Review Article

The early history of military radiology (1896-1916): From Wilhelm Conrad Röntgen to the first world war

Magiorkinis E, Vladimiros L, Diamantis A

Office for the study of the History of Hellenic Naval Medicine, Naval Hospital of Athens, Greece

Abstract: The purpose of our study was to pinpoint the hallmarks of military radiology during the first 20 years after the discovery of x-rays by Wilhelm Conrad Roentgen. X-ray examination became indispensable for the diagnosis and treatments of military wounds. Initially, x-ray apparatus were installed in permanent military hospitals. The evolution of technology and the increasing needs for immediate treatment led to the use of portable x-ray machines in battlefield and temporary military hospitals, as well as in hospital ships. During this period the first important manuals on military radiology will come up such as those of William Borden and Marie Curie. The first twenty years after the discovery of x-rays were the most important part in the establishment of military radiology as a scientific discipline in military medicine.

Keywords: Military radiology, x-rays, surgery, battlefield radiology, history of medicine

The birth of radiology

The 19th century was marked by an impetuous progress in all fields of medicine which was powered mainly by the French medical school, but also the English and German schools as well. Just before the entrance of the 20th century, in 1895, Wilhelm Conrad Röntgen (1845-1923) (Figure 1a), a German physicist and rector of the University of Würzburg, first observed x-rays; he managed to produce and detect electromagnetic radiation in a wavelength range today known as X-rays. The milestone monograph entitled "Über eine neue Art von Strahlen" (On a New Kind of Rays) (Figure 1b) was published on December 28, 1895, fifty days after his initial experiments with this new electromagnetic radiation, an accomplishment which earned him the first Nobel prize in Physics in 1901 [1]. During the same period, military technology evolved rapidly; European armies began to get

Correspondence to: A. Diamantis, MD., PhD., HN. e-mail: aristidis.diamantis@gmail.com
equipped with modern weapons such as Martini-Henry and Mauser, which employed bullets creating small entry wounds and penetrating the human body. Soon after the discovery of X-rays, military surgeons realized the benefits from the use of the new technology as a diagnostic tool especially for soldiers wounded by bullets. In the past, military surgeons could locate bullets or shell fragments by exploratory surgery, a laborious process which was not always successful and most of the times resulted in fatal infection. It was quite clear that X-rays could easily locate bullets or shell fragments embedded in soft tissues [2]. On 4th of February 1896, in the scientific journal Medizinische Wochenschrift it was announced that the Prussian Ministry of War examined the use of X-rays for the examination of ill and wounded soldiers; the next month the Kaiser Academy Guillermo in Berlin was equipped with the first military radiological unit [3]. One month later, German Surgeon General von Scherning and his associate Kransfelder published a paper on the use of X-Rays to detect bullet-wounds [4]. The British Army installed its first equipment of radiology in the Royal Hospital Victory, Netley, November 1896 [5]. In France, Kelsch carried out in 1897 the first systematic radiological examinations of thorax in the Military Hospital Desgenettes, in Lyons [6].

First use of radiology during warfare: the Abyssinian campaign (1895-1896)

The first use of radiology during warfare should be attributed to an Italian Lieutenant Colonel Giuseppe Alvaro, who published in 1896 an article in Giornale Medico del Regio Esercito reporting his experience with the use of x-rays in the identification of bullet wounds in the Italian Campaign against the kingdom of Abyssinia (Campagna d'Africa Orientale) [7]. This campaign was disastrous for Italy, since Italians lost the battle at Adowa on 1st March 1896, and all casualties returned in Italy to base hospitals; Alvaro managed to obtain x-rays in two soldiers with fractures caused by bullets in forearm bones, thousands of kilometers away from the front, in the military hospital of Naples, and more than 2 months after the initial battle. He managed to pinpoint the bullets in the x-rays and mentioned that the new technique "demonstrated to be of much aid in diagnosis, allowing to determine mathematically the location of the foreign bodies" [7].

The birth of battlefield radiology: the application of x-rays at battlefield in the Tirah campaign (1897-1898).

The conflict of the territorial and colonial ambitions of the Russian and British Empire brought both sides close to war. The British Army already had experience with the use of x-ray machines, since the first radiographs were made at the Royal Victoria Hospital at Netley near Southampton in November 1896, whereas x-ray machines were installed in Aldershot, Woolwich, Dublin and Gibraltar in the mid-1898. The 'Expeditory force of Tirah' composed of 8,000 British and 30,000 Hindu soldiers under the command of General Sir William Lockhart and was sent to put down a rebellion to the North West Frontier, at the borders between India and Afghanistan (now part of Pakistan). Since the nearest hospital was in Rawlpindi, 23 field hospitals were founded in the Tirah plateau where 900 wounded soldiers were hospitalized [8]. There, Major Surgeon Walter Beevor examined 200 patients with X-rays and later he did the same in the hospital of Rawlpindi, using a prototype apparatus developed by A E Dean of Hatton Garden, London. This, with its three Cossor x-ray tubes, came in a collection of wooden cases carried, suspended on poles, over the rough terrain by Indian bearers. His problems were associated with batteries and the tendency for the emulsion of his Eastman x-ray papers to melt. Beevor managed to publish his experience with a mobile X-ray unit in the Tirah campaign in 1898 in the Journal of Royal United Service Information (Figure 2) [9]. For the first time, X-rays were used in the battlefield, where equipment was taken on the back of mules and ponies along a 150 km hostile, escarped and dangerous route. Two of the most famous Beevor's patients were General Wodehouse and General Ian Hamilton. The use of X-rays in the Greco-Turkish War of 1897-1898.

X-rays were used as a diagnostic tool also during the Greco-Turkish War of 1897; the English Red Cross Mission financially sup-
ported by an appeal by the Daily Chronicle sent two hospital units to help the Greeks. The expedition was under the command of Sir Francis Abbott (Figure 3), a surgeon from St. Thomas's Hospital in London and the man in charge of radiography was Robert Fox Symons (later Sir Robert). Despite the fact that, in Greece, professor of physics Timoleon Argyropoulos was the first to take x-ray images in 1896, however, those images were not taken for medical purposes [10]; it seems that since the advent of the British expedition, x-rays were not in use in Greece, due to the poor economic situation. Abbott, in his two major papers in Lancet in Jan 14, 1899 and in Jan 21, 1899, referred to the improvements of military surgery during the last European wars, as far as the experience of the damage caused by bullets in living tissues is concerned, as well as the use of antiseptic methods which reduced post-operative morbidity and mortality [11, 12].

The English Red Cross Mission established two temporary base hospitals, one in Phaleron and one in Chalkis. The X-ray apparatus, which was transferred to Greece, was installed in the base hospital of Phaleron; it consisted of three Crooke's tubes, a powerful coil which produced, according to Abbott, a 10 in. spark and two batteries, since electric supply was not available in the base hospital at Phaleron. Batteries were recharged from "H.M.S. Rodney" which moored at the Piraeus port. Instead of glass negatives, Eastman's positive paper was used, while a cupboard in the house of Phaleron was used as a dark room.

Of 153 cases described in Abbott's paper, 114 were bullet and shell wound cases of which 6 finally died (mortality rate 5.26%), 37 cases were complicated fractures. Due to the fact of the absence of antibiotics- penicillin was discovered in 1928 by Sir Alexander Fleming- most of the deaths were due to generalized infection (one death from septic pneumonia, two deaths from emphysematous gangrene and one death by septic embolism). Abbott, in his paper, reported that he was impressed by the good condition of the wounds; he mentioned that in most cases antiseptic bandages were used, in other cases clean bandages, but there were also some cases with uncovered wounds.

As far as the X-rays examination was concerned, one of the major problems during the examination of the wounded, as referred by Dr Abbott, was that the wounded considered the machine as a work of (devil) and continuously crossed themselves during the X-ray examination. X-ray skigrams were particularly useful in the detection of

Figure 2. Francis Charles Abbott, M.S. (Lond.), F.R.C.S. assistant surgeon and teacher of practical surgery in St. Thomas's Hospital; Surgeon to the Evelina Hospital for Sick Children (obtained by St Thomas's Gazette, 1903, vol 13).

Figure 3. X-ray of a soldier's elbow showing an impeded fragment of bullet obtained by W. Beevor [8].
bullets in soft tissues in situ, in the tracking of the course of the bullet through patient's body and in the identification of fractures. The use of X-rays, in most of the cases, was crucial if not life saving; Abbott describes characteristically the case of a bullet wound of the back of the patient's thigh, who had unbearable pain below the head of the fibula. Surgical exploration of the area in the outer side of the leg did not reveal any findings, whereas an X-ray skiagram conducted afterwards revealed a shrapnel ball in the soft tissues on the outer side of the upper part of the popliteal space. In his paper, Abbott illustrated his point by presenting eight characteristic X-ray skiagrams [11, 12].

On the other side, the Yildiz temporary Military Hospital was established in Instanbul in order to hospitalize the increasing casualties of the Turkish Army. Doctor Esad Feyzi was the first to install and operate the Roentgen apparatus, which was transferred from the Medical School to the Yildiz Hospital [13]. The German Red Cross Mission under the command of Dr. Hermann Küttner, a physician from the Tubingen University Hospital, also installed a similar X-ray apparatus in May 1897 and worked with the other Turkish colleagues. Küttner, as Abbott, also published his experience along with several X-ray skiagrams in 1898 [14].

The war at Sudan (1896-1898)

During the British campaign under the command of General Herbert Kitchener against the Madhists in Sudan, the medical department asked for a portable X-ray apparatus to be sent in the expedition. John Battersby was put in charge of the apparatus; he managed to make an accurate diagnosis in 20 out of 21 cases, which could not be diagnosed by conventional surgical approach. In his report, Battersby refers to the adverse climate of Sudan, which made the operation of the device problematic and a soldier using a bicycle generated electricity for the apparatus (Figure 4). He concluded that radiography prevented suffering by unnecessary probing of the wound and in addition to simple radiography, he used the cross-thread localization device of James Mackenzie Davidson [15].

Figure 4. Method of electricity employed by J. Battersby in Sudan War [15].
The use of X-rays during the Spanish-American War (1898)

During the Spanish-American War (1898), X-ray machines were installed in permanent hospitals and, for the first time, in Hospital Ships Relief, Missouri and Bay State; however, it should be noted that the first ship to be equipped with radiological unit was the Russian Aurora [16]. In 1898, American General Sternberg will publish a treatise relating his experience on the use of radiology in wartime. In 1900, Captain William C. Borden will publish his monumental monograph The Use of the Röntgen Ray by the Medical Department of the United States Army in the War With Spain, in which he summarizes his experience of the US Medical Corps on the use of x-rays. Borden was the first to set two crucial questions regarding the use of x-rays during military operations: which X-ray machine would be suitable under military conditions and which localization method most precisely located embedded bullets. The most important part of his book is the clinical cases included along with radiograms. Borden also refers to the harmful effect of x-rays presenting the first two cases of X-ray burns in military radiography, concluding that exposure time and proximity of the cathode tube to the body surface are the most important factors in the process (Figure 5). Borden also suggests a series of ‘guidelines’ for the operation of x-ray apparatus, according to which exposure should never exceed 30 min and the X-ray tube should never be closer than 25 cm [16, 17].

In 1900, Nicholas Senn, surgeon of the Relief hospital ship, will also publish his experience with the use of x-rays during the Spanish-American War suggesting that the Medical Corps should be supplied with portable X-ray apparatus [18].

The Second Boers (Afrikaaners) War

During the Boer War (1899-1901), 150,000 British soldiers were employed during the operations of which 6,000 were killed and 16,000 died of diseases, whereas Boers, who were defeated, lost 5,000 men. Medical facilities were organized in general hospitals and field hospitals, whereas X-ray apparatus were supplied in general hospitals as essential equipment for the campaign. During the siege of the city of Ladysmith, Lieutenant Forbes Bruce will operate a mobile x-ray apparatus for diagnostic purposes, improving significantly the electric-supply of the apparatus [19, 20].

Towards the first world war: the period 1900-1914

In Germany, all military hospitals were equipped with a radiological apparatus, whereas medical field services were provided with mobile instruments [3]. During the Russo-Japanese War (1904-1905), Japanese employed German equipment to carry x-ray examinations, which were reported by the French doctor Major Matignon [21]. In Greece, although the British expedition proved the utility of the x-rays machine, x-rays were not in use in the Greek Army. During the First Balkan War of 1912-1913, no radiology facilities were established in the city of Thessaloniki [22].

The First World War (1914-1918)

At the beginning of the war, all major hospitals behind the front were equipped with X-ray apparatus [23]. As the war progressed, the need for mobile equipment urged and, for that reason, Marie Curie (1867-1934) (Figure 6) developed a x-ray car (voiture radiologique) and equipped 18 cars for the French Army, whereas electricity for the operation of the apparatus was provided by
the engines of the car; Marie Curie also established more than two hundred radiological units [24]. The increasing need for technicians and radiologists led the French radiologist Antoine Béclère (1856-1939), (Figure 7) to open a school for X-ray technicians at Val-de-Grâce hospital in Paris. Marie Curie along with her daughter Irene Joliot-Curie (1897 - 1956) opened and operated a school for female x-ray technicians (manipulatrices) in 1916 (Figure 8) [25]. According to the authors the invalid "Madame Curie", probably, was the first x-ray technician in the history of Military Medicine. X-
ray examination, during WW I, become indispensable part of surgical examination of war wounds and surgeons become accustomed with the idea of working in a team with radiologists; it is not an overstatement to say that WW I established military radiology as an important discipline in military medicine. Marie Curie, after the end of World War I, in 1921 published her experience in her monumental monograph La radiologie et la guerre (Figure 9) [25].

References
