

## **Management of Wounds Sustained by British Forces on the Western Front, 1914-18**

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### **Abstract**

This paper uses relevant primary and secondary sources to present the most important surgical advances which saved lives and limbs during the First World War. The first such advance was wound excision, the complete resection of devitalised and contaminated tissue, a procedure which had to be performed early before potentially lethal organisms had the chance to become established. Inappropriate over-reliance on antiseptics during the opening months of the conflict, coupled with delayed operative intervention, had resulted in many avoidable deaths from aerobic and anaerobic infections. Management of chest wounds was transformed when unsubstantiated fears about thoracotomy were dispelled and excision of such wounds became standard practice. Urgent laparotomy for penetrating abdominal wounds spared many an early death from blood loss or a later one from peritonitis. Effective resuscitation including blood transfusion and a better understanding of anaesthesia in severely compromised patients significantly improved chances of survival.

### **Keywords**

Wound excision, Penetrating wounds of the chest, Penetrating wounds of the abdomen, Resuscitation, Blood transfusion, Anaesthesia

### **Introduction**

During the First World War in France and Flanders 1,988,969 battle casualties were treated in total of which 151,356 died. Numbers treated in all other theatres between

1914 and 1918 totalled 178,779 with 13,503 deaths.<sup>1</sup> Armies in France and Flanders kept trustworthy records but data collection from distant theatres was unreliable.<sup>2</sup> Consequently surgical advances in France and Flanders had the greatest impact and dominated medical literature. In 1914, medical officers were influenced by experience gained during the South African War of 1899-1902 (hereafter referred to as 'Boer War') and surgical practice in the opening months of the First World War bore striking similarities to methods employed in South Africa.

### **The Boer War lays the foundation for surgical practice in 1914**

The Boer War was fought in dry grasslands of the Transvaal and Orange Free State, where most wounds were caused by small-bore conical lead bullets with a steel or copper jacket fired by Boer marksmen from long range. Few were caused by shellfire. Surgeon General Stevenson (1844-1922) noted that the ratio of soldiers killed outright to being wounded in the field was 1:3.5 for officers and 1:3.9 for men. Only 8.7 per cent of those wounded died in hospital, less than any previous conflict other than the Spanish-American War (1898). He observed a low suppuration rate of 20 per cent and attributed this to antiseptic dressings, declaring that unless antiseptic cleansing of the wound and of the skin around it was possible from the first, suppuration was certain to occur.<sup>3</sup> Stevenson emphasised that antiseptic dressings prevented infecting organisms gaining access to sterile wounds.<sup>4</sup>

### **Management of penetrating abdominal wounds in the Boer War**

In the months leading up to the Boer War, many surgeons believed that penetrating abdominal wounds should be treated by laparotomy on suspicion of intestinal damage.<sup>5</sup> A handful of clinicians including Frederick Treves (1853-1923) performed abdominal procedures in South Africa.<sup>6</sup> Most undergoing laparotomy died because conditions in the field made success well-nigh impossible. Furthermore, during busy times, four medical officers working in a field hospital might have to deal with a hundred casualties and the performance of an abdominal operation could involve three, leaving the fourth to deal with all other wounds. In such circumstances, the greatest good had to be done for the greatest number.<sup>7</sup>

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<sup>1</sup> Mitchell TJ, Smith GM. *History of the Great War based on official documents. Medical Services, Casualties and Medical Statistics of the Great War*. London: HMSO; 1931.

<sup>2</sup> Mitchell, Smith. *History of the Great War*, 1931 (Note 1). xi.

<sup>3</sup> Stevenson WF. Notes on Surgical Experience of the Boer War. *Journal of the Royal Army Medical Corps*. 1903; 1(2): 83-91.

<sup>4</sup> Stevenson WF. *Wounds in War: The Mechanism of their Production and Treatment*, Second Edition. London: Longman Green and Co; 1904. p.130.

<sup>5</sup> Stevenson. *Wounds in War*, 1904 (Note 4). p.391-392.

<sup>6</sup> Treves F. The war in South Africa after Spion Kop. *British Medical Journal*. 1900; 1: 599-607.

<sup>7</sup> Stevenson. *Wounds in War*, 1904 (Note 4). p.391-393.

Matters were not helped by anecdotal evidence that penetrating abdominal wounds healed spontaneously if left alone.<sup>8</sup> There was a belief that damage from a small-bore rifle bullet was so limited that any holes in the intestines could be sealed by adjacent loops of small bowel covering the hole and adhering to it. Because of poor surgical outcomes, Sir William MacCormac (1836-1901), Consulting Surgeon to the South African Field Force, declared: 'In this war a man wounded in the abdomen dies if he is operated upon and remains alive if he is left in peace'.<sup>9</sup> This would become known as 'MacCormac's Aphorism'. He also stated:

Many surgeons went to South Africa anticipating a large field of surgical enterprise in this direction, but I feel sure the surgical records of the campaign, when published, will prove the advantages of non-interference in the greater number of instances. This has also been the experience of Americans in the war with Spain, where the weapons were precisely similar. There, all but one of the abdominal cases operated on died, while many treated expectantly recovered.<sup>10</sup>

### **Management of penetrating wounds of the chest in the Boer War**

Chest wounds that were not rapidly fatal due to damage to the heart and great vessels were treated expectantly. Wounds of lung tissue caused by bullets were generally regarded as fairly trivial and healed quickly with a mortality of 27.2 per cent.<sup>11</sup> If a patient developed a haemothorax (blood in chest cavity) of sufficient size to cause respiratory embarrassment, dyspnoea (breathlessness) was alleviated by aspiration of the blood within the chest cavity. Occasionally a bleeding intercostal vessel required ligation and in the event of infection in the pleural cavity an empyema (pus in chest cavity) was drained by insertion of a trocar and canula.<sup>12</sup> Thoracotomy (surgical exploration of chest) was never considered.

### **Russo-Japanese War (1904-05) – a missed opportunity**

During the Russo-Japanese War (1904-05), Russian princess and surgeon Vera Gedroits (1870-1932) performed early laparotomy for penetrating abdominal wounds. Between 28 September and 28 October 1904, she dealt with 1,255 patients in tents smeared with clay to help keep out the cold. Sixty-one had penetrating abdominal wounds. By January 1905, a Red Cross ambulance train in Manchuria was adapted to provide an operating theatre and beds for between 200 and 300 patients. Gedroits believed the closer the surgeon was to the battle front, the more productive was the work. It was here she

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<sup>8</sup> Dent CT. Slighter bullet wounds. *British Medical Journal*. 1900; 1: 662.

<sup>9</sup> Bennet JD. Abdominal surgery in war-the early story. *Journal of the Royal Society of Medicine*. 1991; 8: 554-557.

<sup>10</sup> MacCormac W. Some remarks, by way of contrast, on war surgery old and new. *British Medical Journal*. 1901; 2: 459-462.

<sup>11</sup> Stevenson. Notes on Surgical Experience of the Boer War, 1903 (Note 3).

<sup>12</sup> Stevenson. *Wounds in War*, 1904 (Note 4). p.376-382.

demonstrated the value of early laparotomy.<sup>13</sup> In a six-month period she performed surgery on 168 patients for perforating abdominal wounds. Good results were partly attributable to a strict policy of operating only when the interval from time of injury was three hours or less.<sup>14</sup> Although she published articles on other subjects in journals from 1903 to 1913, her abdominal work was not brought to the attention of surgeons in Western nations.

### **Outbreak of war in 1914; evacuation pathway for the wounded**

An evacuation pathway for the wounded was established during the second half of the nineteenth century and modified after the Russo-Japanese War (Figure 1).

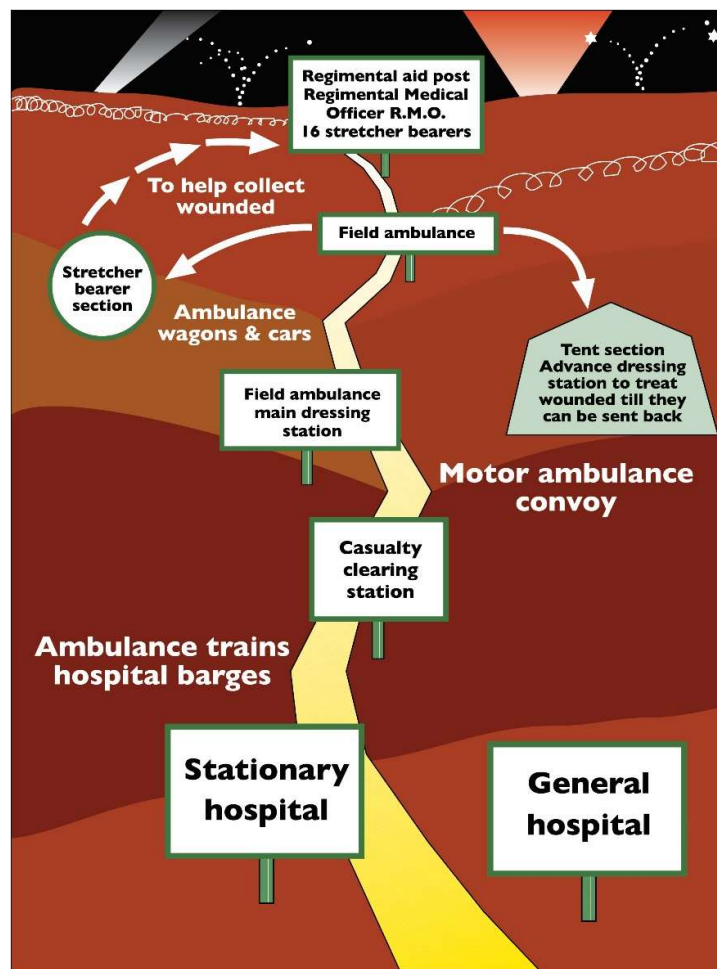


Figure 1. Evacuation pathway for the wounded. Author's image; prepared by Gordon Stables, Department of Medical Illustration, University of Aberdeen.

<sup>13</sup> Bennett JD. Princess Vera Gedroits: military surgeon, poet and author. *British Medical Journal*. 1992; 305: 1532-1534.

<sup>14</sup> Pruitt BA. Combat casualty care and surgical progress. *Annals of Surgery*. 2006; 243: 715-727.

Clearing hospitals, renamed casualty clearing stations (CCSs) in January 1915, were introduced after the Russo-Japanese conflict because it had been associated with large numbers of casualties. Fearing that a European war with similar numbers of wounded would overwhelm field ambulance facilities, clearing hospitals were introduced several miles behind the field ambulances to allow their rapid evacuation.

The fighting withdrawal of the British Expeditionary Force (BEF) from Mons on 23 August 1914 to the River Marne some 130 miles to the south had resulted in significant disruption of the evacuation pathway. Clearing hospitals providing the vital link between the field ambulance units and lines of communication were forced to withdraw. The clearing hospitals had been assembling at St Quentin prior to placement, but the rapid German advance in pursuit of the BEF had made their position untenable and they were transferred to Rouen on 26 August. St Quentin, which had been the principal point to which evacuation of the wounded was directed, was abandoned on the night of 27 August.

As a result of sustained German pressure, general and stationary hospitals at Amiens, Rouen, Le Havre and Boulogne were transferred to St Nazaire on the Atlantic coast and to Nantes, 40 miles upstream from St Nazaire on the River Loire.<sup>15</sup> When fighting moved north to Flanders around Ypres in early October, the decision was made on 9 October to close the Atlantic bases, and general and stationary hospitals returned to Rouen, Le Havre and Boulogne, although this was not finally implemented until 27 October.<sup>16</sup>

### **Management of wounds in the opening months of the war**

Antiseptic dressings were applied to keep harmful organisms out, just as they had been in South Africa. Provided this regimen was strictly adhered to, it was believed that wounded considered for surgery could safely wait for definitive management until they had been transported to general or stationary hospitals (base hospitals) near the French coast:

The experience of the South African War and with surprisingly moderate variation of the Russo-Japanese, led to the belief that, in a large proportion of wounds, superficial or very casual chemical antisepsis with immediate suture was not only permissible but desirable.<sup>17</sup>

It later transpired that this was a very dangerous policy. The war on the Western Front was fought in richly manured fields teeming with lethal bacteria. Wounds were caused by high-energy shell fragments and sharp-nosed streamlined bullets of enormous muzzle velocity which drove contaminated clothing and debris into the depths of wounds along with aerobic and anaerobic organisms. Sir Berkeley Moynihan (1865-

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<sup>15</sup> Macpherson WG. *History of the Great War based on official documents. Medical Services, General History, Vol. 2.* London: HMSO; 1923. p.229-239.

<sup>16</sup> Macpherson. *History of the Great War*, 1923 (Note 15). p.337.

<sup>17</sup> Butler AG. *The Australian Army Medical Services, in the war of 1914–1918, Vol. II.* Canberra: Australian War Memorial; 1940. p.311-312.

1936) visited medical facilities in France between December 1914 and March 1915. He described the wounds and declared that neither civil nor military experience of the previous forty years had prepared surgeons for the type of work they were called upon to perform. Suppuration occurred in the majority and this was perceived by surgeons as a failure of antiseptic regimens employed.<sup>18</sup> Table 1 shows that high explosive shellfire was the commonest cause of 10,789 wounds sustained during a 24-hour period.<sup>19</sup>

WOUNDING AGENT	NUMBER OF WOUNDS	PERCENTAGE
High Explosive	3,867	35.8
Shrapnel	2,142	19.9
Bullet	2,933	27.2
Hand Grenade	77	0.7
Bayonet	17	0.2
Gas	209	1.9
Uncertain	1,544	14.3
TOTAL	10,789	100.0

Table 1. Causes of wounds sustained in the Great War. From: Macpherson. *History of the Great War*, 1924 (Note 19).

### **Management of wounded soldiers at clearing hospitals**

In December 1914, Senior Consulting Surgeon Sir Anthony Bowlby (1855-1929) documented the management of various wounds at clearing hospitals (Figure 2). Simple flesh wounds required an antiseptic dressing, while fractured forearm bones needed a splint and a dressing. Soldiers with compound fractures of the femur needed an antiseptic washout of the wound, an antiseptic dressing and a splint.<sup>20</sup> These patients would be sent by hospital train to base hospitals for definitive surgery, a journey that could take days:

In the field ambulances during the first five or six months of the war, and later in the first clearing hospitals, wounds were superficially disinfected and sutured. The time between first aid at the front and effective operation at the base was commonly several days.<sup>21</sup>

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<sup>18</sup> Moynihan B. The treatment of gunshot wounds. *British Medical Journal*. 1916; 1: 333-337.

<sup>19</sup> Macpherson WG. *History of the Great War based on Official Documents. Medical Services, General History, Vol. 3*. London: HMSO; 1924. p.170-171.

<sup>20</sup> Bowlby A. The work of the clearing hospitals during the past six weeks. *British Medical Journal*. 1914; 2: 1053-1054.

<sup>21</sup> Butler. *The Australian Army Medical Services*, 1940 (Note 17). p.312.

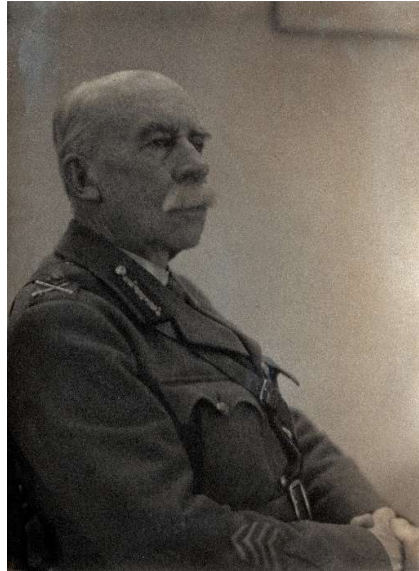


Figure 2. Sir Anthony Alfred Bowlby. Photograph by Doris V Jaeger. Wellcome Collection. Reference: 12383i. Public Domain Mark.

During the opening hectic weeks of the war, soldiers with penetrating wounds of the chest and abdomen were treated expectantly. The only option was to evacuate them to base and keep them as comfortable as possible.<sup>22</sup> By December 1914, the First Battle of Ypres was over, Ypres Salient had become established and front lines had stabilised. The war had changed from rapid movement to static confrontation. Field ambulances and clearing hospitals were more secure and conditions more favourable for surgical management of abdominal and chest wounds. This possibility had not yet been considered, however, because Bowlby noted in December 1914 that those with chest wounds were kept at clearing hospitals and given morphine. They were nursed semi-upright and after 24 hours became more comfortable. He thought they did well with this regimen. He declared that for *all* chest wounds, surgery *must* be avoided.<sup>23</sup>

Management of penetrating chest wounds had not changed since Wellington's most famous surgeon George Guthrie (1785-1856) treated wounded soldiers during the Peninsular War (1808-14), except that surgeons in 1914 did not suck chest wounds; Guthrie had written:

The advantages derived from the closure of punctured wounds of the chest in former times led to the practice of sucking them by the mouths of irregular practitioners, generally the drum major of the regiment, and the consequences, although in some cases miraculous, were in others quite unfortunate. Punctured wounds of small size may be sucked chirurgically, if anyone be willing to do it, after which a bit of dry lint should be placed on the wound.<sup>24</sup>

<sup>22</sup> Bowlby A, Wallace C. The development of British surgery at the front. *British Medical Journal*. 1917; 1: 705-721.

<sup>23</sup> Bowlby. The work of the clearing hospitals, 1914 (Note 20).

<sup>24</sup> Guthrie JG. *Commentaries on the Surgery of the war in Portugal, Spain and the Netherlands*, Sixth Edition. Philadelphia: Lippincott; 1862. p.414-415.

Bowlby noted there were fewer abdominal wounds than in South Africa since men were protected by their trenches. He had seen 50 or 60 penetrating abdominal wounds and concluded that they should usually not be operated on. Bowlby's policy was to keep all chest and abdominal wounds in clearing hospitals for several days before transferring survivors to Boulogne. The quieter such patients were kept, the better they did.<sup>25</sup>

### **Disastrous wound infections in the opening months of the war**

By the end of December 1914, losses sustained by the BEF in France and Flanders amounted to 11,937 killed and 25,661 either missing or prisoners of war. A total of 56,301 wounded had been seen by the medical services and 3,562 had died.<sup>26</sup> It became obvious to medical personnel at base hospitals that they had a disaster without precedence on their hands:

The results were appalling. During the first six months of the conflict the mortality and morbidity from "septic" infection dealt to the surgical profession in every nation concerned a staggering blow, from which it recovered only through tedious and painful apprenticeship.<sup>27</sup>

Some patients reached base hospitals with overwhelming pyogenic wound infections caused by *staphylococci*, *streptococci* and faecal organisms. Others had tetanus or gas gangrene. The incidence of tetanus was 8 per 1,000 wounded with a mortality of 80 per cent. Following the introduction of anti-tetanus serum in late 1914, the incidence of tetanus fell to 1.7 per 1,000 with a mortality of 50 per cent.<sup>28</sup> The incidence of gas gangrene was 5-6 per cent of all wounds, with a mortality of 22 per cent.<sup>29</sup> While antiseptic dressings may have been of value in the dry grasslands of South Africa they were of no use in the ploughed fields of France and Flanders where lethal organisms had been introduced at the instant of wounding. Sir Almroth Wright (1861-1947), Professor of Pathology at St Mary's Hospital before the outbreak of war, took charge of a laboratory at General Hospital No. 13 in Boulogne and declared that no antiseptic would sterilize a wound if bacteria were in a good cultivation medium:

The principle that microbes can be held off from wounds by an antecedent employment of antiseptics has no application to projectile wounds for these are infected before they are seen by the surgeon.<sup>30</sup>

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<sup>25</sup> Bowlby. The work of the clearing hospitals, 1914 (Note 20).

<sup>26</sup> Mitchell, Smith. *History of the Great War*, 1931 (Note 1). p.123.

<sup>27</sup> Butler. *The Australian Army Medical Services*, 1940 (Note 17). p.312.

<sup>28</sup> Butler. *The Australian Army Medical Services*, 1940 (Note 17). p.309.

<sup>29</sup> Butler. *The Australian Army Medical Services*, 1940 (Note 17). p.310.

<sup>30</sup> Wright AE. *Pathology and Treatment of War Wounds*. London: William Heinemann Medical; 1942. p.14.



## **Wound excision**

Consulting surgeon Henry Gray (1870-1938), in charge of surgical activity in a group of base hospitals in Rouen, and a young Australian surgeon Edward Milligan (1886-1972), working in the forward area, realised that it took far too long for patients with limb wounds to reach base hospitals, where for many it was too late. Wound excision, the early radical removal of dead and contaminated tissue, was essential to reduce the incidence of overwhelming pyogenic infections and abolish the anaerobic conditions for gas gangrene. With effective intervention, the incidence of gas gangrene fell to one per cent.<sup>31</sup> Surgery had to be performed early before infection took hold.<sup>32 33</sup>

In selected cases, Gray advocated excision and primary closure of wounds. This required sound judgement and great expertise because if any devitalised tissue remained, primary closure would be disastrous. If there was doubt about completeness of resection of necrotic tissue, delayed primary closure was a much safer option.<sup>34</sup> As a junior surgeon, Milligan faced opposition from surgeons who could not see beyond existing antiseptic methods of treatment. Fortunately, he had the support of Gray and Bowlby and CCSs were expanded to undertake early wound excision to save limbs and lives. Milligan wrote:

Opposition was so great locally that I first carried out excision of wounds under local anaesthesia, and general anaesthetics induced by myself and continued by an orderly; and this often at late hours and unknown to those in authority. At the request of a Consulting Surgeon of the Army, who opposed this treatment, my Commanding Officer ordered me to discontinue surgery, and only allowed me to return with the request that I should cease excision of wounds ... Sir Anthony Bowlby, the chief consultant of the B.E.F., expressed himself in agreement with my publication at the time. Sir Henry M. W. Gray, to whom war surgery owes so much, was carrying out the treatment independently at the Base in France, and soon afterwards advocated it energetically at the front. Under pressure of these opinions, and from their own convictions, many surgical specialists now took up the treatment, and the necessary administrative alterations were made by the R.A.M.C. for carrying it out.<sup>35</sup>

Surgeons of all belligerent nations encountered the same problems with wound infections. French and Belgian clinicians began to employ a technique called 'debridement' which had been used one hundred years previously by Dominique Larrey (1766-1842), Surgeon-in-Chief to Napoleon's Army. The term debridement comes from the French verb *débrider* which means to unbridle. An incision made through the deep

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<sup>31</sup> Butler. *The Australian Army Medical Services*, 1940 (Note 17). p.310.

<sup>32</sup> Gray HMW. The treatment of gunshot wounds by excision and primary suture. *Journal of the Royal Army Medical Corps*. 1915; 24 (6): 551-554.

<sup>33</sup> Milligan ETC. The early treatment of projectile wounds by excision of the damaged tissue. *British Medical Journal*. 1915; 1: 1081.

<sup>34</sup> Gray HMW. *The Early Treatment of War Wounds*. London: Henry Frowde, Hodder and Stoughton; 1919, p.160-166.

<sup>35</sup> Butler. *The Australian Army Medical Services*, 1940 (Note 17). p.328.

fascia unbridles, or relieves, the pressure on the underlying muscle. Antoine Depage (1862-1925) began employing debridement on war wounds in 1914.<sup>36</sup> Not only did he unbridle the wound, by making an incision in the deep fascia, he also excised dead and contaminated tissue beneath, making the procedure the same as wound excision.

The most serious musculoskeletal wound was the compound fracture of the femur. Gray documented a mortality of 80 per cent in the opening two years of the war.<sup>37</sup> The standard Lee-Enfield rifle splint failed to immobilise the fracture effectively and most patients arrived at CCSs in shock due to excessive bleeding, unfit to withstand wound excision to save their limbs and lives. In 1915, Robert Jones (1857-1933), who became Director of Military Orthopaedics in 1916, introduced the very effective Thomas Splint. His uncle by marriage, Hugh Owen Thomas (1834-91), had designed the splint to immobilise knee joints affected by tuberculosis, but it had proved equally effective in stabilising femoral fractures. When the Thomas Splint was used to treat compound gunshot fractures of the femur, blood loss with associated surgical shock was reduced and the mortality fell to 20 per cent.<sup>38</sup>

### **Wound excision for penetrating injuries of the chest**

There were three reasons for Bowlby's firm declaration in December 1914 that surgery should never be employed for penetrating wounds of the chest. First, experience from the Boer War had led surgeons to believe that chest wounds were best left alone. Second, it was thought that it would be fatal to open the chest cavity without some form of pressure chamber. Third, it was believed that handling the lung would provoke fast and fatal bleeding. Experience proved these assumptions wrong and surgical practice changed, because it was becoming obvious that chest wounds were every bit as susceptible to lethal infections as wounds of the extremities. The general principles of surgery which governed the treatment of wounds, namely early mechanical cleansing by operation (wound excision) followed by early closure, was every bit as applicable to penetrating wounds of the chest.<sup>39</sup>

Soldiers with chest wounds made up two per cent of the total number admitted to clearing stations. The most favourable cases were those in which a bullet had gone right through the chest and least favourable those made by a shell fragment retained within the chest.<sup>40</sup> Soldiers seen by the medical services and who died fell into three categories: those who died early in the CCS from such severe wounds that surgeons were unable to help; those who died in a CCS after a few days, invariably from infection; and those

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<sup>36</sup> Helling TS, Daon E. The Great War, Antoine Depage and the resurgence of débridement. *Annals of Surgery*. 1998; 228(2): 173-181.

<sup>37</sup> Jones R. Crippling due to fractures: its prevention and remedy. *British Medical Journal*. 1925; 1: 909-913.

<sup>38</sup> Watson F. *The Life of Sir Robert Jones*. London: Hodder and Stoughton Ltd; 1934, p.152-163.

<sup>39</sup> Gask GE. Gunshot wounds of the chest. *British Medical Journal*. 1939; 1: 1043-1045.

<sup>40</sup> Herringham W. Penetrating wounds of the chest at casualty clearing stations. *British Medical Journal*. 1917; 1: 721-722.

who died later at a base hospital, also from infection.<sup>41</sup> Early wound excision could salvage those who would otherwise have succumbed to pyogenic infection or gas gangrene. The British surgeon most associated with the operative management of chest wounds was George Gask (1875-1951). He and French surgeon Pierre Duvalle (1874-1941), deserve credit for evolving techniques to deal with such wounds.<sup>42</sup> Before describing Gask's work, it is important to consider other developments, without which surgical treatment would have had a less successful outcome.

### **Wound shock-resuscitation, blood transfusion and improved anaesthesia**

In 1917, a Special Investigative Committee on Surgical Shock and Allied Conditions was established by the Medical Research Committee. Wound shock was defined as a condition of circulatory failure due to deficient entry of blood into the heart.<sup>43</sup> In the opening months of the war, unsuccessful attempts had been made to improve the condition of shocked patients by giving pre-operative subcutaneous and intra-rectal saline, neither of which improved matters.<sup>44</sup> Patients with chest wounds were even given intra-rectal coffee.<sup>45</sup> In 1915, Geoffrey Marshall (1887-1972), a respiratory physician, was sent to CCS No. 17 at Remy Siding near Poperinghe by Bowlby. Marshall had been having a very pleasant time working on a hospital barge looking after mainly chest and head wounds until Bowlby drove up one day:

Then a dreadful old man, who was the senior consultant, Sir Anthony Bowlby, drove up to my barge one day-lovely day-and said, 'Marshall, we are having an awful lot of deaths in the forward hospitals from shock, and you did a lot of work on the physiology of anaesthesia before the war, so I want you to come along and see if you can do anything about these chaps'.<sup>46</sup>

Many wounded were dying during or immediately after surgery. It became obvious to Marshall that chloroform and ether were dangerous anaesthetic agents to use in shocked patients, as was spinal anaesthesia. His first task was to combat shock and the single most important measure available in 1915 was to warm the patient up, increase the stroke volume of the heart and enable the wounded man to better withstand the anaesthetic and operation. Marshall found that nitrous oxide and oxygen was the safest anaesthetic to use in severely compromised patients. Provided the general condition of

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<sup>41</sup> Gask GE, Wilkinson KD. Penetrating gunshot wounds of the chest and their treatment. *British Medical Journal*. 1917; 2: 781-784.

<sup>42</sup> Gordon-Taylor G. Abdomino-thoracic wounds of warfare. *British Medical Journal*, 1919; 2: 131-134.

<sup>43</sup> Butler. *The Australian Army Medical Services*, 1940 (Note 17). p.953.

<sup>44</sup> Marshall G. The administration of anaesthetics at the front. *British Medical Journal*. 1917; 1: 722-725.

<sup>45</sup> Roberts JEH, Craig JG. The surgical treatment of severe wounds of the chest. *British Medical Journal*. 1917; 2: 576-579.

<sup>46</sup> Evans B. A doctor in the Great War; an interview with Geoffrey Marshall. *British Medical Journal*. 1982; 2: 1780-1783.

the patient could be improved, he subsequently recommended oxygen and chloroform warmed in a Shipway apparatus for penetrating wounds of the chest, and oxygen and warm ether for abdominal wounds, once operative treatment for these categories had been approved.<sup>47</sup>

The English physician Sir Francis E Shipway (1875-1968) was a leading anaesthesia specialist. He believed that inhalation of cold vapour caused patients to experience lung complications and falling body temperatures during surgery. His warm vapour insufflation inhaler, which was introduced in 1916, was used by the Royal Army Medical Corps (RAMC) during the war.

In ongoing efforts to combat shock, intravenous saline was administered in 1916 during the Battle of the Somme. Like intra-rectal saline, it produced a transient rise in blood pressure, only for the pressure to quickly fall again when hydrostatic effects forced the saline into the interstitial space.<sup>48</sup>



Figure 3. L Bruce Robertson in uniform, [c1914-18]. L Bruce Robertson fonds, F 1374, Archives of Ontario, I0050303.

Blood transfusion was introduced by Canadian medical officer Lawrence Bruce Robertson (1885-1923) (Figure 3), which he first employed in late 1915 while working in Canadian General Hospital No. 14. He transfused four patients suffering from secondary haemorrhage (caused by infection) using a syringe-cannula technique to transfuse 800-1,000 cc whole blood from lightly wounded donors. Two patients survived.<sup>49</sup> Robertson was transferred to Remy Siding Canadian CCS No. 2 in 1916 from where he published a series of 36 cases in 1917. He estimated that without transfusion all would have died. Twenty-two of his cases who were doing well were evacuated to base hospitals. Nine who originally did well subsequently died from

<sup>47</sup> Marshall. The administration of anaesthetics, 1917 (Note 44).

<sup>48</sup> Van der Kloot W. William Maddock Bayliss's Therapy for Wound Shock. *Notes and Records of the Royal Society of London*. 2010; 64(3): 271-286.

<sup>49</sup> Robertson LB. The transfusion of whole blood. *British Medical Journal*. 1916; 2: 38-40.

complications of surgery including infection. Two died as a result of transfusion reactions and three died without any benefit.<sup>50</sup> Transfusion of whole blood was a major step forward and American Oswald Hope Robertson (1866-1966) of American Base Hospital No. 5 had expertise in transfusion using preserved blood which could be stored for up to 26 days provided it was kept cold.<sup>51</sup>

### **Management of penetrating wounds of the chest**

Patients admitted with suspected penetrating chest wounds were put to bed and allowed to rest undisturbed for one or two hours while hot drinks and warmth were provided to raise body temperature and sedation administered to relieve pain. One exception to this rule was when there was a large opening into the pleura through which air was sucked. In such cases, the opening was immediately closed by temporary skin suture without anaesthesia, providing immediate relief. Gask (Figure 4) believed that all such wounds should be sewn up at advanced dressing stations. The procedure was easy, rapid, and much more efficient than plugging and strapping.<sup>52</sup>



Figure 4. Colonel George Gask and other medical personnel operating, c1917. L Bruce Robertson fonds, F 1374, Archives of Ontario, I0050276.

<sup>50</sup> Robertson LB, Gordon Watson C. Further observations on the results of blood transfusion in war surgery. *British Medical Journal*. 1917; 2: 679-683.

<sup>51</sup> Robertson OH, Transfusion with preserved red blood cells. *British Medical Journal*. 1918: 1: 691-695.

<sup>52</sup> Gask. Gunshot wounds of the chest, 1939 (Note 39).

Cardiac tamponade from a haemopericardium was another indication for immediate intervention. Many patients had suffered major blood loss which required vigorous measures in a specially equipped and warmed resuscitation ward by a 'shock team' comprising an experienced medical officer and specially trained nurses and orderlies. Patients were provided with warmth, sedation (Omnopon, a morphine-based drug), absolute rest and transfusion, which were the chief successful remedies for the worst cases.<sup>53</sup> A useful anaesthetic was oxygen and chloroform through a Shipway's apparatus, particularly valuable during long operations.<sup>54</sup> An alternative regimen was local anaesthesia using one per cent novocaine with or without adrenaline for the chest wall and nitrous oxide and oxygen for the intrathoracic stage of the procedure.<sup>55</sup>

Ragged and contaminated wounds were excised by resecting foreign material and sharp fragments of broken ribs. The chest was explored either by extending the initial wound or by making a separate incision allowing access to carry out a full examination of the pleural cavity. Bleeding was controlled and any foreign bodies in accessible positions were removed. It was essential to primarily close the chest, preferably in layers, at the end of the procedure. If necessary, muscle flaps were used to cover large pleural defects.<sup>56</sup>

### **Gask's results**

Gask reported 365 cases which had come under his care between 7 June 1917 and 31 August 1917 at Canadian CCS No. 2.<sup>57</sup> There were 76 deaths (20 per cent mortality). Forty-five had associated pathology (Table 2), leaving 31 (9.6 per cent) where the chest wound was the sole cause of death. Nineteen of the 31 deaths were attributable to haemorrhage and shock, ten to pyogenic infection or gas gangrene and two to bronchitis. Wounds caused by shell fragments with both entry and exit wounds had the highest mortality (47 per cent) and those caused by shrapnel balls the lowest (10 per cent).<sup>58</sup> Two examples of Gask's patients reported by Robertson are presented here.

*Case 25. GSW chest, femoral vein and knee joint; evacuated to base in good clinical condition.*

Dr CJB; admitted in a very grave condition under the care of Major G. Gask, DSO RAMC; Penetrating wound of chest; tear of left femoral vein; penetrating wound of right knee joint. After operation the patient was blanched and collapsed. The pulse was 180 and barely perceptible; blood pressure 60mm Hg. Blood transfusion started, but before 60cc had been injected, death was imminent. The patient's lips were bloodless, pulse imperceptible, breathing

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<sup>53</sup> Gray. *The Early Treatment of War Wounds*, 1919 (Note 34). p.76.

<sup>54</sup> Robertson A. *Anaesthesia, Shock and Resuscitation*. In Scotland T, Heys S. (eds) *War Surgery, 1914-18*. Solihull: Helion and Co; 2012, p.92.

<sup>55</sup> Wallace C, Fraser J. *Surgery at a Casualty Clearing Station*. London: A & C Black; 1918. p.199.

<sup>56</sup> Gask. Gunshot wounds of the chest, 1939 (Note 39).

<sup>57</sup> Gask, Wilkinson. Penetrating gunshot wounds, 1917 (Note 41).

<sup>58</sup> Gask. Gunshot wounds of the chest, 1939 (Note 39).

slow and jerky; 80cc of very hot saline and 1cc of pituitrin were now given intravenously and transfusion continued. When 400cc of blood had been injected, the breathing had improved greatly. At the end of the transfusion (1,200cc), the face was flushed, the pulse strong and the patient was attempting to clear his throat. After transfusion, the pulse was 108, blood pressure 144, and further progress uneventful. He was evacuated to base seven days later. Two weeks later he had been evacuated to England in good condition.<sup>59</sup>

*Case 26. GSW chest, Haemothorax and laceration of lung; death.*

Gunner EG, wounded early that morning, was admitted in a very collapsed state under the care of Major Gask, DSO, RAMC, on July 17<sup>th</sup> 1917; severe penetrating wound of the chest; extensive damage to lung; blood transfusion (700cc); slight response lasting a very short time. Death occurred some five hours later; necropsy showed gas gangrene infection in haemothorax and severe laceration of lung.<sup>60</sup>

PATHOLOGY	NUMBER
Chest and head	6
Chest and abdomen	14
Chest and spine	4
Chest and heart	4
Chest and great vessels	2
Chest and multiple wounds	14
Chest and gas gangrene	1

Table 2. Casualty clearing station and base hospital deaths of 45 patients who had chest wounds associated with other complications. From: Gask, Wilkinson. Penetrating gunshot wounds, 1917 (Note 41).

### **Wounds of the heart**

Surgical intervention for wounds of the heart was rare. Surgeon Sir Charles Ballance (1856-1936) documented 63 bullet wounds of the heart and pericardium from British, French and German literature and noted that sixteen died (26 per cent mortality). Ballance observed that surgery was often performed long after receipt of the injury when the external wound was well healed. French surgeons undertook the greatest number of

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<sup>59</sup> Robertson, Gordon Watson. Further observations, 1915 (Note 50).

<sup>60</sup> Robertson, Gordon Watson. Further observations, 1915 (Note 50).

procedures on these patients and were relatively successful.<sup>61</sup> Seven cases were British and only two survived. Captain John Fraser (1885-1947) treated one soldier soon after injury who presented with cardiac tamponade. He had a large collection of blood within the pericardium and a tiny hole in the right auricle caused by a fragment of bomb, which Fraser sutured.<sup>62</sup> Major L Jones (dates unknown) operated on a soldier eight days post-wounding following a dramatic deterioration in the patient's condition. The pericardium contained a large volume of foul-smelling fluid which grew *Clostridium perfringens* and a few *staphylococci* and *enterococci*. A shell fragment was found to have grazed but not penetrated the anterior border of the heart. The patient's condition improved after draining the pericardium and, although the post-operative course was stormy, he recovered.<sup>63</sup>

### **Penetrating wounds of the abdomen**

The incidence of penetrating abdominal wounds at nine field ambulances over a six-month period was 1.92 per cent compared with 0.75 per cent at CCSs during that same period. The discrepancy may be partly attributable to over-diagnosis at field ambulances and partly because some severe cases died in dressing stations or en route to CCSs.<sup>64</sup> Surgeon Owen Richards (1873-1949) performed the first successful bowel resection on 18 March 1915. He reported a series of nine cases of intestinal perforation, seven of small bowel and two of large intestine. Two patients who underwent small bowel resection survived, but all others died after unsuccessful surgery.<sup>65</sup> His work helped to stimulate interest in the operative treatment of penetrating abdominal wounds and in May 1915 an enquiry into causes of death from such wounds established that bullets resulted in very extensive injuries.

Much emphasis had previously been put on spontaneous recovery due to smallness of lesions caused by small bore bullets. Cuthbert Wallace (1867-1944), a very experienced surgeon who had been with Sir Anthony Bowlby in South Africa during the Boer War, showed by autopsy studies that haemorrhage was the chief cause of early death. This was an important observation, since only rapid evacuation and surgery to arrest bleeding would give a better chance of survival.<sup>66</sup> Peritonitis was a later danger, arising from rupture of a hollow viscus and only early surgery to repair or resect the perforated segment of bowel would reduce deaths from this cause.<sup>67</sup> A determined effort

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<sup>61</sup> Ballance CA. *The Bradshaw Lecture on the Surgery of the Heart*. London: MacMillan and Co; 1920, p.142-149.

<sup>62</sup> Bowlby A, Wallace C. The development of British surgery at the front. *British Medical Journal*. 1917; 1: 705-721.

<sup>63</sup> Jones L. Gunshot wound of pericardium and heart; pneumo-haemopericarditis; operation; recovery. *Journal of the Royal Army Medical Corps*. 1916; 27(4): 495-498.

<sup>64</sup> Wallace, Fraser. *Surgery at a Casualty Clearing Station*, 1918 (Note 55). p.145.

<sup>65</sup> Richards O. The pathology and treatment of gunshot wounds of the small intestine. *British Medical Journal*. 1915; 2: 213-215.

<sup>66</sup> Bowlby, Wallace. The development of British surgery, 1917 (Note 62).

<sup>67</sup> Don A. Abdominal injuries in a casualty clearing station. *British Medical Journal*. 1917; 1: 330-334.



was made to provide facilities for early operative treatment and Wallace was instrumental in bringing this about (Figure 5).



Figure 5. Sir Cuthbert Sydney Wallace by Walter Stoneman; National Portrait Gallery, London; License: Non-commercial/Academic and non-commercial journal, inside use; Licence No. 57126.

Antoine Depage, mentioned previously in connection with debridement, appreciated the importance of early surgery when he organised mobile surgical units called *postes avances des hospitaux du front* (advanced surgical posts) located only two to three miles from the front to deal with penetrating wounds of the chest and abdomen.<sup>68</sup> German surgeon Victor Schmieden (1874-1945) proposed early laparotomy for abdominal wounds in 1915.<sup>69</sup>

### **Early surgery for penetrating abdominal wounds**

In September 1915 during the Battle of Loos, advanced operating centres were established to deal with abdominal wounds as rapidly as possible. Experienced surgeons from CCSs staffed them. Captain John Fraser (Figure 6) from CCS No. 7 went to an advanced centre at Bac St. Maur, while Captain Owen Richards from CCS No. 6 went to one at Noeux-les-Mines.<sup>70</sup>

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<sup>68</sup> Helling, Daon. *The Great War*, 1998 (Note 36).

<sup>69</sup> Sachs M, Encke A. Victor Schmieden (1874-1945) and his contribution to the development of modern surgery [Article in German]. *Zentralblatt für Chirurgie*. 1997; 122(7): 597-609.

<sup>70</sup> Macpherson. *History of the Great War*, 1923 (Note 15). p.457.



Figure 6. From left to right: Captains John Fraser and AN Hooper, RAMC and Captain Walter B Cannon, US Army Medical Service. The photograph was taken in October 1917 at CCS No. 33, Bethune, where the three men were researching surgical shock. Harvard Medical Library in the Francis Conway Library of Medicine.

In 1916 during the Battle of the Somme, advanced operating centres were established by field ambulances at Warloy and Authui and specialised teams of surgeons from CCSs staffed them. The centre at Authui was located in a small but well-equipped civilian hospital with 75 beds, supplemented by accommodation for 375 other wounded in tents, huts and other buildings. There were three surgeons and nine nursing sisters at Warloy.<sup>71</sup> During the opening weeks of the Third Battle of Ypres, which began on 31 July 1917, there were three CCSs located at Brandhoek (Figure 7) which dealt exclusively with penetrating wounds of the chest and abdomen and compound fractures of the femur.

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<sup>71</sup> Macpherson. *History of the Great War*, 1924 (Note 19). p.20.

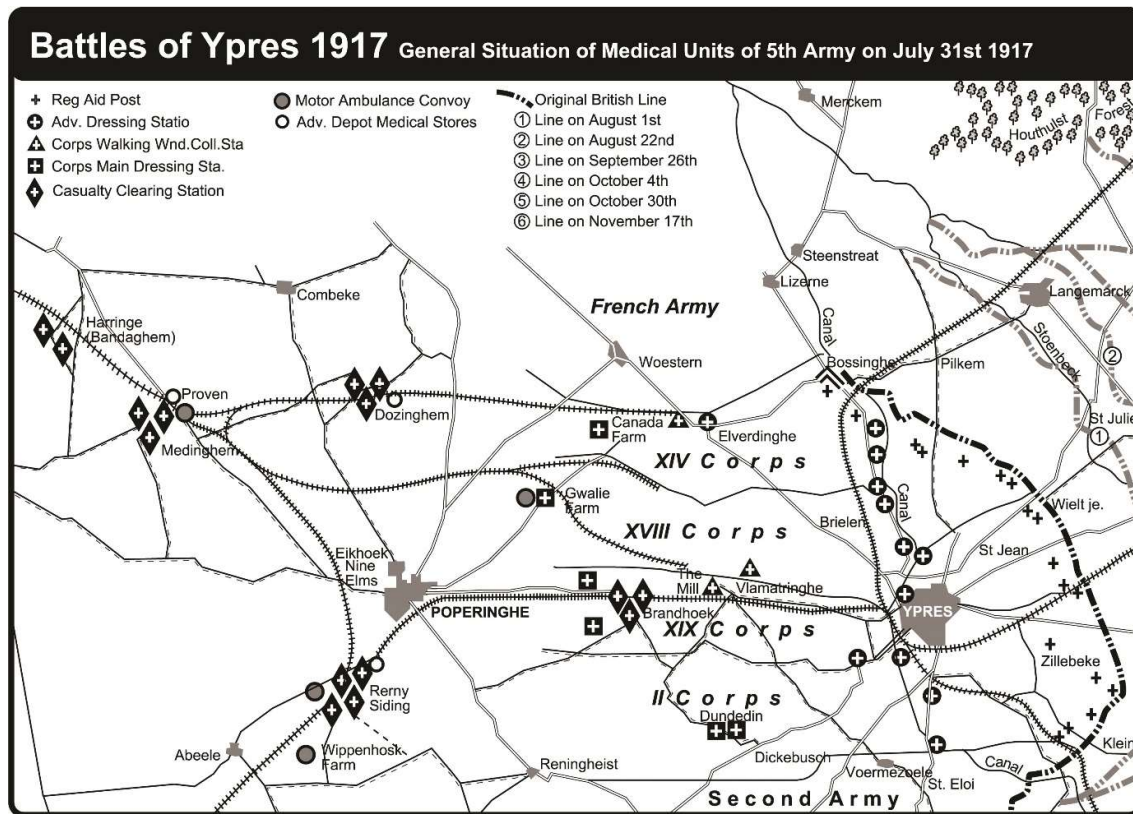


Figure 7. Author's image, prepared by Gordon Stables, Department of Medical Illustration, University of Aberdeen, showing Medical Units 5<sup>th</sup> Army, 31 July 1917. Source: Macpherson. *History of the Great War*, 1924 (Note 19). p.138.

British CCSs No. 32 and No. 44 and Australian CCS No. 3 were closer to the front line than any other clearing stations. Miss Kate Luard (1872-1962), senior sister of the Queen Alexandra's Imperial Military Nursing Service at CCS No. 32, wrote:

This venture so close to the line is in the nature of an experiment in lifesaving, to reduce the mortality rate in abdominal and chest wounds. Our thirty medical officers include the largest number of F.R.C.S.'s ever collected in any hospital in France.<sup>72</sup>

One of those posted to Brandhoek from CCS No. 5 was Major Gordon Gordon-Taylor (1878-1960), an advocate of early surgical intervention. He stressed the importance of decisive and rapid action:

Speed is the handmaid of success. There is no place for the surgical sluggard on the floor of the operating theatre of the casualty clearing station. As captain of a surgical team handling abdominal injuries, the surgeon who dawdles is wasteful of the time of others as well as his own. By reason of his very slowness,

<sup>72</sup> Stevens J, Stevens C. (eds). *Unknown Warriors, the Letters of Kate Luard*. Stroud: History Press Limited; 2017.

he will compass the death of many wounded men who might have been saved by an operator of quicker turn of speed.<sup>73</sup>

Blood transfusion proved to be every bit as important for abdominal wounds as it was for penetrating wounds of the chest. Gordon-Taylor stressed that results did not improve in a spectacular fashion until blood transfusion became available, but 'some men are, from the very first, mortally wounded'.<sup>74</sup>

### **Factors affecting prognosis of penetrating abdominal wounds**

Timing of surgery was critical. If a period of six hours or less had elapsed, the chances were in favour of the patient surviving. After six hours, the situation was reversed and, with every hour of delay, the chances of recovery grew smaller.<sup>75</sup> Other factors which influenced the prognosis included the type of projectile. Fragments of bombs and grenades were generally tiny and associated with a lower mortality than larger fragments of shell casing. The irregular outline and ragged edges of shell fragments caused extensive damage. The organ injured made a difference. Simple wounds of the small intestine requiring suture only had the lowest mortality. Wounds of solid viscera had the next best outcome. Wounds of the liver were less serious than wounds of the kidney or spleen. Colon wounds were especially dangerous when retroperitoneal tissues were injured owing to the liability of retroperitoneal sepsis. Complicated wounds of the small intestine with extensive injury to the mesentery and to other viscera, especially the bladder, had the highest mortality. Wounds of the upper abdomen did better than wounds of the lower abdomen, because the latter were associated with a higher incidence of perforated small and large intestine. A pulse rate of 100 was usually associated with a more favourable prognosis, while few survived with a pulse rate >120 at presentation.<sup>76</sup>

Wallace and Fraser noted that the overall mortality of 2,127 penetrating abdominal wounds seen between 1 July 1915 and 30 September 1917 was reduced from 80 per cent to 60 per cent. There were 420 moribund patients who were kept comfortable and put aside to die. The total mortality was 50 per cent excluding the moribund cases and 60 per cent if they were included. In all, 1,707 cases were considered for surgery and operation was deemed unnecessary in 102. The 1,605 operations performed had a mortality of 53 per cent.<sup>77</sup> While overall reduction in mortality from 80 per cent to 60 per cent may seem modest, this was the first time British military surgeons had decided on a policy for treating abdominal wounds operatively and, given the numbers, a 20 per cent reduction was important.

Wallace reported on the relative frequency with which different organs of the abdomen were wounded. The total number of cases under consideration was 965 (Table 3).

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<sup>73</sup> Gordon-Taylor G. *The Abdominal Injuries of Warfare*. Bristol: John Wright and Sons Ltd.; 1939. p.6.

<sup>74</sup> Gordon-Taylor. *The Abdominal Injuries of Warfare*, 1939 (Note 73). p.87.

<sup>75</sup> Wallace, Fraser. *Surgery at a Casualty Clearing Station*, 1918 (Note 55). p.144-145.

<sup>76</sup> Wallace, Fraser. *Surgery at a Casualty Clearing Station*, 1918 (Note 55). p.156-159.

<sup>77</sup> Wallace, Fraser. *Surgery at a Casualty Clearing Station*, 1918 (Note 55). p.156.

VISCUS	NUMBER	VISCUS	NUMBER
Stomach	82	Kidney	74
Small bowel	363	Bladder	45
Colon	252	Ureter	3
Liver	163	Pancreas	5
Spleen	54		

Table 3. Relative frequency with which abdominal viscera were wounded. From: Wallace, Fraser. *Surgery at a Casualty Clearing Station*, 1918 (Note 55). p.151.

### **Abdomino-thoracic wounds**

Gordon-Taylor reported that in 1916 only 18 per cent of wounds involving both chest and abdomen were saved, but that in November 1917, Bowlby had quoted a recovery rate of 49 per cent. In the autumn of 1918, Gordon-Taylor collected the results of 207 operations for abdomino-thoracic injury performed by six surgeons (including himself) attached to the British Fourth Army. Gordon-Taylor's recovery rate was 66.6 per cent, and for two others was as high as 80 per cent. Individual results depended largely upon involvement of hollow or solid abdominal organs. The latter type of wound was associated with a lower mortality rate, but even in the case of hollow viscus involvement, Gordon-Taylor had a 50 per cent recovery rate.<sup>78</sup>

Towards the end of the war, the French conceived the idea of aerial ambulances to convey patients with gunshot wounds of the chest and abdomen from aid-posts just behind the line to hospitals well equipped for dealing with such cases. Nemirovsky and Tilmant (dates unknown) in the ensuing years organised an aeroplane which they named the 'Aerochir' to carry the surgeon to the patient.<sup>79</sup>

### **Final observations and conclusion**

Definitive management of wounds during the early months of the war was delayed until those soldiers selected for surgery reached base hospitals, sometimes several days later. Lulled into a false sense of security by the use of antiseptics, surgeons were not prepared for appalling wounds caused by shellfire and streamlined bullets of enormous muzzle velocity. They displayed startling ignorance, which Butler summed up in the official history of the Australian Army Medical Services:

Unfortunately, the medical profession entered the war in 1914 with an interesting and very remarkable handicap. Well up in the methods of ensuring

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<sup>78</sup> Gordon-Taylor G. The Abdominal Injuries of Warfare – II. *British Medical Journal*. 1939; 2: 235-239.

<sup>79</sup> Gordon-Taylor G. *The Dramatic in Surgery*. Bristol: John Wright and Sons Ltd.; 1930. p.22.

asepsis in surgical wounds, for the most part it knew little of 'septic' wounds. In the early stages of the war the more fulminant forms of wound infection fell like the scourge of an unexpected pestilence on a race of surgeons grown complacent in the atmosphere of prophylactic asepsis, with whose toilsome and tedious evolution they were acquainted chiefly by tradition and Listerian Orations. For the best part of a year, indeed, at the beginning of the Great War, the treatment of wounds in the field was vitiated by neglect of the fact that the infection was contained within the wound itself.<sup>80</sup>

One cannot blame Joseph Lister (1827-1912) for the shortcomings of military surgeons in 1914, although British surgeons were frankly 'rattled' by the failure of antiseptic regimens which they regarded as failures of Listerian principles. When Lister wrote his seminal paper on antiseptic surgery in 1867, he could never have imagined that his methods would be applied to the grossly contaminated wounds seen in 1914.<sup>81</sup> Moynihan came swiftly to Lister's defence when he returned from France in March 1915. He pointed out that Lister clearly distinguished between prophylactic and therapeutic application of antiseptics, emphasising the importance of the former and inadequacy of the latter.<sup>82</sup>

One antiseptic regimen which gained recognition worthy of mention and which provided some reassurance to those whose surgical practice had been governed by 'tradition and Listerian Orations' was that of French surgeon Alexis Carrel (1873-1944) and English chemist Henry Dakin (1880-1952). 'Dakin's solution' with the active ingredient sodium hypochlorite was delivered continuously by Carrel to every part of a wound using a series of glass applicators and perforated tubes until daily bacteriological counts indicated that it was safe to secondarily close the wound. Although shown to be useful in September 1915, Carrel's method was not generally adopted by the British until 1917. Diaries of Australian surgeons working at Remy Siding during the Third Battle of Ypres showed that many cases were sent to the base hospitals under 'Carrel treatment', for which special arrangements were made on ambulance trains.<sup>83</sup> There was strong competition, however, from simpler methods which 'did not involve the extra paraphernalia and the attention required'.<sup>84</sup>

It had become clear that wound excision was vital to prevent infection and no antiseptic could ever be a substitute for adequate surgery. This applied equally to penetrating chest wounds and, once irrational fears associated with thoracotomy had been dispelled, early wound excision salvaged many patients by reducing avoidable deaths from aerobic and anaerobic infections. The first successful bowel resection performed in 1915 by Owen Richards was a catalyst for progress and when research showed that many soldiers with penetrating abdominal wounds were bleeding to death under the noses of medical officers responsible for their care, surgeons were duty bound to intervene. Although the overall percentage mortality from abdominal wounds only

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<sup>80</sup> Butler. *The Australian Army Medical Services*, 1940 (Note 17). p.311-312.

<sup>81</sup> Lister J. On the antiseptic principle in the practice of surgery. *British Medical Journal*. 1867: 2: 246-248.

<sup>82</sup> Moynihan. The treatment of gunshot wounds, 1916 (Note 18).

<sup>83</sup> Butler. *The Australian Army Medical Services*, 1940 (Note 17). p.321-322.

<sup>84</sup> Gray. *The early treatment of war wounds*, 1919 (Note 34). p.122.

fell from 80 per cent to 60 per cent, a determined start had been made. Advances in resuscitation and anaesthesia associated with early effective surgical intervention helped to provide an all too brief window of opportunity to save limbs and lives.

Surgeons today would do well to acknowledge and understand the progress made by their predecessors during the Great War. In doing so, they might avoid repeating their mistakes, especially those made in the early months of that conflict.

### **Biographical details**

In his previous life, the author was an orthopaedic surgeon who worked in Aberdeen. Since retiring from the National Health Service he has pursued a longstanding interest in the history of the Great War and has researched many surgical advances which were made during that conflict. He has presented papers at national and international meetings, has written peer reviewed articles, and has co-edited, co-authored and authored books on the subject.

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