

Stop the Bleeding: Wartime Orthopaedic Advances

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Abstract

Every medical specialty has its own unique story demarcating imperative historic events that enabled major advancements in care. For orthopaedics, the major catalyst for advancements resulted from experiences during wartime. Early during WWI, gunshot wounds that caused femoral fractures were among the most fatal injuries of war, as poor immobilization and wound irrigation contributed to eventual shock, gas gangrene and secondary hemorrhage. It was not until late in the War that the Thomas splint with traction became routine for transport and the British mortality for gunshot femoral fractures fell from 80% to 15.6%.

Prior to WWII, contaminated wounds were managed with delayed primary closure, which required the examination of culture or smear to determine if wound closure was desirable. This technique, however, dramatically changed during WWII whereby clinical appearance alone became a main criterion for the appropriateness of wound closure and is still considered today as a major advancement in wound care. Advancements in antibiotics, in particular penicillin, led to a decreased rate of infection and consequently mortality rates associated with extremity wounds were documented in WWII in comparison to WWI.

Dr. Kuntschner, a German surgeon, pioneered a huge advancement in the treatment of fracture care in the 1940s. He developed the use of intramedullary nails for long bone fractures, and this technique made tremendous difference in the speed of recovery of injured soldiers and has continued to evolve as the standard method of treatment of femoral and tibial fractures. The development of hand surgery as a specialty even has ties with WWII. At that time, hand centers were established, due to the large casualty load, and many surgical techniques used today were refined or invented there. In the end, it was the great tragedy of war, with its many casualties, that facilitated the growth of the orthopaedic specialty.

Introduction

Orthopaedics was initially founded because of necessity in the population: There was a need to correct childhood deformities, a need to restore function to an injured limb, a need to alleviate pain, and a need to prevent wound infection, sepsis and ultimately death. Orthopaedics, like many other specialties, has its own unique story demarcating imperative historical events that enabled major advancements in care.

Orthopaedics did not become an operative specialty, however, until after the advent of the three "big guns:" anesthesia in 1846, asepsis in 1867, and X-rays in 1895

(Rang, 2000). It was only then, at the turn of the century, that Orthopaedic surgery began to grow as an individual specialty with new institutions and associations being founded, especially with other fields of trauma surgery. At this time, arguably one of the most significant figures in the orthopaedic field was Sir Robert Jones (1857-1933), nephew of the infamous British surgeon Hugh Owen Thomas (1834-1891). Jones built up a system of organization for the care of orthopaedic patients. He published an invaluable textbook on injuries to joints in 1916 and, averaging four literary papers per year on every aspect of Orthopaedics, it has been said that Robert Jones made Orthopaedics a specialty. In addition to this, Jones also founded the British Orthopaedic Association in 1918.

Education on the history of medical techniques enables one to appreciate the past labour and dedication contributed to the respective medical field. More importantly, though, it highlights past misconceptions and mistakes made and the reasons for their failure. History thus becomes the applied field for evidence-based behaviour. It is through wrong direction in treatment that a new treatment must be sought. It is only then that we can build upon this platform of care to perfect it with advancing technology. For Orthopaedics, the major catalyst for advancements in care resulted from experiences during wartime. Many of the greatest contributors to this field were military surgeons. Despite the fact that orthopaedic advances undoubtedly occurred during most wars throughout history, this paper will only focus on advances resulting from World Wars I and II.

World War I (1914-1918)

The physical environment of World War I strongly challenged the earlier progress made in wound healing (Noe, 2006): Injured soldiers often suffered from contaminated wounds and were faced with severe delays in evacuation from the bunkers and positions of trench warfare (Kirkup, 2003). At aid posts, morphine was given and field dressings, usually contaminated, were changed. Advanced or main dressing stations gave *tetanus toxoid*, reviewed dressings and splintage and arranged wheeled evacuation. At the casualty clearing station, out of shooting range, operative care was initiated under general anesthesia.

Most surgeons at the beginning of the war generally accepted the importance of wound irrigation. However, the choice of antiseptics changed dramatically over the course of the war. During the early stages of war, most surgeons felt that since iodine solution was used prior to scheduled surgical procedures, and then it would suffice as a primary wound disinfectant (LeVay, 1990). Others believed in the use of mercury chloride, carbolic acid, and even the use of pure phenol to rid poison from the wound. Phenol was later abandoned following very unfavorable outcomes, but the idea of chemical antiseptics remained strong. Surgeons' faith in the effectiveness of antiseptics was so great that they sutured less extensive wounds and amputations but, unfortunately, most arrived at the hospital bases in terrible states with sepsis, gangrene or tetanus. By 1915, there was a change in attitude toward the early management of wounds, pioneered by Edward Milligan. He noted that cleaning of wounds with antiseptics was ineffective if any infective material was inseparably attached to devitalized tissue, as this acted as a culture medium. Thus, he proposed that it was necessary to excise the skin wound completely, along with any damaged muscle, foreign bodies and dead matter, so as to provide ample exposure and drainage for proper healing. With favorable results to

back his claims, sterilization via wound excision (*i.e.* debridement) was founded. Early excision quickly became the new alternative to the previous simple incision and drainage, and before long it became regular practice as it was found to be the most effective method of preventing gas gangrene.

There were those, however, who would not give up on the idea of primary wound irrigation. Sir Almroth Edward Wright's (1861-1947) method was based on the idea of "physiological" irrigation with 5% saline and 0.5% sodium citrate, in essence "to draw out bad lymph and replace it with good" (Wright, 1915; LeVay, 1990). He believed this hypertonic solution would have an osmotic effect that stimulated lymph flow and phagocytosis to control sepsis from within. This method was popular among British surgeons but was later abandoned in 1915 when the era of Carrel-Dakin (Alexis Carrel, 1873-1944, from France and Henry Drysdale Dakin, 1880-1952, from England) hypochlorite irrigation became popularized. It was really a solvent rather than an antiseptic, which dissolved and degraded organic debris into nontoxic products upon interaction with pus and tissues. The use of this solution was responsible for a dramatic reduction in the number of amputations as well as mortality (Cooter, 1993). As for the suitability of secondary suture, Carrel only deemed closure safe when bacterial counts of wounds were below a stringent threshold. Primary closure was nearly always disastrous and was eventually forbidden. Secondary closure was the rule if possible. However, at a Surgical Conference in Paris in 1917, it was stated that when a wound had been properly prepared via excision and foreign bodies removed, primary suture might give good results (Duval, 1917). But primary suture was not to be performed unless the wound was recent, at most eight hours standing, and only when the surgeon had the means of direct observation of the patient for 15 days. Before long, under good aseptic conditions and after excision of damaged tissues and removal of foreign bodies, good results were reported with primary closure, some as high as 88% success rate (LeVay, 1990).

Early during war, aside from difficulties attaining aseptic techniques, gunshot wounds that caused femoral fractures were a major problem. They were among the most fatal injuries, as the wounded developed shock, gas gangrene, and secondary hemorrhage (Kirkup, 2003). One of the main underlying reasons for the high fatality rate was poor immobilization of the injured site during transport to the casualty clearing station. The Liston's wooden side splint was the favoured immobilization device used by the British early during the war mainly because it was well-known at that time, as it had been used for over a century, but also because it was promptly fitted to the injured limb and trunk. Unfortunately, this device covered open wounds and was poor in providing support to immobilize the fracture. The splint of Robert Liston (1794-1847) was later modified by American surgeons; better wound access was made possible by replacing a portion of the splint with a metal bar, which coincided with the wound site, and additional support was addressed by the use of a groin strap and foot piece. Despite these efforts, effective traction was still poor. In 1915, Sir Robert Jones proposed that the Thomas knee splint was a viable alternative, over less effective splints, for transporting those with femoral fractures. Hugh Owen Thomas initially designed the splint in the 1870s for patients with knee conditions, mainly caused by tuberculosis. His design, with the ovoid ring opposed to the ischium, enabled the body weight of those crippled to be transferred through the caliper side-bars to a shoe extension pattern, thereby bypassing the injured knee. This design shed light on a major breakthrough in the management of fractured femurs. With the injured victim in the supine position, the Thomas splint, along with boot traction, provided excellent immobilization of the fracture site by being firmly extended

against resistance of the ischium. In fact, it has been reported that when the Thomas splint with traction became routine for transport, the British mortality for gunshot femoral fractures fell from 80% to 15.6% (Jones, 1925; Sinclair, 1927). Most of those deaths occurred during transport to casualty clearing stations and, unfortunately, it was not until late in the war that the Thomas splint was routinely used for transport.

Another important discovery to arise from World War I was the realization that rehabilitation was imperative for full recovery. Surgeons began to realize for the first time that their work did not end with a healed wound. Sir Robert Jones strongly believed in this theory and, in 1915, he set up several special facilities, focusing on rehabilitation for orthopaedic patients (Hagy, 2004). By 1918, twenty special *Military Orthopaedic Centers* had been established in Britain under Jones's direction, requiring an excess of 20,000 beds (Cooter, 1993).

World War II (1939-1945)

The knowledge gained in treating fallen soldiers in World War I undoubtedly improved the quality of care that could later be offered during World War II. Just prior to World War II, blood transfusions were a routine hospital procedure as blood banks were finally established (Klenerman, 2002). Nevertheless, since the conditions of this war were very different and weapons far more destructive than previous wars, some of the lessons previously established had to be relearned or modified (LeVay, 1990). For instance, after primary suture had been associated with positive results at the end of World War I, younger generations of surgeons were ignorant to the remarkable contributions made in this area of medicine and, once again, primary suture was deemed far too risky to be attempted. As the war continued however, so did advancements in contaminated wound management, antibiotics, and fracture care. Hand surgery as a specialty even evolved from World War II.

Contaminated wounds prior to World War II were managed usually with secondary closure or delayed primary closure, which required the examination of culture or smear to determine if wound closure was desirable (Pool *et al.*, 1919). This technique, however, dramatically changed during World War II, whereby clinical appearance alone became a main criterion for the appropriateness of wound closure. Promising results were reported with over 2000 patients using this technique, which involved assessing for foreign material, erythema, drainage, and healthy appearing tissue, to decide if closure was appropriate (Cleveland and Grove, 1945). Wound treatment was increasingly influenced by the Trueta closed plaster method. Unsplit and unpadding plaster was applied over an unexcised wound, which provided much needed support during transport back to the base. This technique was often used in combination with topical sulfa antibiotic preparation powder in an attempt to prevent infection. As the war proceeded, it became apparent that quicker recovery could be obtained with early closure rather than persisting with closed plaster as the definite treatment. Furthermore, early observation by surgeons found that the dusting technique with sulfa antibiotics did not prevent infection of open wounds and was no substitute to early surgical care (DeBakey, 1947). Ultimately, with the advent of penicillin, great strides were made with respect to prevention of infections. It was noted that, during World War II, penicillin was a major factor in the prevention of massive infections that plagued those wounded in World War I (Fisher *et al.*, 1944).

In the 1940s, Dr. Gerhard Kuntscher (1900-1972), a German surgeon, pioneered a huge advancement in the treatment of fracture care. Early during World War II, Kuntscher recognized the importance of axial forces in long bone healing. Thus, he proposed to pass a long solid nail through the medullary cavity (the "*Marknagelung*") for proper fixation and, in doing so, convert all stresses into axial ones (Kuntscher, 1965). The nail was moderately flexible and introduced blindly over a guide under X-ray screening. Germans used this technique widely during World War II (especially at the Eastern Front, where Kuntscher served as an officer in the army medical service), it had become apparent that it could make a tremendous difference in the speed of recovery of injured soldiers with little specialized care needed (Rang, 2000). Widespread knowledge of this nailing method was not until after World War II, at which point many surgeons modified their own technique.

In the United States, the founding of hand surgery as a specialty was spearheaded by the hard work and dedication of Dr. Sterling Bunnell (1882-1957) during and immediately following World War II. As the Civilian Consultant for Hand Surgery to the Secretary of War, he was specific about the proper treatment of hand injuries and who were qualified to treat them (Newmeyer, 2003). Nine hand centers were established in the United States during the war to accommodate the large number of casualties. Bunnell was responsible for attaining qualified personnel to staff these centers. This included finding a skilled chief surgeon who had a deep desire for this area of medicine, along with being clever and creative. In addition, the chief surgeon was required to have had a plastic, orthopaedic, or neurosurgical background. Bunnell then spent about a month at each center providing an intensive educational training program, including academic teaching as well as clinical and surgical training. The academic training including lecturing on various topics such as features of the normal hand, proper hand examination techniques, different principles of reconstruction, and mechanisms of injuries to joints, bones, tendons, and nerves. Clinical experience was acquired through examination of approximately sixty patients with specific recommendations made by Bunnell regarding treatment. Finally, surgery was performed on numerous patients by the surgeon on service with the assistance of Bunnell. The large casualty load resulting from the war provided intense clinical and surgical experience to the surgeons at these hand centers. Interestingly, all of the chief surgeons from these centers became founding members of the *American Society for Surgery of the Hand*. Numerous techniques were in fact either invented or refined at the nine hand centers, many of which were documented and later published (Bunnell, 1955). The text actually became a classic in the field of hand surgery, as it describes the surgical technique for nearly every general method used in hand surgery today (Dougherty, 2004).

Conclusion

It is clear that many developments in orthopaedic surgery resulted from the ample experiences that surgeons faced during wartime. In fact, approximately sixty-five percent of all casualties of war involved impairment of locomotor functions, mainly as a result of fractures caused by bullets and shrapnel (Cooter, 1993). In essence, war represented an epidemic of orthopaedic traumatology and, consequently, it was the great tragedy of war, with its many casualties, that facilitated the growth of the orthopaedic specialty. World War I saw much advancement made in the field of orthopaedics including, but not limited to, improvements in wound management with irrigation and debridement, traction and effective immobilization of femoral fractures, and

the importance of rehabilitation. World War II also saw much advancement in contaminated wound management, whereby clinical appearance alone became a main criterion for the appropriateness of wound closure and the use of antibiotics dramatically decreased mortality. A major advancement in fracture care was also dramatic with the use of intramedullary nails for long bone fractures. In addition, hand surgery as a specialty even evolved from World War II. The history of medicine reveals the importance of creativity and the necessity for solutions to disease complications. It is imperative that we build upon the knowledge acquired in the past, as this will allow improvement in the future. In the end, the most optimal care can be offered to the patient.

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