

Trepanation at War Times: Napoleonic Wars and North American Civil War

Trepanation had been carried out almost exclusively to treat head wounds and cranial fractures since ancient times. A large number of trepanned skulls of the pre-Columbian primitive cultures had skull fractures and injuries probably caused by weapons. The Hippocratic and Medieval texts make unequivocal reference to the treatment with trepanation of cranial and intracranial lesions produced by knives, swords, spears or projectiles used in battles. On the other hand, any type of head injury or cranial fracture described in ancient texts can be produced in combat by direct head trauma by sharp or blunt objects, falls, impact of heavy stuffs or hand-to-hand fighting [1, 2]. However, these injuries should not be very different from those that occurred in civil life or work activity.

Therefore, wars were a mine of cases and a source of experience for surgeons [3, 4]. According to Laín Entralgo, one of the relevant facts in the evolution of surgery between the Middle Ages and the Renaissance was the use of firearms in wars [5]. This also changed the type of wounds and it required a renovation of the treatment techniques that had been used until then, particularly those concerning head wounds and fractures and trepanation. In addition to the weapons, there were other changes in the period of time on which we are now going to focus, such as military tactics, number of soldiers involved and fight types. The disasters caused in the battles forced to design specific training systems for

army surgeons and healthcare systems for injured soldiers. However, we only have reliable records of these aspects from the Napoleonic Wars that took place in Europe and the North of Africa and in the seas around the world. The information about the American Civil War is particularly rich and accurate.

John Fletcher Horne (1849–1941) described the evolution of the frequency of the trepanation in war head injuries. This evolution follows the general indications of the trepanation. In the latter part of the eighteenth century trepanation was widely employed, even as a preventive measure to avoid brain inflammation in every case of gunshot injury of the head, without sings of cerebral compression. Later, along the Peninsular Napoleonic Wars at the beginning of the nineteenth century, the number of trepanations declined. In the second half of the century, in the Italian War of 1859 or in the Franco-German War of 1870–1871, trepanation was exceptionally employed. Moreover, in every of these few cases, the results were unfavourable [6].

18.1 Trepanation in the Napoleonic Wars

The Napoleonic Wars devastated all mainland Europe between 1792 and 1815, causing millions of deaths and injuries. Most of the deaths were caused by infectious diseases, malnutrition or

environmental consequences, particularly the cold weather. The most frequent causes for injuries in battles were low-speed projectiles that were shot by muskets, carbines and rifles as well as the shrapnel from grenades. The wounds made by sabres, bayonets and lances were less common.

In general terms, the medical services of the English and French armies were poorly supplied and organised. The English surgeons of that time started being trained at the age of 15 and worked as apprentices for 5–7 years accompanying their master. They learnt minor surgery, bloodlettings and bandages and helped the surgeon. They were granted the authorisation to work as a military or civil surgeon by an examining board of the College of Surgeons. Military surgeons quickly learnt their job at war and were subjected to a strong hierarchy. They were general surgeons and included among their tasks treating head wounds caused by projectiles and sabres as the helmets of that time offered no effective protection. Trepanations were carried out to treat cranial fractures and remove projectiles. However, they were not very frequent and many trepanation sets were never used. These instruments were sold by surgical instrument manufacturers in cases that contained all necessary material for surgery in the battlefield. The instrument case for trephination and amputation manufactured by J.C. Schenetter from Munich for the Imperial Russian Army during the first years of the nineteenth century contained 29 pieces. Among them, the following were aimed at trepanation: trepan with brace handle and three cylindrical trephine crowns of 5 cm, three Hey skull bone saws, a fragment lifter with a separate support to lever and lift the fragments, pincers for bone fragments, lenticular knife, lenticular separator for the dura mater, whale bone dissector to separate the dura mater and, finally, a brush [7].

The war ships also had surgeons who had been trained to carry out trepanations offshore [8]. To do so, among the crew of each vessel there was a surgeon with the necessary instruments. Due to the characteristics of the environment where they were used these instruments were subjected to strict controls. The Royal Navy Regulations of

1731 made it compulsory to keep the surgical instruments in a chest that was checked before shipping it and marked with the surgeon's seals and those from the Surgeons Company. No sea captain admitted it on board if both seals were not intact. This was done for two reasons, the first one to ensure that the necessary instruments were loaded on board and the second one to avoid selling the instruments due to their high price and the low salary of surgeons and barbers. The manufacturing companies sent the list of the instruments contained in the chests to the Surgeons College, who approved or modified it. The instruments were acquired in the Royal Navy and belonged to the surgeon himself or herself (Fig. 18.1). The chests had different sets for amputation, trephining, draining, dentistry, wound catheters and minor surgery, cupping and bloodlettings and also a mixture of assorted instruments and supplies. The trepanation set was made up of three trephine crowns with T-handle, a skull bone saw, periosteal elevators or '*rugines*', a fragment lifter, a pair of forceps and a brush.

Among the military surgeons of both sides we must highlight Dominique-Jean Larrey in France and George James Guthrie in England. We are now going to describe their points of view concerning the trepanation in war wounded.

Dominique-Jean Larrey (1766–1842) was a surgeon in the Napoleonic armies and was involved in many campaigns throughout Europe and Egypt, including the invasion of Russia and retreat therefore. He was famous not only for his work as a physician but also for his achievements in the organisation of an early assistance in the battlefield as he designed an efficient system of ambulances and medical carriages ('flying ambulances'). Concerning trepanation, he affirmed that trepanning was essential in cranial wounds with depressed fractures or projectiles that might injure the dura mater or the brain or cause accumulation that might require to be drained. These comments are in his book '*Clinique Chirurgicale, exercée particulièrement dans les camps et les hôpitaux militaires depuis 1792 jusqu'en 1829*', which was published in 1829 [9]. The brain compression was identified by the more or less extensive paralysis of different parts of the body that



Fig. 18.1 Photograph taken by the author that corresponds to a trepanation box dated at the end of the eighteenth century (National Maritime Museum Greenwich, London) and built with cloth, wood, leather and steel. The box contains a wooden T-handle with two different diameter trephine crowns and a perforator. There is also a scraper, as well as a horsehair brush with ivory handle.

The box is completed by a lenticular knife and a lenticular dura mater depressor. Finally, there is a multipurpose clamp. The bone elevator is shown outside the box mounted on a support, but it has a slot in the box where it would normally be housed. This box contains the basic trepanation surgical instruments of British and American army surgeons

were in the opposite side to the wound. It appeared soon after the wound or gradually. It was not necessary to wait until these symptoms appeared to trepan in case the wound affected the frontal sinuses. Those projectiles embedded in the bone could be removed if the procedure was easy. However, if it was difficult it was preferable to leave them so that they would be expelled later naturally. He recommended exploring the path of the wound with an elastic rubber catheter. If the projectile was found it was removed through a counter-opening and by trepanning. He describes two illustrative cases. In case of a foreign body the burr hole had to be carried out so that the projectile was in the centre of the hole. If the projectile dipped in the brain substance the surgeon should not search for it. Larrey was aggressive with the wounds and projectiles that affected the frontal sinus and recommended trepanning. He described trepanations in the posterior fossa and lesions of the cerebellum. Curiously, he wrote a long chapter about the relationships between these lesions of the cerebellum and the sexual function. The optimal moment for the intervention was within the first 24 h, as the inflammation increased later. The book describes a great number of cases of injured soldiers, their injuries, treatment and clinical results. He repeatedly stressed the idea that the trepanation was useless when foreign bodies dipped in the brain and there were liquid accumulations extravasated away from the cranial vault as it was impossible to know where they were. He also considered unnecessary to trepan cranial wounds without foreign bodies, with non-depressed fractures or those that widely extended but had no brain compression signs. He talked about brain herniations through trepanation defects and their fatal prognosis in spite of the solutions used, such as surgical resection, compression with lead sheets or some methods of local treatment.

On the other hand, George James Guthrie (1785–1856) was a well-known English surgeon who served in the English armies during these wars, particularly in Spanish territories [10]. He published his *Commentaries in the surgery of the war* in 1815 and a monograph titled *Injuries of the head affecting the brain* in 1842, where he

described his experiences. The indications of trepanation for war injured were depressed, open cranial fractures or bone fragments or shrapnel that eroded the brain, as well as those life-threatening brain compression situations that were due to supposed blood clots. The trepanation aimed to remove all bone fragments and the epidural blood to decompress the brain. The dura mater was the natural barrier of surgery and it was never opened, even the projectiles or bone fragments had invaded it. He only recommended the dural opening for those late cases, when a taut dura mater suggested a haematoma or empyema. The trepanation had to be carried out in the adequate moment, preferably soon. He was against late or last-resource trepanation. Although he was in favour of trepanation, he recognised his seriousness and stated that among ten healthy people trepanned at a civil hospital one died of the intervention itself whereas three or four would hardly escape from death due to the inflammation of the brain or the meninges or due to other problems.

18.2 Trepanation in the North American Civil War

The Napoleonic Wars were the last ones with a massive use of soldiers and cavalry and where the wounds (regardless of their type and localisation) produced by sharp or cutting weapons were more frequent than those caused by firearms. In this conflict there were the first attempts to organise an effective and efficient military healthcare for the warring factions. The cause of war wounds changed later but the healthcare organisation was still poor and the new developments concerning the anaesthesia, aseptic and antiseptic techniques were not efficiently incorporated. During the Crimean War between the Russian Empire and France, the United Kingdom and the Ottoman Empire that took place between years 1853 and 1856 only the Russian and French armies had a minimal healthcare organisation. In spite of it, the mortality was incredibly high.

John Fletcher Horne (1849–1941) described in Chapter IV of his book *Trephining* the topic ‘Trephining in gunshot wounds of the head’ and

reviewed the result of the operation in the different wars. Horne analyses the trepanation in the Crimean War. He says that the proportion of cases of trephining to gunshot head injuries in Crimean War was 3.11%, higher than in the American Civil War with a 2%. However, the recoveries were only 14.28% in the Crimean War compared with a 42.5% in the American Civil War. Horne does not find a clear explanation for this difference, only the much better knowledge of the cerebral localisation that allows the surgeons to apply the trephine more accurately according to the symptoms of the wounded. During the Crimean War the results were disappointing in every medical service of every Army involved in the war. A review of the casuistry showed that among 28 trepanned soldiers 24 died (86%). Only four trephined soldiers operated on by English surgeons survived and the results of the French surgeons were constantly unsuccessful. During this time it was suggested that the trephining could be only an additional complication to the original injury without any probable advantage. Therefore, some authors compared the results of the different types of treatment with the aim to isolate the trepanation as a risk factor. S.W. Goss found a crude mortality of 60.62% in 160 cases where trephine was used but 5.07% lesser when the fragments of the fractured skull were elevated or removed without boring the skull, that is, using elevators, saws or forceps. The conservative treatment had an ominous prognosis, with a success ratio of 25.26% of the cases.

The American Civil War or Secession War between the Northern and Southern States devastated the United States between years 1861 and 1865. It was probably the first conflict with a large amount of medical information.

The general situation of healthcare in the union and confederate armies was well described by Howard H. Kaufman, a neurosurgeon from West Virginia, in an interesting review of this topic that was published in the *Journal of Neurosurgery* [11]. Generally, both sides had a very poor caring capacity and the surgeons of both sides were not trained enough to attend cranial traumas and war wounds on the head. In addition to this, there was a lack of

all kind of antiseptic measures and limitations in the availability of ether, chloroform or morphine. However, a great amount of the interventions were carried out with general anaesthesia. Military surgeons of both sides published manuals on surgical techniques. The surgeons had the trepanation kits described above. The result was a very high global mortality of 27.3% of those wounded in the Yankee side and of 37.3% in the Southern faction and 3.75% and 4.17% of those ill but not wounded in each side, respectively.

Soon after the American Civil War started the General Surgeon of the United States, Joseph K. Barnes (1817–1883), established some instructions to write detailed registers or medical and surgical records of the injured soldiers [12]. They included the information about not only the army of the United States but also soldiers of the confederate army, as well as about civilians who served the army. They separated the unionist white soldiers from the coloured ones. They also created a remarkable collection of relevant anatomical pieces from surgeries and necropsies (Fig. 18.2). The specimens were asked to regiment and hospital surgeons. The data about soldiers who were not attended by hospital doctors were not included, either due to the lack of importance of their wounds or because they had deserted or died before being attended. No files were opened in these cases. The General Surgeon Office used the data of this register soon after the war ended to create an amazing and detailed report entitled '*United States Army Surgeon General. The medical and surgical history of the war of the rebellion (1861–65)*' published in 1870. The report classified and described the type of injuries that were treated and had numerous summaries of clinical cases of each situation included in the classification. Part I of Volume II of such report included the information about head injuries in the chapter '*Wounds and injuries of the head*'. Head injuries were classified in three large groups: those mainly caused by sabres, bayonets and stabs, wounds of miscellaneous causes due to falls and blunt weapons, and last but not least wounds caused by firearms.

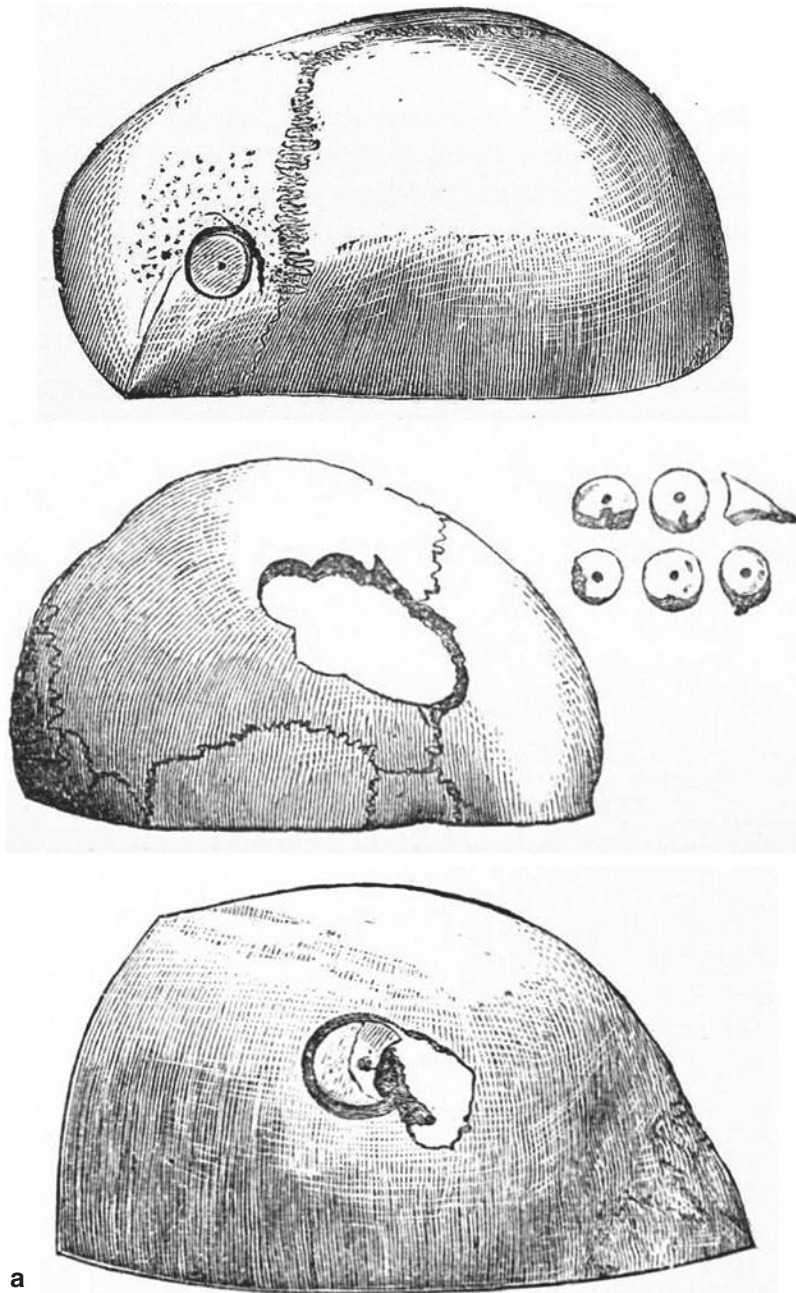


Fig. 18.2 Trepanned skull specimens belonging to soldiers of the American Civil War and collected in the Medical Army Museum. (a) Upper calvaria trephined in the left frontal region for gunshot contusion; centre: section of a cranium, exhibiting five trephine perforations for evacuation of pus, the result of a gunshot contusion of the right parietal; lower: segment of left parietal, from a patient trephined for depressed gunshot fracture.

(b) Upper: section of a skull much shattered by gunshot, and trephined; centre: segment of skull trephined after fracture by a musket ball; lower: section of a skull trephined after a fracture by a shell fragment (US Army Surgeon General. [The medical and surgical history of the war of the rebellion \(1861–65\) \(Volume 2, Part 1\)](#). Washington: Government Printing Office; 1870)

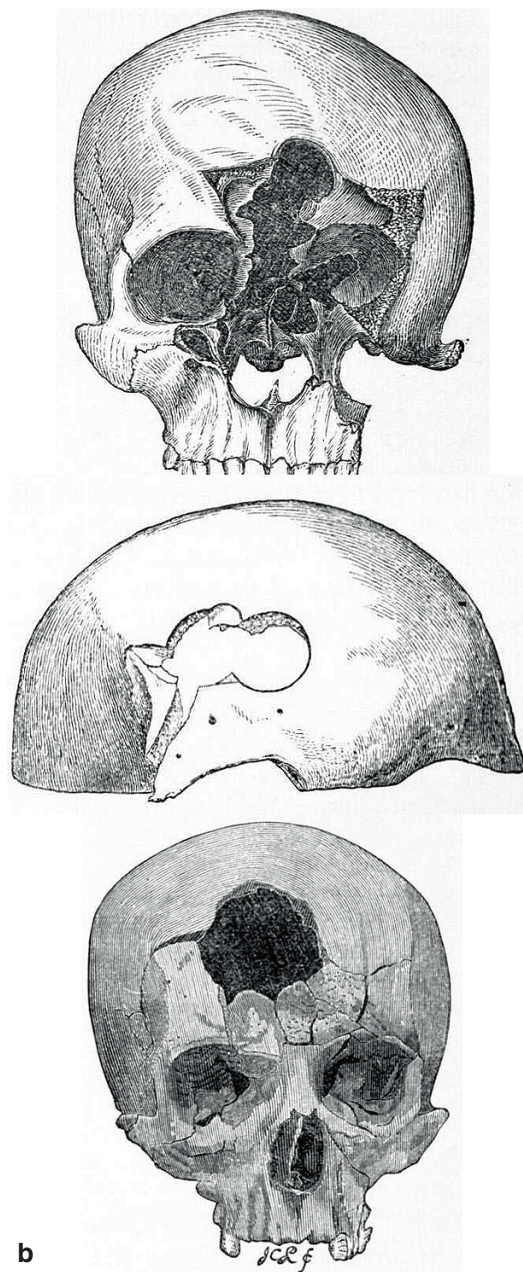


Fig. 18.2 (continued)

In the first chapter of stabbing and puncturing wounds caused by knives 282 soldiers with stabbing wounds on the pericranium were treated as well as 49 stabbing fractures of the skull. Among them, 5 surgical removals of the fragments and 3 trephinations were carried out, as well as 3 late revisions. It also included 18 puncturing wounds

on the skull and finally 6 puncturing fractures of the skull. The report stated that the number of cranial wounds was undervalued as there were more wounds involving the head than those 21,444 stabbing wounds that were attended. The scarce number of puncturing wounds that pierced the skull was attributed to the type of weapons as

the bayonets, lances and rapiers or swords were barely used. In any case, when they were used they aimed at the chest or abdomen of the contrary. However, cranial wounds of this type were fatal and all patients died, except one who became critically disabled.

A total amount of 508 cases were treated due to cranial traumas of different aetiology and made up the second chapter of injuries. It included injuries in soft tissues (with no mortality), injuries with brain affection but without a fracture (with a mortality of 19.4%) and injuries with skull fracture (with a mortality of 55.8%). We must also highlight that the classification system they used initially dichotomised to prove the existence or the absence of a cranial fracture. If there was no fracture, the next dichotomy was the existence or absence of brain affection symptoms, which included neurological signs or symptoms of any type, either mild or severe. A total amount of 26 surgical interventions were carried out in this group of patients. They consisted of fragment removals and trephinations (18 patients) to treat depressed fractures. A total of 14 patients died (53.8%).

The largest group of patients included those with head wounds caused by a firearm, with a total amount of 7739 patients injured by bullets and shrapnel. They were mainly low-speed projectiles. Within this group, 162 deaths (2.09%) were not only due to the wound itself or complications thereof, including infection, haemorrhage, gangrene or tetanus, or complications derived from the treatment in three-quarters of the cases, but also due to breakthrough infectious systemic pathology such as typhus, malaria, dysentery or pneumonia. In the remaining quarter they were due to a mixture of other causes. Even if we admit the relative reliability of the administrative target data and the desertions, 552 soldiers were discharged with disability certificates and the remaining 7055 presumably returned to service (*'probably recovered'*). The general good prognosis can be attributed to the scarce energy of the projectiles that depleted in the soft tissues or bounced off the skull, which worked as an internal helmet in a war where the soldiers did not use any type of external cranial protection.

Among the 2493 cases of soldiers who were treated due to wounds on soft tissues caused by firearms there was a mortality of 4.4%. The primary treatment of the wounds on the pericranium consisted of washing, shaving the hair around the wound, removing foreign bodies, controlling the bleeding and protecting with a drape soaked in cold water. Most of the surgeons brought the margins of the wound closer with elastic bandages in such a way it was not too taut. A few of them used stitches when they aimed a primary wound closure. Otherwise they applied a drape or a waxed cotton gauze and did not bring the margins closer. Blind paths were rinsed with injections and washed to remove foreign bodies, particularly in the paranasal sinuses. They carried out counter-openings when applicable. When the wound swelled up (got infected) they used different treatments, from the simple wash to the use of emollient pastes, or applied drugs. Those wounds that had drained the pus were washed and kept open.

A more serious injury caused by the projectiles of firearms was the contusion of skull bones with bone excoriation but without evident cranial fracture. It generally had a good prognosis but there were cases of severe complications and with all kind of neurological symptoms. The mortality of the group was higher (55 of 328 patients, i.e. 16.8%) and 16 trephinations were carried out with a very high mortality of 14 patients (87.5%). The mean survival was only 3 days after the surgical intervention. Most of the deceased patients had intracranial pus accumulations in different places.

The next severity level in injuries would be the fractures of the outer table, including fractures of frontal and mastoid sinuses, with a total amount of 138 cases and 12 deaths (8.7%). 20 fractures of the internal table were described without a fracture of the outer table. They could only be diagnosed after the trepanation or the necropsy. All these patients except one died of infections. Four of them underwent trepanation without success. Linear fractures of both tables were described in 19 cases, 7 of which died (36.8%).

Most cranial injuries caused by firearms were different types of fractures of both tables. They

included both simple linear fracture of both cranial tables and those cases with cranial fragments and projectiles lodged in the brain. The total amount of these injuries included 2911 cases of non-depressed cranial fractures with a mortality of 62.7%, 364 depressed fractures with a mortality of 35.4%, 486 penetrating cranial fractures with a mortality of 82.7%, 73 penetrating fractures with a mortality of 76.7% and finally 9 bursts with a mortality of 100%. A total amount of 385 cases underwent a surgical treatment to remove the skull fragments with a '*mortality rate of 37.6% only*'. Many patients also underwent trephination. Among 180 trephines carried out to treat cranial fractures caused by a firearm there were 96 deaths (53.3%). A 32.7% of those who underwent surgery survived with different degrees of disability. They were relieved of their duties and only four remained active in the Veteran Reserve Corps. Only 15 trephined soldiers (8.3%) were capable of resuming active service and other 6 were exchanged or judged.

Finally, 51 cases of brain herniation were described with a mortality of 86.3% in patients, many of which underwent fragment removal or trephination. Repairing the osseous defect was not considered in any case. They pointed out that, in those cases with a favourable prognosis, the cranial defect made by the trephine was filled at the end of the cicatrisation process with fibrous tissue and no bone callus was formed. Some physicians recommended protecting outwardly the osseous defect with metal sheets or leather discs. A suggested alternative to promote bone callus formation was to keep the denuded periosteum when the trephination was carried out and spread it over the dura mater.

Among those patients who were attended due to any of these injuries, 900 cases underwent surgery. Projectiles were removed in 175 cases (with a mortality of 48.3%), 33 vessel ligations were carried out due to haemorrhage (with a mortality of 36.3%), bone fragment removals or fracture lifting were carried out in 220 cases (with a mortality of 39%), 29 interventions were carried out to treat brain herniation (with a mortality of 75.8%), and finally 220 conventional trephinations were carried out (with a mortality of 56.6%).

The general principles of the indication of surgical treatment for war cranial fractures were the following. Primary treatment was justified for cranial wounds with cranial fractures with depressed fragments. In these cases, the fragments that compressed the brain were removed with a pair of strong forceps. A second indication was a wound with foreign bodies, such as tissue or projectiles, that had invaded the brain. In this case, if the fragments were found near the entry hole after carefully exploring the wound with a catheter they recommended removing them through the hole (which could also be enlarged). The third indication of primary surgery was in those cases without a wound on the skull but that showed brain compression symptoms, particularly if they were gradual. They considered that it would be very probable to find an epidural haematoma due to the rupture of the meningeal arteries. The drilling method used by military surgeons was the trephine with circular crown and T-handle with variable size and central pin. The trephine was applied once or several times in adjacent points or overlapping them until achieving a cranial opening with the appropriate size. The dura mater was still the most important anatomical barrier. However, many cases of removal of bone fragments and projectiles lodged in the brain were described. Some of them even survived. Many interventions were carried out at an intermediate stage of the patient's evolution before the wound had healed, particularly to debride the wounds, to treat complex injuries or due to the bad evolution. Finally, some interventions were carried out at a later stage, such as those for brain herniations.

Although written decades before, the book by Charles Bell (1774–1842) shows in some beautifully and dramatic pictures the most frequent traumatic injuries in war times [13]. The work is a publication with 19 plates on various surgical procedures, without text, of which the first four refer to instruments and technique of trepanation (Fig. 18.3). In *plate 1* the trepanning instruments are represented: Fig. 1: Trephine of crown with handle in T and pyramid of adjustable length. Fig. 2: Hey's cranial bone saw. Fig. 3: Drilling tip. Fig. 4: Instrument, apparently to remove the

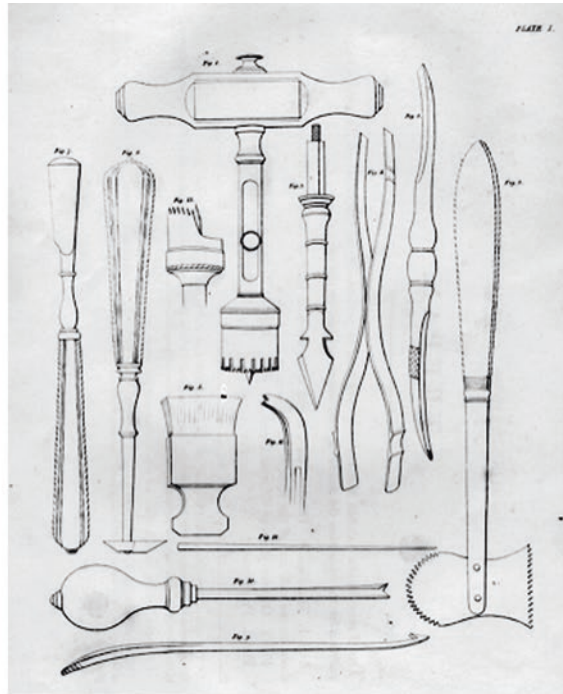


Fig. 18.3 Instruments for trephine by Charles Bell and some pictures with patients with head injuries (Bell C. Illustrations of the great operations of surgery. Trepan, hernia, amputation, aneurysm and lithotomy. London: Longman, Hurst, Rees, Orme and Brown; 1821)



Fig. 18.3 (continued)

bone disc. Fig. 5: Brush. Figs. 6–10: Different rugines, elevators and chisels. Fig. 11: Instrument, apparently pincer tip. Fig. 12: Probe. And finally Fig. 13: Partial-cut trephine crown. *Plate II* presents an African-looking patient undergoing trepanation, apparently in a case of trauma with a

depressed fracture. The cranial wound has been enlarged in cross, the fragments have been removed and trepanation with a trephine crown has been practiced. The dura mater appears intact. Below are drawn several bone discs obtained after trephining and on a sheet of paper the frac-

ture and the placement of the trephine are drawn, with the point of application of the central pin (D). *Plate III* shows a dry skull with several fractures and trepanations. Finally, *plate IV* presents a patient with a moribund or perhaps dead appearance, with a frontal brain hernia after the removal of the fragments of a compound frontal fracture. The fragments of the bone are seen in the bed, next to bandages. The incision is surgical, with its typical cross shape.

The instruments for trepanation in war hospitals were stored in cases and their composition was regulated by the medical services of the armies. The trepanation sets started being manufactured in Europe at the beginning of the seventeenth century. They were exported worldwide and later they started being manufactured in the United States. The American Civil War triggered the mass production of instrument cases for general surgery, amputation and trepanation by the surgical instrument manufacturing companies in the United States, particularly those made by George Tiemann and Co. and Wade & Ford. The cases contained the instruments included in the lists that eminent surgeons had written for particular surgical interventions in the battlefield. The aim was to compile all instruments that would predictably be necessary for an urgent surgery in a single case and that such case would be compact and light enough to be easily carried from one place to another. The purpose of these kits, rather than containing all what could be found in hospitals or was used by regiment surgeons, was to forget the need of carrying several instrument cases when only a few are required.

The US Army and Navy ordered about 4900 surgical instrument sets for the Civil War to manufacturers placed in New York (Tiemann, Hernstein) or Philadelphia (Kolbe', Kern, Gemrig). Many others were confiscated, particularly 1150 trepanation cases. The surgeons hired for the war carried their own instrument sets at the beginning. A circular letter from the Surgeons General's Office described the composition of the instrument cases depending on the healthcare level in 1863. The instrument cases for major surgical interventions in hospitals included a trun-

cated cone-shaped trephine and a small crown trephine, both mounted on T-handles. However, those sets for minor surgery or pocket cases did not include trephines. Field instrument cases of the regiment surgeons included a truncated cone-shaped trephine. The medical departments of the army of the confederate states used similar available cases and others that were imported from Europe after evading the naval blockade to which they were subjected.

18.3 Illustrative Cases

In this section we describe and discuss three cases of battlefield injuries treated with trepanation. The first two cases are patients operated on by Larrey and included in his book '*Clinique Chirurgicale, exercée particulièrement dans les camps et les hôpitaux militaires depuis 1792 jusqu'en 1829*'. He described them along with a series of cases to show the need of using the trepan for depressed cranial fractures with injury or depression of the dura mater (case I) and open cranial fractures (case VII), this case with a more complex clinical evolution.

The third case in one selected among the countless cases described in the book '*The medical and surgical history of the war of the rebellion (1861-65)*' was directed by the Surgeon General Barnes and published in 1870. This work includes thousands of cases. Some of them were briefly described and others were explained in detail. Some cases, such as the one we are presenting, included many details about the clinical evolution, the intervention carried out, the evolution and the findings of the necropsy. It is amazing that among those case reports we can find the one that starts as follows: '*CASE.—L.—, aged 56 years, was shot in the head, at Washington, in the evening of April 14th, 1865, by a large round ball, from a Derringer pistol, in the hands of an assassin*'. The case corresponds to Abraham Lincoln (1809-1865), who was murdered on the 15th of April of 1865. He was shot at point-blank range on the occipital region. He died some hours later without undergoing any surgical treatment. A detailed report about his clinical evolution,

treatment and necropsy is portrayed. It was included just like any other anonymous case among the thousands that were described in a more or less detailed way in the report. This proves the exhaustive data collection and the unaltered statistical processing of the information. The physicians involved in his treatment examined Lincoln's wound with a probe. Considering the patient's condition and the depth of the wound they decided to keep the wound open so that it spontaneously drained the blood. This was facilitated by manually cleaning the wound and removing some bone fragments with the fingers. The president was attended at a guest house in front of the theatre where he was shot. The autopsy showed that bullet was lodged very deep inside the brain, particularly in the frontal lobe near the corpus callosum.

18.3.1 Open Fracture Caused by a Firearm, Epidural Haematoma and Bone Fragment Removal

Larrey pointed out that the patient AP was a rifleman-grenadier who was shot on the right temporal region during the campaign in Austria. The patient showed *'les accidents de la commotion et de la compression'* at the same time. They were so severe that his life was at risk. Larrey debrided the wound, ligated the bleeding pericranial arteries, exposed the skull and found a fragment of the bullet that detached by itself. He lifted a large bone fragment with the lifter and felt that he was a lucky man after finding a second fragment of the bullet that was squashed between the dura mater and the skull. In that moment a great amount of black blood was spontaneously evacuated thanks to what he called a *'trépan accidentel'* and all the symptoms improved and gradually faded. The patient completely healed after 55 days. The scar was depressed and the brain pulsations could be noticed.

It was a case of open cranial fracture caused by the projectile of a low-speed firearm. It produced an acute epidural haematoma that caused

loss of consciousness and focal neurological symptoms. The quick examination of the wound and the lifting of the fracture in search of the projectile fragments allowed an accidental evacuation of a non-suspected acute epidural haematoma. This saved the soldier's life. The line of action was flawless, considering the diagnostic possibilities of that time.

18.3.2 Open Fracture Caused by a Direct Trauma, Epidural Haematoma and Trepanation

Larrey presented the case of JB, a 32-year-old male who was a soldier of the first Swiss Regiment of the Royal Guard. He was attended the morning of the 22nd of January of 1826. His condition was critical when he arrived (*'fut apporté presque mort à l'hôpital de la garde'*) and he showed a blunt trauma on the left side of the head with a complex fracture of the skull and plunged fragments caused after falling or being hit with a blunt object. The detailed neurological examination was as follows: *'Ce militaire avait entièrement perdu l'usage des sens et de l'intellect; tout le côté droit était frappé de paralysie, et il y avait des mouvements fréquents et désordonnés aux deux membres correspondants à la blessure. La commissure des lèvres de ce côté était fortement tirée vers l'oreille; les pupilles étaient très-dilatées, privées de leurs mouvements; la lumière vive ne paraissait point faire la moindre impression sur l'organe de la vue, et le sujet ne pouvait proférer une seule parole. Le pouls, petit et traînant, donnait à peine quarante-cinq à quarante-six pulsations par minute; il y avait eu émission involontaire de l'urine, et effusion de sang par l'oreille du côté blessé: enfin tout annonçait une mort prochaine'* (This soldier had entirely lost the use of the senses and the intellect; the whole of the right side was paralyzed, and there were frequent and disoriented movements in both limbs corresponding to the wound. The commissure of the lips on this side was strongly drawn towards the ear; the pupils were very dilated, deprived of their movements; the bright light did not seem to make the slightest

impression on the organ of sight, and the subject could not utter a single word. The pulse, small and trailing, gave scarcely 45–46 pulsations per minute; there had been involuntary emission of urine, and bloodshed from the ear of the wounded side; in the end everything announced a near death).

The surgical intervention was carried out immediately. After shaving the skull, a cross-shaped incision was made and the skull was denuded about an inch around the fracture. The pericranium and the '*muscle crotaphite*' (temporal muscle) were cut in a circular shape and removed until reaching the skull and ligating the bleeding arteries. As a lifter could not be used to lift the fragments a trephination ('*trépan*') was carried out in the most declining area of the fracture. When they lifted the bone disc a lot of blood exited. They collected two ounces (1 ounce = 28.4 cc) of blood that was partially coagulated, evidencing the active bleeding of the meningeal artery. Once the epidural blood was drained, they observed that the dura mater was depressed and did not transmit the brain pulsations. Although they considered opening the dura mater they rejected doing it due to the serious complications that the procedure could involve. Therefore, they proceeded with coagulating by cauterisation of the bleeding meningeal points with an incandescent iron stylet. They applied the usual dressings, filling the osseous defect. A Galen's bandage was applied on the wound.

The patient improved right after the intervention was over as he started moving the right hand and emitting some words. The post-operative evolution was slow but the accepted medical treatment was constantly applied, from ice on the head to bloodlettings and repeatedly washing and cleaning the wound. The patient got out of bed 5 days after. 96 days after the accident and the surgical intervention the wound had completely cicatrised. It showed a central depression where the pulsations of the brain could be noticed.

It was a case of open cranial fracture caused by a direct trauma. It produced an acute epidural haematoma that caused loss of consciousness and focal neurological symptoms. He was a critical patient when he was brought to the hospital with

a clinical situation that would correspond to a score of 5 in the Glasgow Coma Scale (eyes closed: 1, lack of verbal response: 1, uncoordinated spontaneous moves on the left side of the body: 3), which assesses the severity of the cranial trauma, ranked in this particular scale between 3 (the worst) and 15 points (normal). The patient showed dilated non-reactive pupils and a contralateral hemiplegia. Once again, Larrey's quick intervention and his trepanation allowed to evacuate an acute epidural haematoma that saved the soldier's life. The cause of the epidural haematoma due to the rupture of the meningeal artery and its treatment were described clearly and accurately. The line of action was flawless, considering the diagnostic possibilities of that time. The long evolution of the wounds was due to the fact that the surgeons preferred a cicatrization by second intention, avoiding the primary wound closure. The circular resection of soft tissues fell within this category.

18.3.3 Wound Caused by a Firearm, Infection and Trepanation

Samuel Altman, a Private of the A company from the 50th Regiment of Georgia, was injured in the Battle of Antietam on the 17th of September of 1862 by a musket projectile. It left exposed about 2 in. long × about ¾ in. wide of the left frontal bone, with no bone depression or fracture. The patient was admitted at the hospital on the 27th of September. The wound quickly granulated and the patient had a very positive evolution, except for a personality disorder that was attributed to other causes. However, he started showing headache, fever and shivers on the 8th of October. The situation got worse 5 days later as he showed a quick but weak pulse, non-reactive natural pupils and loss of consciousness. The patient was suspected to have an abscess so he was anaesthetised with ether and the frontal bone was trepanned through the wound. The disc of bone was removed and the brain was punctured obtaining 6–7 ounces of a sero-purulent liquid with bone fragments. The liquid came out with so much pressure that it spurted reaching more than 3 ft (about a meter).

The patient improved in all aspects after evacuating the haematoma. His pulse and breathing were better and the wound was closed. However, the patient died that same day. The autopsy showed a necrosis of the internal table and caries of the frontal bone diploe. An abscess with indurated greenish walls was found in the anterior (frontal) lobe of the left-brain hemisphere. It had a diameter of 3 in. and was open to the ventricular system. There was no pus on the surface of the brain and no apparent continuity between the diseased bone and the brain.

This case shows the interest and fear that ancient surgeons had about linear cranial fractures, fractures of the outer table or cranial contusions as they might involve fatal complications. The evolution of this patient was what they aimed to solve scrapping the fracture, as we have previously discussed. It is obvious that the dramatic symptoms of the patient were due to the massive infection with osteitis, cerebral abscess and ventriculitis that could not be solved with the trepanation. The frontal osteitis can be explained by the direct wound infection due to contamination. However, the lack of communication between the osseous infection and the frontal abscess does not exclude retrograde contamination through a thrombophlebitis. An abscess that opens to the ventricular system is today an extremely life-threatening situation, even with an external ventricular drain and systemic or intraventricular antibiotic therapy.

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