This observation is quite contrary to commonly-held perceptions of a complete lack of understanding of infection prior to the discovery of bacteria, and shows that there was an appreciation of the importance of hygiene to surgical practice.

Gunshot wounds

A surgeon in the British Civil Wars would have had to deal with a variety of weapon types, but with musketeers comprising approximately two thirds or more of infantry units, the most common injury they were likely to encounter would be from gunshot. The projectile shot from a musket was a spherical ball, referred to interchangeably as a ball or bullet. It was typically 15–20mm diameter, weighed around 38–45g and cast in lead (see Figure 1).[28] The lead used in

seventeenth-century musket balls was softer than modern lead, which is alloyed with a small amount of antimony. The irregular shape of the ball (from casting), its poor fit inside the barrel, and its propulsion by low-quality loose-grain gunpowder[29], meant the musket ball trajectory was low velocity (400–500 metres per second), with maximum range of up to 180 metres, and moderate-to-poor accuracy.[30] Projectile force lessened with distance, so the effective range was significantly less, possibly as little as 50 metres.[31] A musket ball was expected to be able to penetrate armour, while a pistol ball would be repelled by a metal breastplate or helmet, but would penetrate through clothing.

Modern, high-velocity bullets typically have a small entry wound, and a large exit wound. Surgeons in the seventeenth century recognised the different forms of wound, with the entry wound usually being small, tight and blackish, the exit wound (if one existed at all, as the bullet often did not leave the body) large, ragged and inflamed.[32] The treatment of the exit wound involved debridement and eventual closing of the wound after cleansing. The entry wound was easier to treat, either by cauterisation (using hot metal or oil to close the wound), by suture (stitching), or by a ligature (a bandage or thread tying the wound closed). Paré observed that surgeons around him typically cauterised gunshot wounds using boiling oil of elders, mixed with treacle. However, after running out of this mixture, he resorted to using a non-boiling poultice of egg yolk, oil of roses and turpentine, which resulted in better patient outcomes and is reflected in seventeenth-century writings.[33] Entry wounds could often be mistaken as gangrenous due to the blackish skin around the hole (now termed a ‘gunpowder tattoo’),[34] and be erroneously treated as such by inexperienced surgeons, without the wound being investigated for the bullet or other matter taken into the wound.[35]

Treatment of soft tissue damage from gunshot

Musket-shot wounds are complex and variable in their nature,[36] due to the ballistics of the bullet, and this was understood by early modern surgical authors.[37] A travelling bullet causes

three potential areas of compression (see Figure 2(a)).[38] Firstly, a displacement shockwave ahead of the bullet. Secondly, the bullet tearing through the body will cause direct physical damage (the permanent cavity). Finally, the compression caused by the wake of the bullet, analogous to the wake of a boat through water, will cause damage from temporary pressure on internal tissues (the temporary cavity). The temporary cavity is usually considerably wider than the permanent cavity,[39] though even with a modern, high-velocity bullet, rocking or yawing (and sometimes flipping) of the bullet inside the body (see Figure 2(b)) will cause the permanent cavity to widen. Although there have been no published ballistic tests undertaken on seventeenth-century musket balls using seventeenth-century powder mixtures, the internal effect on the body is likely to be broadly similar to a soft-headed bullet (see Figure 2(c)). This bullet flattens and even fragments, and therefore causes a much wider permanent cavity, with a temporary cavity still present. The bullet, if it emerges at all, is likely to be severely misshapen.

The impact of a musket ball on the body was therefore likely to result in deformation of the ball, and some deviation from the direction of travel when the ball entered the body. As the ball moved between tissues or cavities of differing densities, its pathway would be refracted. This refraction was noted by seventeenth-century surgeons, Wiseman noted that 'It being wonderful to consider how these Shots do twirl about'.[40] There are several accounts of this, such as a soldier shot in the cheek had the bullet removed from the back of his neck; another shot in the lower leg had the bullet removed from the thigh above the knee; another shot near the breastbone, had the bullet removed from near the spine.[41]

The erratic path of the ball posed considerable challenges for the surgeon. The bullet was not always straightforward to find. It was advised for the patient to be sat in the same position as when he received the injury, as this allowed the surgeon to better find and access the bullet.[42] The symptoms of the patient could also be used as an indicator of the bullet's location.[43] But on occasion it was necessary to let the bullet identify itself by either symptoms resulting from sepsis, or by being physically identified against the skin, or a muscle.

Internal investigation would be used to find the bullet, either using the surgeon's fingers,[44] or a probe,[45] an eight to twelve inch thin metal rod, sometimes with a rounded or widened end. The feel of metal touching metal could be used to identify the lead bullet, and the probe could then be used as a guide for the implement used to extract the bullet. Care needed to be taken not to cause additional damage during this process,[46] although it was noted that on occasion the surgeon would have to widen the wound with a knife, to allow free access.[47] This process of finding the bullet remained essentially unchanged until the late nineteenth century, with the finger,[48] and a metal probe,[49] still the methods of choice. The only refinement in surgical kits from the American Civil War and Crimea being finer, better quality probes.

Removal of the bullet

Should the bullet be retained within the body, it would need to be extracted before the wound could be treated. Lead musket balls, or iron shrapnel from a cannon or mortar, were not in themselves liable to induce infection and 'of their own nature do carry no Poyson in'.[50] The bullet could be left within the body, indefinitely if necessary,[51] but that this was usually undesirable due to the 'rusting' (oxidation) of the metal potentially causing septicaemia.[52] Certainly this would be the case for oxides of lead, iron, or copper[53] which are particularly toxic. However, the more pressing concern for the surgeon was the potential for other matter to have been brought in with the bullet – fragments of the soldier's own clothing, splinters of wood, hair or other solid items.[54]

The removal of cloth and other extraneous items was of very great importance, and failure to do so would result in patients failing to heal, becoming feverish, developing sepsis or even dying.[55] Even after the wide-scale introduction of antibiotics in the latter half of the twentieth century, this imperative continued. The importance given to the removal of foreign items, and the clear link between their removal and the patient recovering, is indicative that the

surgeons did understand the link between septicaemia / sepsis and contamination of the wound, as shown by Wiseman:

> A person having been shot in the Arm, and the Wound undigested, I … advised the laying open of the Wound, and extraction of the Bullet, Rags, *&c.* but was over-ruled by others... Two days after I visited the Patient, and asked the Chirurgeon whether he had laid open the Wound. He replied, there was no need, for he could turn his finger in it, and pull out the Bullet and Rags, if it was necessary. As I was going out of the house, I met the Physician, who inquiring of me the Patient's health, I replied that the Chirurgeon had unwittingly given me the certain sign of his Death… A day or two after he died, too certainly justifying my Prognostick.[56]

Once it had been located, the soft lead bullet, as well as fragments of bone or splinters of wood, could be removed by a *Terebellum*[57] or Tirefond[58] (see Figure 3a & b), a metal rod, or long hollow tube containing an internal baffle, tipped with a sharp screw. There were also other implements for extraction, each a variant on pliers or forceps.[59] The Crowe's Bill (see Figure 3c & d) was a pair of levered pliers, either straight or curved, with short, toothed fronds. The Crane's Bill (see Figure 3e & f) had longer fronds for deeply-embedded bullets. The Duck or Drake's Bill (see Figure 3g & h) had tips that were rounded to surround the ball. The 'catch-bullet' (see figure 3i) had cupped ends, operated by an internal mechanism, the 'Lizards Mouthe" (see figure 3j) being a narrower equivalent. The Parrot's Bill (see Figure 3k & l) had sharpened edges for gripping flat bones, such as skull fragments. Finally, the Swan's Beak (see Figure 3m) was used to dilate wounds. Except for becoming more slender and reliable, these implements remained relatively unchanged for the next two centuries.[60]

Once the bullet had been extracted and the wound confirmed as clean, Wiseman recommended dressing the wound with a clean dressing, soaked in *oleum catellorum* (oil of

puppies). The *Oleum catellorum* recipe was gained from Paré, [61] and involves boiling two newborn puppies in lily oil until 'their flesh departed from the bones', along with one pound of earthworms – purified of their stomach contents in white wine – and *aqua vitae,* then strained and mixed into a balm with turpentine. Wiseman's own summary of the recipe is almost identical to that of Paré, though less detailed.[62] Given that this was a treatment for gunshot wounds, potentially the most common wound type Wiseman would have encountered, it is unlikely that this method was plagiarised and included in the text without being used. Wiseman does not hesitate to challenge the methods of other notable surgeons, and so it is reasonable to conclude that the use of *oleum catellorum* was effective. The biomedical properties of boiled puppies and earthworms are, as-yet, untested by modern science, but are unlikely to be biomedically significant. However, possibly neonates and cleansed earthworms were chosen due to a lack of internal faecal matter, little hair, and high proportion of protein and fat. The balm would be sterilised and kept sterile and malleable through the alcohol and turpentine, properties enhanced by it being applied 'as hot as the Part will bear'.[63] *Oleum catellorum* may have been effective in creating an antibacterial seal to prevent further contamination. However, it is likely that the alocohol and turpentine were the active ingredients, rather than the puppies.

Management of infection in wounds

Although, through alcohol, vinegar, heat or poultices, surgeons had methods in place to reduce infection levels, large wounds were prone to developing infection. To address this, instead of being sutured closed, the wound would deliberately be left open,[64] and the lips of the wound kept apart from each other. For this the surgeon would use either tents (rolls of linen pressed into the wound to keep the lips of the cut apart),[65] or setons (thick thread sewn through the wound to aid in drainage, analogous to a modern-day Shunt).[66] The tent would typically be made of linen and stiffened with egg white,[67] and then steeped in red wine or oxycrate before inserting into the wound.[68]

The methodology was to keep the wound open and allow it to weep and discharge until it took on the appearance of 'Flesh long hang'd in the Air'.[69] By keeping the wound site open, the surgeon was promoting the weeping of lymph at the wound site, fortifying the immune system, recruiting white blood cells and limiting bacterial growth.[70] Although the cell biology behind this approach was not known to the seventeenth-century practitioners, they were aware that it was effective.

This approach to wound healing, 'delayed primary closure' (initially termed 'delayed primary suture' by H. H. Hepburn in 1919,[71] also 'healing by second (or third) intention') continued to be used in the Napoleonic campaigns,[72] the American Civil War,[73] Crimean War,[74] First[75] and Second[76] World Wars, Korea,[77] Vietnam,[78] and Iraq/Afghanistan.[79] In the nineteenth century the wound was typically loosely-packed with lint or cotton, to separate and help drain the wound. By the early twentieth century, irrigation of the wound was employed with saline solution or media such as Carrol-Dakin Solution.[80] Delayed Primary Closure is commonly adopted today after surgical interventions for appendicitis[81] or compartment syndrome.[82] In the absence of antibiotics, use of delayed primary closure by seventeenth-century surgeons was inventive and effective, and illustrates that these surgeons were undertaking sound, evidence-based medical practice.

Treatment of blunt-force trauma damage from projectiles

A musket was a formidable weapon in causing penetrative damage, but the damage caused by blunt force trauma was equally significant. Aside from damage caused using the musket butt as a club in mêlée combat, the musket ball was also capable of causing blunt-force trauma. If a bullet encountered solid bone, then it was possible to cause considerable damage, and either shatter the bone, sever it, or if the strike was a glancing blow, to cause a simple fracture.[83] One of Wiseman's patients had his arm shot off, just above the elbow.[84] The seventeenth century military surgeons show a working knowledge of gun-shot fractures equivalent to understanding

of late nineteenth-century surgeons. When a bone is struck by a bullet of low-medium velocity, it typically receives an X-shaped fracture,[85] the fracture taking the shortest route, combined with the grain of the bone. Wiseman described this appearance, noting that the bone, if not shattered, had the feel of fish scales.[86]

The removal of slivers of bone and extraneous material was the primary concern.[87] Fragmented remnants of bone could cause pressure on nerves, block blood vessels and inhibit healing. Such issues could potentially lead to gangrene, septicaemia, or, at the very least, continued discomfort and increased risk of infection. Where possible the bone would be reset by the application of traction and the manipulation of the bone through the bullet wound until the fracture was aligned.[88] The wound would be splinted, taking care to use wide bandages so as not to 'restrict the heat' of the wound and cut off circulation.[89] The support of a fracture could be achieved either by splints or by suspending the limb in a sleeve of armour with a long screw along the length of the articulated covering, to enable the limb to be extended.[90] This approach was still utilised during the early 1900s, the 'Thomas splint'.[91] Aluminium splints, strapped to the limb by bandages, were joined lengthways by bolts so that the whole splint could be gradually extended to provide traction, whilst maintaining patient mobility and allowing access to the wound site, With the addition of a plaster cover, the Thomas splint was adapted as the Tobruk splint in the 1940s, providing more support.[92] The Tobruk splint parallels the method Wiseman used to treat patients with multiple fractures of limbs.[93] Pasteboard softened with vinegar could form an indentation of the limb, so the limb could be sandwiched between two sheets and immobilised. For example, a mariner whose arm was completely shattered – Wiseman noted he could have amputated the arm without a saw - refused to have the arm removed, as would have been normal practice for a multiply-fractured limb. However, after eight weeks' immobilisation the arm managed to heal enough to be usable.[94] Wiseman attributed this success to the patient's inactivity during the prolongued treatment; without immobilisation the bones would never have knitted together.

For a fracture caused by a gunshot, the surgeon needed to treat the wound without disturbing the fracture and preventing its healing. The approach suggested by Wiseman to accommodate this was to create a broad bandage of soft linen cloth folded-over three or four times.[95] Three slits were then cut longitudinally towards the middle from either end, leaving an uncut region in the centre. The uncut region was placed under the limb, to support the fracture, then the three strips from either end tied together over an absorptive linen pad over the wound. This could absorb discharges from the wound but be changed regularly by moving the three ties aside. Thus the fracture could be supported and the wound receive ongoing treatment.

For cranial fractures caused by gunshots, the challenge was to raise the skull fragments back into place. The scalp had to be cleansed of blood using red wine or vinegar, and any hair removed from the wound site.[96] The fractures could then be levered upright without the need to remove too many bones. Indeed Wiseman castigates some of his fellow surgeons for removing too many bones from patients' skulls and keeping them as souvenirs. For depressed fractures of the skull caused by glancing blows or pressure injuries, without a penetrative wound, two approaches were used: A skull elevator, a frame supporting a long screw which could drill into skull fragments and raise them up, or a trepanning tool (see Figure 3n) which could cut-out a circular disk from the skull, after first paring back the skin of the scalp. Using this hole as an access point, levers could raise skull fragments back into place.[97] A trepanned section could be replaced, or the gap covered using a beaten-out coin. Trepanning appears to have been used for cranial fractures, or to release visible swellings from cranial fluid, rather than as the mediaeval cure for psychiatric disorders or headaches.[98]

Amputation

Should a limb prove to be either beyond repair, infected, or gangrenous, the surgeon would reluctantly be required to amputate .[99] Wiseman discussed a range of suggested methodologies from noted surgeons and contemporaries in London but his own approach was quite clear.[100]

The surgeon should have a well-prepared supply of clean tow (soft linen), bandages, buttons (small, stuffed linen spheres) and an ox bladder to cover the stump. Cooke's advice on amputation suggested similar preparations, including at least two sharp bone saws, so that the operation could be completed rapidly should one break.[101] These items were soaked in oxycrate and left to dry, and buttons also were soaked in wine or oxycrate and dipped in an astringent mix of powders, including mastic and 'dragon's blood'.[102] Cooke also noted that some surgeons used red-hot knives and saws. So without realising the microbiological basis, seventeenth-century surgeons did seem aware of the benefits of an aseptic environment.

Wiseman's approach was to cut off the blood supply with a strong ligature (a thick strip of linen tied tightly as a tourniquet) to inhibit bleeding and facilitate the post-amputation securing of blood vessels.[103] The ligature applied, the surgeon could then operate without fear of excessive blood loss from the patient. The surgeon's mate would pull the skin and muscle of the healthy part of the limb away from the damaged area, so that when the surgeon cut through the skin and flesh (using a single motion from a curved knife, shaped with the curve on the inside), the musculature was immediately pulled back, exposing the bone underneath, which could then be cut through using a sharpened saw. Speed was of most importance to the procedure, to minimise patient discomfort.[104]

After amputation the severed arteries needed to be sealed. Cooke advised suturing the stump shut with artery ends blocked by linen buttons, or tied with a ligature.[105] Wiseman, emphasising speed, advised the use of an 'actual' (heat-based) cautery to sear the ends of the blood vessels together. Cauterisation of blood vessels was a faster and more-secure approach, provided the nerves and bone ends could be avoided, and cauterisation of blood vessels was practiced into the nineteenth century.[106] The approach then was to pull the skin and muscle back over the bone. The bone had been cut shorter than the musculature to enable the fleshy end of the stump to be sewn shut using two stout stiches at right-angles to each other. The stump was then bound using bandages, and covered with the bladder, each soaked in oxycrate.

As a result of the preparations, operation speed and aftercare, the potential for infection of the amputated stump was reduced considerably, although some discharge of pus was expected and encouraged.

Reviewing the equipment and procedures used for amputations in subsequent centuries, the methodology did not change significantly, except for the introduction of the 'flap amputation' method, which used either two or three angled cuts through the flesh (developed in 1715 and 1773 respectively), reducing the strain on the sutured skin of the stump. That numerous soldiers survived amputations emphasises the potential effectiveness of the procedure. However, survival rates for amputations were low, even well into the twentieth century, and depended on the severity of the site of the amputation.

Conclusion: how effective was seventeenth-century surgery?

Due to the lack of comprehensive medical records from the British Civil Wars, it is impossible to directly evaluate the success rates of surgeons' practice. However, as several examples presented within this volume attest, it was possible to survive quite severe wounds. The prevalence of severe wounds presented by maimed soldiers seeking military pensions particularly support this view.[107] Hannah Worthen's data on maimed soldiers' reported wounds indicates a prevalence for wounds of the extremities, but also examples of multiple wounds that were survived.[108] Records of admissions to the Chelsea Hospital in the early 1700s, identified by Eric Gruber von Arni, also cite multiple severe wounds, frequently from successive engagements.[109] Wiseman, Cooke and other authors frequently reported survivors of extreme injuries. The juxtaposition of these accounts against descriptions of patients who were less fortunate, suggests they are reliable. Two extreme cases from the civil wars include Colonel William 'Blowface' Forbes of Tolmads, Aberdeenshire, who was stood near to Sir Thomas Fairfax at the siege of Pontefract Castle when a cannon ball passed between them. The force caused by the passing ball knocked Fairfax to the ground and 'spoyled one side of the

Colonells face and eyes'.[110] Colonel Forbes survived, despite his injuries, continuing in military service until his death in 1646.[111] Whilst the surgical intervention for Colonel Forbes was not recorded, he was clearly treated successfully, and despite disfiguring injuries was able to continue active service. Still more extreme were the wounds of John Tinkler of Durham, a gunner at Hartlepool, who survived blinding and the loss of both his arms.[112] Ian Gentles suggests an estimate of over 90,000, 30,000 and 80-100,000 wounded soldiers in England/Wales, Scotland and Ireland respectively, and suggests the numbers of maimed soldiers in later years to be tens of thousands.[113] It is impossible to know how many of these casualties survived as a result of surgical intervention, or indeed how many casualties died as a result of it, but it was clearly possible to survive often quite severe civil war injuries.

This chapter focuses on a small number of select surgeons who were successful or recognised enough to enjoy sufficient patronage to publish. It is likely there were also less-valid practices amongst unpublished civil-war surgeons, but the consistency of approaches between published authors supports the notion that they were reporting common practices. However, based on their published works, it is possible to suggest that seventeenth-century surgeons were utilising approaches that were biomedically valid. Also that they were using an evidence-based approach to their practice which belies the popular image of dangerously incompetent 'quacks'. Instead it suggests that they were medical pioneers, whose effective methods remained largely unchanged for several generations and who established foundations for modern surgical practice.

Figure 3.1

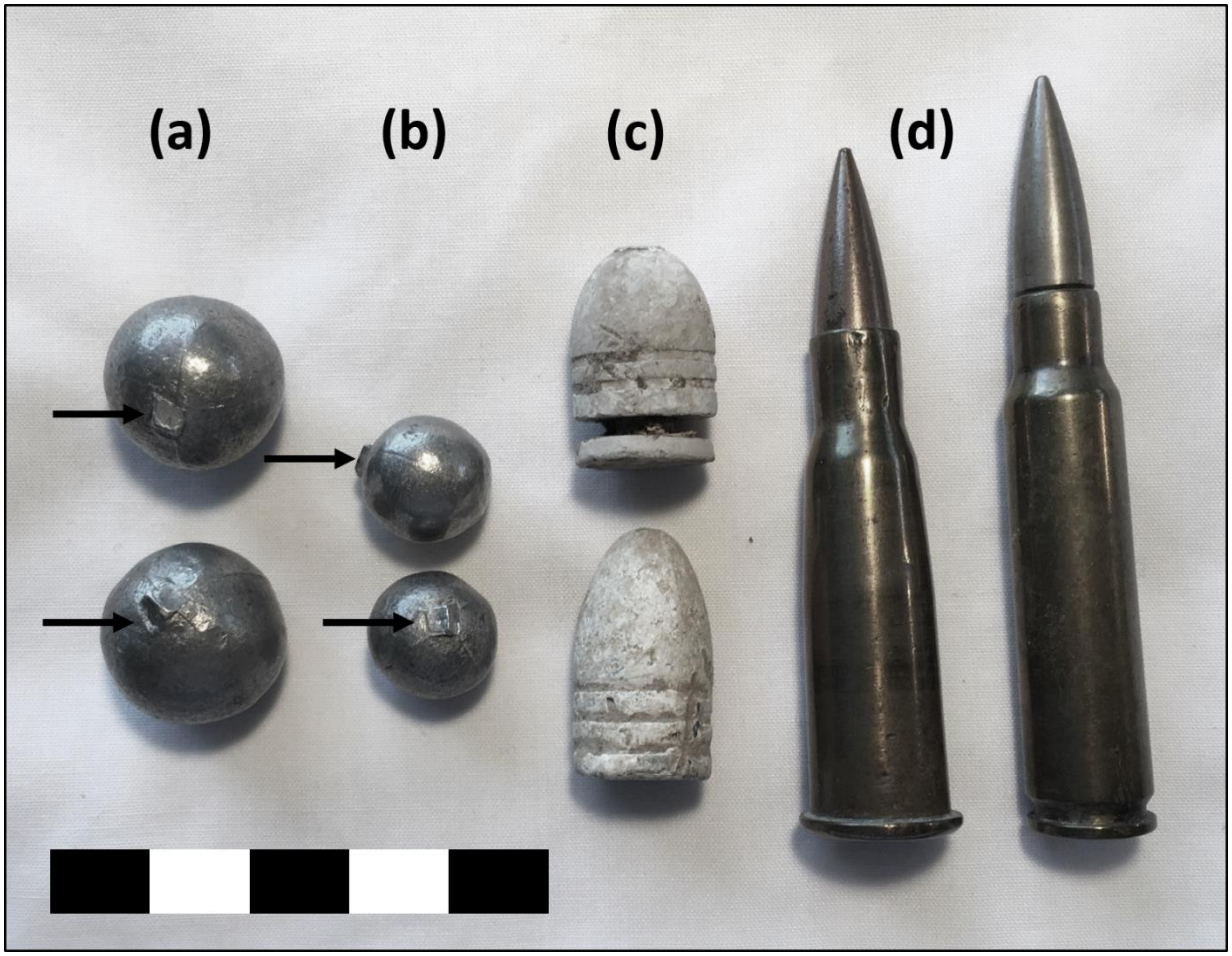

Figure 3.1 Ammunition. (a) Musket and (b) pistol balls typical of the mid-1600s. Note, the visible small surface protrusion, or ‘nipple’ (arrows), a relic of the casting process, which created an asymmetrically-shaped ball. Comparison with (c) ‘Minié Ball’ bullets from the American Civil War (1861–65) and (d) two c.7.5mm calibre rounds from the mid-twentieth century. Bar = 5cm.

Figure 3.2

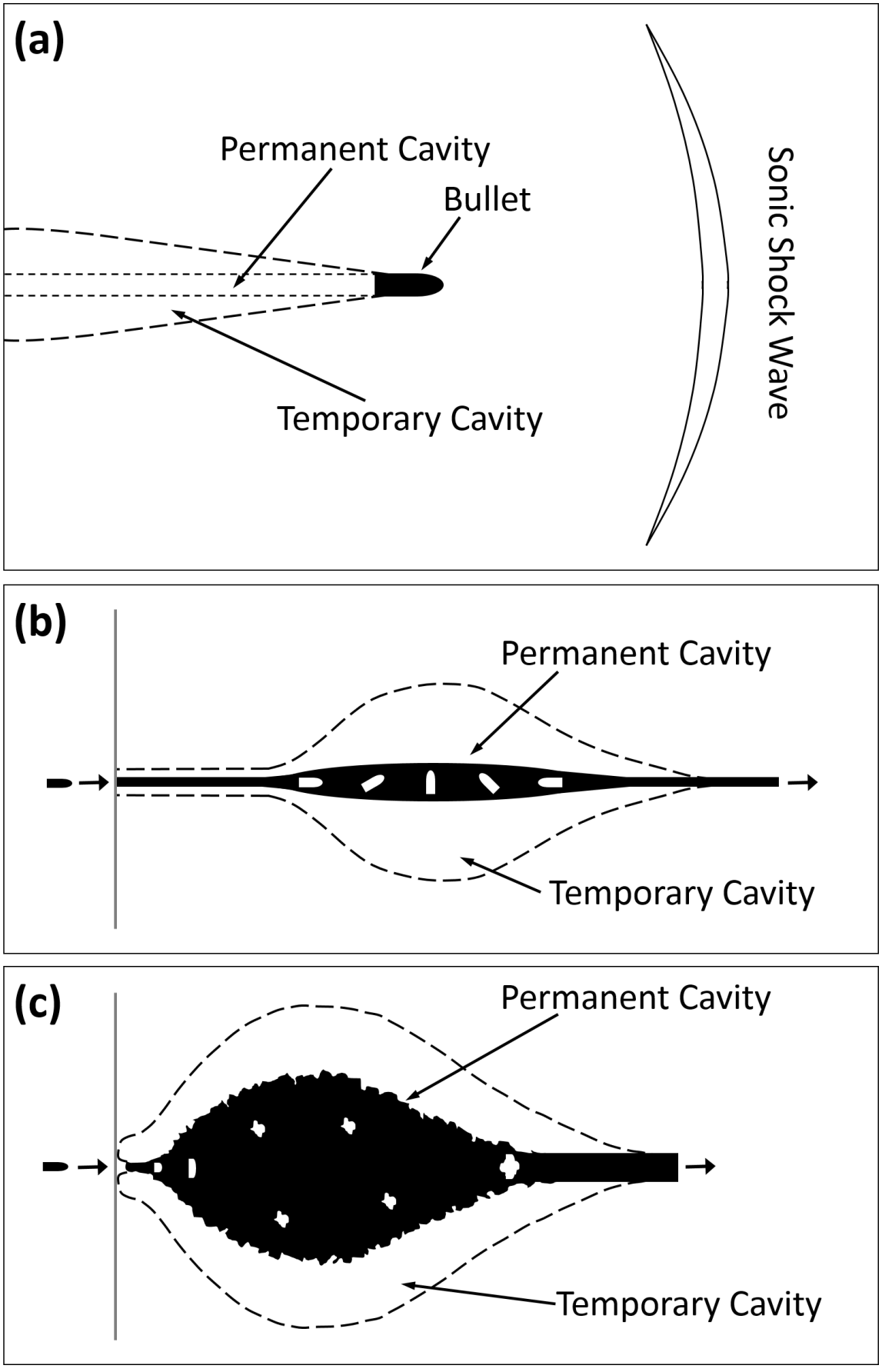
(a)
Permanent Cavity
Bullet
Temporary Cavity
Sonic Shock Wave
(b)
Permanent Cavity
Temporary Cavity
(c)
Permanent Cavity
Temporary Cavity

Figure 3.2 Ballistics of modern bullets. (a) Pathway of a bullet, showing the sonic shock wave, permanent and temporary cavities as a bullet passes through the air or a human body. (b) Plotting the permanent (shaded) and temporary (dotted line) cavities in a high velocity (7.62 mm) bullet. The axes represent proportional distances. White bullet shapes demonstrate the yawing and flipping of the bullet. (c) Cavitation from a soft-headed bullet. The bullet deforms and fragments, causing a wider permanent cavity, and a wider exit path.[i]

Figure 3.3

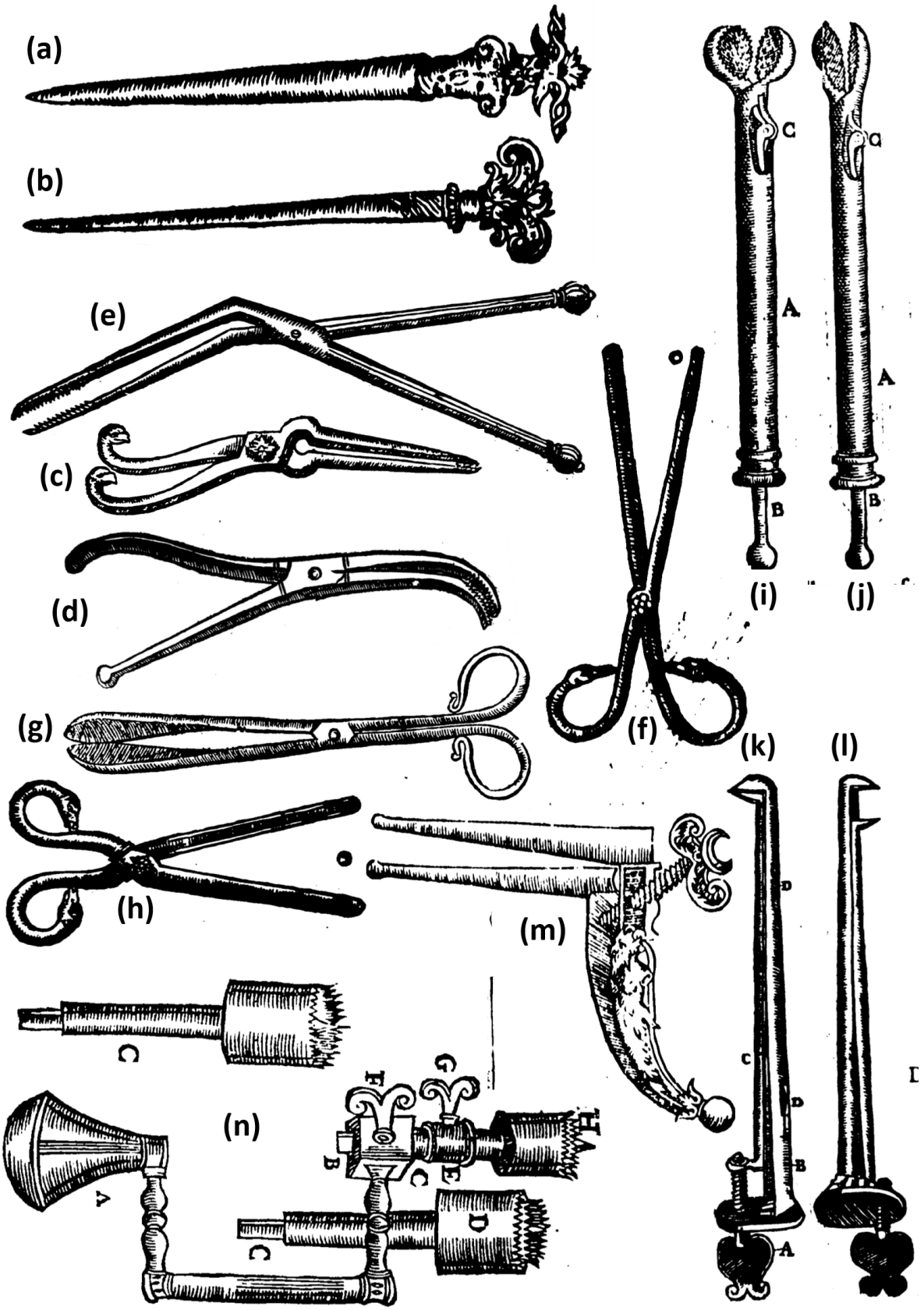

Figure 3. Surgical implements. (a,b) Tirefond bullet extractors, (c,d) Crowe's Bill, (e,f) Crane's Bill, (g,h) Drake's Bill, (i) Catch-bullet and (j) Lizard's Mouthe articulated bullet extractors, (k,l) Parrot's Bill, open and closed respectively, (m) Swan's Beake, (n) Trepanning tool showing fittings. Not shown to scale. Composite of images from T. Johnson, *The workes of that famous Chirurgion Ambrose Parey* (1634), pp. 366 (n), 419 (c), 420 (e,f,h,i), 421 (j-m), 422 (a,b), 459 (d), 676 (g). Reproduced with permission from The Huntington Library, San Marino, California; STC (2nd ed.) / 19189.

Notes

[1] J. E. McCallum, *Military Medicine: From Ancient Times to the 21st Century* (Santa Barbara: ABC-CLIO, 2008), pp. 291–4; R. A. Gabriel, *Between Flesh and Steel: A History of Military Medicine from the Middle Ages to the War in Afghanistan* (Washington DC: Potomac Books, 2013), pp. 65–85.

[2] G. Guyatt, *et al.*, 'Evidence-based medicine: a new approach to teaching the practice of medicine', *Journal of the American Medical Association*, 268:17 (1992), 2420–25.

[3] For a more detailed account of the early modern surgeon, see S. M. Rutherford, 'Ground-breaking pioneers or dangerous amateurs? Did early-modern surgery have any basis in medical science?', in I. Pells (ed.), *New Approaches to the Military History of the English Civil War* (Stroud: Helion and Company, 2016), pp. 153–85.

[4] The London Company of Barber-Surgeons alternated each year between a surgeon and a barber for the Master of the Company; A. Griffin, 'William Clowes (1582–1648)', *ODNB*; McCallum, *Military Medicine*, p. 292.

[5] J. O. Robinson, 'The barber-surgeons of London', *Arch. Surg*., 119:10 (1984), 1171–5.

[6] E. Gruber von Arni, *Justice for the Maimed Soldier: Nursing, Medical Care and Welfare for Sick and Wounded Soldiers and their Families during the English Civil Wars and Interregnum, 1642–1660* (Aldershot: Ashgate, 2001), pp. 228–31.

[7] Richard Wiseman was particularly disdainful of the errors that civilian surgeons would make, based on their inexperience of wounds.

[8] Richard Wiseman's surgeon's mate at the Battle of Worcester, William Clarke, later became a surgeon based in Bridgnorth: R. Wiseman, *Severall Chirurgical Treatises* (London: Norton and Maycock, 1676), p. 438.

[9] S. B. Ghosh, 'Human cadaveric dissection: a historical account from ancient Greece to the modern era', *Anat. Cell Biol.*, 48:3 (2015), 153–69; Rutherford, 'Ground-breaking pioneers or dangerous amateurs?', p. 160.

[10] R. A. Cohen, 'Documents concerning James Cooke, surgeon, of Warwick', *Medical History*, 1:2 (1957), pp. 168–73.

[11] *Ibid.*

[12] J. Kirkup, 'Richard Wiseman (bap. 1620?, d. 1676)', *ODNB*.

[13] Wiseman left considerable sums to his family in his will (including £2000 to his son); TNA, PROB 11/352/88, 12 September 1676.

[14] The extent to which Wiseman collaborated with his fellow surgeons is discussed in detail in M. McVaugh, 'Richard Wiseman and the medical practitioners of Restoration London', *Journal of the History of Medicine and Allied Sciences*, 62:2 (2007), 125–40.

[15] G. Ballingall, *Outlines of Military Surgery* (Edinburgh: A&C Black, 1844), pp. 215–6.

[16] P. Hernigou, 'Ambroise Paré's life (1510–1590): part I', *International Orthopaedics*, 37:3 (2013), 543–7; P. Hernigou, 'Ambroise Paré III: Paré's contributions to surgical instruments and surgical instruments at the time of Ambroise Paré', *International Orthopaedics*, 37:10 (2013), 975–80.

[17] E. Jones, 'The life and works of *Guilhelmus Fabricius Hildanus* (1560–1634): Part I', *Medical History*, 4:2 (1960), 112–34; E. W. P. Jones, 'The life and works of *Guilhelmus Fabricius Hildanus* (1560–1634): Part II', *Medical History*, 4:3 (1960), 196–209.

[18] J. Scultetus (transl. E.B.), *The Chirurgeons Store-House* (London: J. Starkey, 1674); 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), 130–9.

[19] *Ibid*.; W. Fabry (J. Steer transl.), *Gulielm Fabricus Hildamis, His Experiments in Chyrurgerie* (London: Barnard Alsop, 1643).

[20] Wiseman, *Severall Chirurgical Treatises*, p. 447.

[21] *Ibid*, p. 445.

[22] *Ibid*, pp. 445–6.

[23] *Ibid*, p. 445.

[24] Also known as 'laudable quittor', J. Cooke, *Mellificium Chirurgiae, or the Marrow of Chirurgery much enlarged, to which is added Anatomy* (London: J.D., 1676), pp. 51, 145.

[25] *Ibid.*, pp. 223, 395; A. Paré (trans. W. Hamond), *The Method of Curing Wounds made by Gun-shot, Also by Arrowes and Darts, with their Accidents* (London: Isaac Iaggard, 1617), pp. 8–9; Wiseman, *Severall Chirurgical Treatises*, p. 442; Wing / B5124, J. Browne, *A Compleat Discourse of Wounds* (London, 1678), p. 95.

[26] S. Ankri and D. Mirelman, 'Antimicrobial properties of allicin from garlic', *Microbes and Infection*, 1:2 (1999), 125–9.

[27] 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* 4:10 (2009), pp. 7238.

[28] V. Eyers, 'Ballistics of matchlock muskets' (MSc Thesis, Cranfield University, 2006), p. 12.

[29] R. Magee, 'Muskets, musket balls and the wounds they made' *Aust.N.Z. J.Surgery*, 65:12 (1995), pp. 890-895.

[30] V. Eyers., pp. 29–33. The velocity of bullets from modern rifles is three times faster.

[31] *Ibid.*, p. 52.

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

[33] Paré, *The Method of Curing Wounds made by Gun-shot*, pp. 5–6.

[34] 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*, 9:3 (2007), 147–50.

[35] Wiseman, *Severall Chirurgical Treatises*, p. 408; Brown, *Compleat Discourse*, pp. 100, 102.

[36] *Ibid.*, p. 102.

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

[38] A. C. Szul (ed.), *Emergency War Surgery: NATO Handbook, US Revision 3* (Washington, D. C.: United States Government Printing Office, 2004), pp. 1–13.

[39] M. L. Fackler, 'Gunshot wound review', *Ann. Emergency Medicine*, 28:2 (1996), 194–203; R. A. Santucci and Y.-J. Chang, 'Ballistics for physicians: myths about wound ballistics and gunshot injuries', *Journal of Urology*, 171:4 (2004), 1408–14.; V. J. M. DiMaio, *Gunshot Wounds: Practical Aspects of Firearms, Ballistics, and Forensic Techniques* (2nd edn, New York: CRC Pres s, 1999), pp. 51–61.

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

[41] *Ibid.*, p. 413.

[42] Brown, *Compleat Discourse*, p. 109.

[43] *Ibid.*, p. 412.

[44] T. Johnson, *The Workes of that Famous Chirurgion Ambrose Parey* (London: Cotes and Young, 1634), p. 421; Wiseman, *Severall Chirurgical Treatises*, p. 427.

[45] *Ibid.*, p. 412.

[46] *Ibid.*, p. 413.

[47] Brown, *Compleat Discourse*, pp. 350–1; Wiseman, *Severall Chirurgical Treatises*, p. 431.

[48] T. Chevalier, *A Treatise on Gunshot Wounds: Which obtained the premium given by the Royal College of Surgeons in London for the year 1803* (London: S. Bagster, 1806), pp. 69–70; S. D. Gross, *A Manual of Military Surgery or Hints on the Emergencies of Field, Camp, and Hospital Practice* (2nd edn, Philadelphia: J.B. Lippincott & Co., 1862), p. 70.

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

[50] Brown, *Compleat Discourse*, p. 100.

[51] Browne recounts reading of an individual for whom he had 'extracted a Leaden Bullet, which was received in the Groyn, five years after its reception, in which time it had fallen near the Knee, at which place it was drawn forth': *Ibid.*, pp. 100, 110.

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

[53] Wiseman referred to iron or brass fragments, *Ibid.*, p. 411.

[54] *Ibid.*, p. 431.

[55] Johnson, *The Workes*, pp. 424–6; Wiseman, *Severall Chirurgical Treatises*, pp. 411–12.

[56] *Ibid.*, pp. 445–6.

[57] Brown, *Compleat Discourse*, pp. 7, 37, 107.

[58] Paré, *The Method of Curing Wounds made by Gun-shot*, p. 52.

[59] Johnson, *The Workes*, pp. 421–4; G. Fabritius Hildanus, *Cista Militaris: or A Military Chest* (London: W. Godbid, 1674), pp. 21–8; Browne, *Compleat Discourse*, p. 37.

[60] M. Crumplin, *Men of Steel: Surgery in the Napoleonic Wars* (Shrewsbury: Quiller Press, 2007), pp. 188–91; Hamilton, *A Practical Treatise on Military Surgery*, pp. 139–41; Gross, *A Manual of Military Surgery*, pp. 71–3.

[61] Paré, *The Method of Curing Wounds made by Gun-shot*, pp. 6–7.

[62] Wiseman, *Severall Chirurgical Treatises*, pp. 414–15.

[63] *Ibid.*, p. 415.

[64] Cooke, *Mellificium Chirurgiae*, p. 180; Wiseman, *Severall Chirurgical Treatises*, p. 326; G. Keynes (ed.), *The Apologie and Treatise of Ambroise Paré, 1585* (Chicago: University of Chicago Press, 1952), pp. 124–5, 436; Brown, *A Compleat Discourse*, pp. 7, 37, 107.

[65] W. Clowes, *A Prooved Practise for all Young Chirurgians* (London: T. Cadman, 1588), p. 15; Paré, *The Method of Curing Wounds made by Gun-shot*, pp. 64–5; Fabritius Hildanus, *Cista Militaris*, p. 29; Cooke, *Mellificium Chirurgiae*, p. 179**;** Brown, *Compleat Discourse*, p. 108.

[66] H. C., *An Explanation of the Fashion and use of Three and Fifty Instruments of Chirurgery* (London: Sparke, 1631), pp. 52–3.

[67] Clowes, *A Prooved Practise*, p. 14; Cooke, *Mellificium Chirurgiae*, pp. 371–2, 456.

[68] Wiseman, *Severall Chirurgical Treatises*, p. 437.

[69] *Ibid.*, p. 430.

[70] J. H. Binns, 'Wound closure by delayed primary techniques', *Journal of the American College of Emergency Physicians*, 4:2 (1975), 133–4.

[71] H. H. Hepburn, 'Delayed primary suture of wounds', *British Medical Journal*, 1:3033 (1919), 181–3.

[72] Chevalier, *A Treatise on Gunshot Wounds*, pp. 125–6; Crumplin, *Men of Steel*, pp. 227–9.

[73] Hamilton, *Practical Treatise on Military Surgery*, pp. 149–52.

[74] 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. 322, 352, 392; T. Scotland and S. Heyes, *Wars, Pestilence and the Surgeon's Blade* (Stroud: Helion & Co., 2013), p. 244.

[75] A. J. Hull, *Surgery in War* (London: J. & A. Churchill, 1916), pp. 52–8; Hepburn, 'Delayed primary suture of wounds', 181–3; T. Scotland and S. Heyes, *War Surgery, 1914–18* (Solihull: Helion & Co., 2012), p. 68.

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

[77] T. E. Rasmussen and R. M. Tai, *Rich's Vascular Surgery* (3rd edn, London: Elsevier Life Sciences, 2016), p. 9.

[78] 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 Joint Surgery*, 50A (1968), 945–54.

[79] 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*, 61:5 (2006), 1207–11.

[80] A weak solution of bleach and boric acid. D. P. Penhallow, *Military Surgery* (London: Oxford University Press, 1916), p. 73.

[81] 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*, 180:1 (2000), 55–7.

[82] M. Willcox, 'Cleaning simple wounds: healing by secondary intention', *Nursing Times*, 100:46 (2004), 57; F. J. Verdam, *et al.* 'Delayed primary closure of the septic open abdomen with a dynamic closure system', *World Journal of Surgery*, 35 (2011), 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), 120–24.

[83] Browne, *Compleat Discourse*, p. 101.

[84] Wiseman, *Severall Chirurgical Treatises*, p. 423.

[85] Penhallow, *Military Surgery*, p. 163.

[86] Wiseman, *Severall Chirurgical Treatises*, p. 420.

[87] Cooke, *Mellificium Chirurgiae*, pp. 198; Wiseman, *Severall Chirurgical Treatises*, pp. 422, 431, 437.

[88] *Ibid.*, p. 422.

[89] *Ibid*., p. 447.

[90] W. Fabry (J. Steer transl.), *Gulielm. Fabricius Hildamus, his experiments in chyrurgerie* (London: B. Alsop, 1642), pp. 58–9

[91] Penhallow, *Military Surgery*, pp. 171–9.

[92] Scotland and Heyes, *War Surgery*, pp. 154–5; Ogilvie, *Forward Surgery*, p. 37.

[93] Wiseman, *Severall Chirurgical Treatises*, pp. 425, 428–30.

[94] *Ibid*., p. 427–30.

[95] *Ibid.*, pp. 424–5.

[96] *Ibid.*, pp. 384–5.

[97] *Ibid.*, pp. 401–4.

[98] Cooke, *Mellificium Chirurgiae,* p. 141.

[99] Cooke reflected that 'Dismembering is a dreadful Operation; yet necessary, that the dead part may not injure the living, nor procure death. Sphacelus is the perfect Mortification of any part, invading not only the soft parts, but also the bones.' *Mellificium Chirurgiae*, pp. 722–7.

[100] Wiseman, *Severall Chirurgical Treatises*, pp. 454–8.

[101] Cooke, *Mellificium Chirurgiae,* pp. 724–5.

[102] Wiseman, *Severall Chirurgical Treatises*, p. 455.

[103] *Ibid.*, p. 457.

[104] Wiseman claimed to have performed amputations without needing the patients restrained: *Ibid.*, p. 457; Cooke, *Mellificium Chirurgiae,* pp. 723–5.

[105] Cooke, *Mellificium Chirurgiae,* p. 725.

[106] Crumplin, *Men of Steel*, pp. 186–8.

[107] See Chapter 9 of this volume.

[108] E. Gruber von Arni and A. Hopper, *'Battle-Scarred': Surgery, Medicine and Military Welfare during the British Civil Wars* (Leicester: University of Leicester, 2016), p. 11.

[109] E. Gruber Von Arni, *Justice to the Maimed Soldier*, Vol. 2 (Nottingham: Caliver, 2015), pp. 198–9.

[110] BL, Thomason E24(23), *Mercurius Civicus*, 9–16 January (London, 1645), p. 790.

[111] Gruber von Arni and Hopper, *'Battle-Scarred'*, p. 21.

[112] Durham County Record Office, Q/S/OB 5, Quarter Sessions Order Book, 1660–68, fo. 72r (Microfilm M7/2), The petition of John Tinckler of the city of Durham, 3 October 1660.

[113] I. Gentles, *The English Revolution and the Wars in the Three Kingdoms, 1638–1652* (Harlow: Pearson Longman, 2007), p. 437.