

## **The Impact of World War 2 on the Development of Neurosurgery as a Specialty in Britain**

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### **Abstract**

This article traces the development of British neurosurgery from the end of the nineteenth century, its state during World War 1, the problems it faced in the inter-war years and up to the end of World War 2. Harvey Cushing influenced the development of neurosurgery though it was the three main British protagonists Hugh Cairns, Geoffrey Jefferson and Norman Dott who together were pivotal in the early development of civilian services in the inter-war years. Neurosurgery during World War 2 developed innovative practices, both civilian and military, which improved patient management and outcomes. Records of surgery from St Bartholomew's Hospital theatre archives suggest that neurosurgical problems were more common than previously thought. The changes in the specialisation in neurosurgery which would continue in peacetime, reaping great benefits for its patients, are reflected in the same archives' post-war operating figures.

### **Keywords**

Neurosurgery, Head injury, Mobile Neurosurgical Units

### **Introduction**

Several key advances in the second half of the nineteenth century facilitated the development of modern neurosurgery.<sup>1</sup> These included the identification and classification of neurological diseases by physicians in Britain and Europe which greatly favoured the development of neurosurgical practice as it improved the knowledge of the structural and functional anatomy of the nervous system. Advances

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<sup>1</sup> Ellis H. The story of neurosurgery. *Journal of Perioperative Practice*. 2019; 29(10): 346-348.

that enabled neurosurgery to be performed included the development of anaesthesia, which allowed access to the nervous system, and the general acceptance of Listerian antiseptic principles, which contributed to the reduction of the risks of sepsis. Both factors contributed to the improved outcome of any operation which involved accessing the brain, spinal cord and peripheral nerves.<sup>2</sup> At the end of the nineteenth century penetrating head injuries were associated with poor outcomes, usually death, due to secondary sepsis.<sup>3</sup> <sup>4</sup> Compared to World War 1 (WW1), military medicine, especially military neurosurgery, had been completely transformed by the end of World War 2 (WW2).<sup>5</sup>

In the early twentieth century, neurosurgery was performed by general surgeons with an interest in operating on the cranium but its development progressed slowly as ‘No surgeon had thought they could make a living out of so recondite a pursuit – nobody that is since Victor Horsley ...’.<sup>6</sup> Despite the advances in anaesthesia and antisepsis, there remained problems with a limited knowledge of neurology, neurophysiology, plus primitive surgical techniques and equipment which included suction and diathermy. Victor Horsley (1857-1916) is considered to be the founder of English neurosurgery and he had addressed some of these anatomical issues with his mapping work on cat and Rhesus monkey brains as well as initiating early stereotactic work on these animals.<sup>7</sup> Stereotaxis is a method of neurosurgery for locating points in the brain using an external dimensional frame of reference.

Surgeons learned from experience that high energy transfer gunshot wounds to the brain were incompatible with life. Horsley’s research showed that such wounds had a cavitation effect and generated a large volume of dead tissue. This dead tissue together with bone and foreign material fragments caused meningitis, encephalitis and abscess formation which were invariably fatal.<sup>8</sup> Despite Horsley’s enthusiastic approach, Sir Charles Ballance (1856-1936) in his presidential address to the newly formed Society of British Neurological Surgeons (SBNS) in 1927 reminisced that Horsley ‘at first only had a kitchen to operate in at the National Hospital’ and that in those days ‘very few operations were performed – probably not more than one a month’.<sup>9</sup>

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<sup>2</sup> Dowdy J, Pait TG. The influence of war on the development of neurosurgery. *Journal of Neurosurgery*. 2014; 120: 237-243.

<sup>3</sup> Stanworth P. A century of British military neurosurgery. *Journal of the Royal Army Medical Corps*. 2016; 162: 139-146.

<sup>4</sup> Pennybacker JB. The development of neurological surgery in Great Britain. *Seara Medica Neurocirurgia*. 1979; 8 (1): 1-8.

<sup>5</sup> Harrison M. *Medicine and Victory: British Military Medicine in the Second World War*. Oxford: Oxford University Press; 2004. p.275.

<sup>6</sup> Taylor J, Handa A. Hugh Cairns and the origin of British neurosurgery. *British Journal of Neurosurgery*. 2007; 21(2): 190-196.

<sup>7</sup> Hughes JT. Sir Victor Horsley (1857-1916) and the birth of English neurosurgery. *Journal of Medical Biography*. 2007; 15: 45-52.

<sup>8</sup> Cairns H. Treatment of head injuries in war. *British Medical Journal*. 1940; 1(4146): 1029-1030.

<sup>9</sup> Ballance C. The Society of British Neurological Surgeons – Remarks and Reminiscences. *British Medical Journal*. 1927, 1(3444): 64-67.

## **World War 1**

World War 1 favoured neurological research due to the sheer volume of casualties, the main example being the ability of Gordon Holmes (1876-1965) and Percy Sargent (1879-1933) to map the brain's visual cortex from over 400 cases of occipital gunshot wounds.<sup>10</sup> Holmes was a neurologist with the British Expeditionary Force (BEF) and at London's Hospital for Nervous Disease, Queen's Square. Sargent was his neurosurgical colleague in London. Together they had 'an unparalleled opportunity to be of service to the individual wounded, but when this is all over, to make a contribution to the physiology, neurology and surgery which will be epochal'.<sup>11</sup> Despite the valuable accumulation of this knowledge, the outcome for the patient was generally poor which is not surprising as protective steel helmets were only issued in late 1915.<sup>12</sup> In 1917, fifteen per cent of casualties on the Western Front sustained intracranial injuries which was estimated to need 300 working neurosurgeons.

One solution proposed by the Americans, towards the end of the war, was a 70-day intensive brain surgery course for their army doctors plus the development of an army manual outlining clinical diagnoses and surgical techniques.<sup>13</sup> It was essential that head wounds were explored, all dead tissue excised, often with the wound left open and secondary closure undertaken.<sup>14</sup> Although 230 surgeons graduated from this rudimentary course only three continued to practice neurosurgery full-time after the war, which also reflected a similar situation in Britain's low number of pure neurosurgeons.<sup>15</sup>

The post-operative mortality rate of soldiers sustaining penetrating head injuries was 50 per cent mainly due to sepsis and most cases were dealt with by general surgeons who turned their skills to brain surgery.<sup>16</sup> It was recognised that head wounds should be explored as quickly as possible though there was no uniform policy. The plight of those men who developed paraplegia from spinal cord injuries was equally dire if not worse. It was estimated that one third died in France, another third died within six weeks of their injury and the remaining third died within the year from sepsis due to pressure sores or urinary tract infections.<sup>17</sup>

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<sup>10</sup> Lanska DJ. Historical Perspective: Neurological Advances from Studies of War Injuries and Illnesses. *Annals of Neurology*. 2009; 66(4): 444-459.

<sup>11</sup> Sargent P, Holmes G. Preliminary notes on the treatment of the cranial injuries of warfare. *British Medical Journal*. 1915; 1(2830): 537-541.

<sup>12</sup> Op't Eynde J, Yu AW, Eckersley CP, Bass CR. Primary blast wave protection in combat helmet design: A historical comparison between present day and World War I. *PLoS One*. 2020; 15(2): e0228802.

<sup>13</sup> Hanigan WC. Surgery of the head and 70-day brain surgeons. *Neurosurgery*. 2003; 53(3): 713-722.

<sup>14</sup> Aminoff MJ. *Victor Horsley: The World's First Neurosurgeon and his Conscience*. Cambridge: Cambridge University Press; 2022. p.157.

<sup>15</sup> Dowdy, Pait. The influence of war, 2014 (Note 2).

<sup>16</sup> Schurr P. The evolution of field neurosurgery in the British Army. *Journal of the Royal Society of Medicine*. 2005; 98: 423-427.

<sup>17</sup> Lanska. Historical Perspective, 2009 (Note 10). p.445.

It is important to acknowledge the influence of Harvey Cushing (1869-1939), considered the father of modern neurosurgery and who, at the beginning of the twentieth century, developed many of the basic techniques for operating on the brain. Cushing was appointed to the professorial chair of surgery at Harvard Medical School in 1912. He was initially director of the US Base Hospital attached to the BEF in France before being promoted to Lieutenant Colonel in June 1918 and Colonel in October 1918, and assigned as senior consultant in neurological surgery for the American Expeditionary Force in France. He reported his extensive experience on the Western Front and set out a definitive approach to tackling head injuries concluding that the ‘earlier a cranial operation is performed the less likelihood there is of sepsis’ thus leading to a better outcome.<sup>18</sup>

Despite the depressing mortality and morbidity figures neurosurgeons Dowdy and Pait argue that ‘the sheer volume of patients with craniospinal trauma’ helped ‘solidify neurosurgery’s position alongside other specialties’.<sup>19</sup> There was significant progress in the diagnosis and treatment of peripheral nerve injuries though the poor outcomes were more reflective of the technical methods used. Essential lessons were learnt in respect to surgical exposure of peripheral nerves from basic transplantation and suturing techniques.<sup>20</sup>

### **Inter-war years**

The influence of Harvey Cushing in the development of neurosurgery cannot be underestimated. He dedicated himself solely to surgical neurology and his philosophy was that neurosurgeons should do the same. One of his major principles was that the neurosurgeon should always attempt to make a diagnosis by preoperative studies, and they should undertake their own neurological and radiological assessments. This was in order to understand the clinical problem and an attempt to predict any potential surgical and neurological complications.<sup>21</sup> This practice did not receive favour with neurologists who could be obstructive, resulting in delays in some surgeons being allowed to operate.<sup>22</sup>

One of Cushing’s major merits was to introduce meticulous care and technical efficiency with gentle handling of tissues whilst maintaining good haemostasis.<sup>23</sup> His mantra was ‘do no harm where you cannot do good’ similar to Hippocrates’ *primum non nocere*. Some of his procedures took hours to perform in contrast to Horsley whom Cushing considered to be very hurried and messy.<sup>24</sup> In the inter-war period most general surgeons were unconvinced by Cushing’s delicate and what were considered

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<sup>18</sup> Cushing H. Notes on penetrating wounds of the brain. *British Medical Journal*. 1918; 1(2982): 221-226.

<sup>19</sup> Dowdy, Pait. The influence of war, 2014 (Note 2). p.140.

<sup>20</sup> Dowdy, Pait. The influence of war, 2014 (Note 2). p.140.

<sup>21</sup> Tailor, Handa. Hugh Cairns, 2007 (Note 6). p.192.

<sup>22</sup> Pennybacker. Development of Neurological Surgery, 1979 (Note 4). p.3.

<sup>23</sup> Tailor, Handa. Hugh Cairns, 2007 (Note 6). p.190.

<sup>24</sup> Aminoff. *Victor Horsley*, 2022. (Note 14). p.172.

to be overly slow and plodding techniques.<sup>25</sup> Many surgeons viewed the speed in operating to be essential since anaesthetic was unpredictable and potentially dangerous, with lengthy operations also increasing the risk of post-operative sepsis.<sup>26</sup>

Notwithstanding these concerns, there was a small number of surgeons who would take up the challenge to establish neurosurgery in Britain. Most of the literature regarding the development of neurosurgery tends to concentrate on the role of three particular individuals. The first two were Hugh Cairns (1896-1952), a Rhodes scholar from South Australia, and Norman Dott (1897-1973), a Scot, both of whom spent a year (at different times) working with Cushing in the US and adopted his clinical principles. The third was Geoffrey Jefferson (1886-1961), based in Manchester, whose success was due to his knowledge of neuroanatomy and neurophysiology being self-taught from the writings of Cushing. Each had his particular strength as summarised by Joseph Burford Pennybacker (1907-83), Cairns' successor at Oxford: 'Dott was probably the best technical surgeon; Jefferson had the most genial personality and philosophical turn of mind; but Cairns was the great teacher'.<sup>27</sup>

Other doctors were involved in neurosurgery as evidenced by the establishment and membership of the SBNS as well as records of surgical activity which will be discussed later. Many of them remained general surgeons 'with an interest' but this group could be said to have 'lit the flame [of neurosurgery] and to have nourished it until the time when specialist neurosurgical centres could be set up'.<sup>28</sup> That time would not be until after WW2 and it was the big three who spearheaded neurosurgical development in Britain by their prolific writings and involvement with governmental planning for the war.<sup>29</sup>

## **Society of British Neurological Surgeons**

This society was created at a meeting in The Athenaeum Club, London in 1926.<sup>30</sup> There were fourteen founding members, all with some neurosurgical experience. The driving force behind the establishment of the society had been Jefferson who was to draw up its constitution.<sup>31</sup> Dott was elected a founder member despite not being present at the inaugural dinner, and Cairns finally became a full member of the society

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<sup>25</sup> Stone JL, Patel V, Bailes JE. Sir Hugh Cairns and World War II British advances in head injury management, diffuse brain injury, and concussion: an Oxford Tale. *Journal of Neurosurgery*. 2016; 125: 1301-14.

<sup>26</sup> Taylor, Handa. Hugh Cairns, 2007 (Note 6). p.193.

<sup>27</sup> Pereira EAC, Green AL, Stacey RJ, Aziz TZ. Great Hospitals of Europe: The Oxford Radcliffe. *World Neurosurgery*. 2010; 74: 407-413.

<sup>28</sup> Pennybacker. Development of Neurological Surgery, 1979 (Note 4). p.7.

<sup>29</sup> Weiner M-F, Silver J. St Hugh's Military Hospital (Head Injuries), Oxford 1940-1945. *Journal of the Royal College of Physicians of Edinburgh*. 2017; 27(2): 183-189.

<sup>30</sup> Society of British Neurological Surgeons (SBNS) – About Us – History. <https://www.sbns.org.uk/index.php/about-us/history/>

<sup>31</sup> King TT. *A History of the Society of British Neurological Surgeons, 1926 to circa 1980*. London: Society of British Neurological Surgeons; 2017. p.65.

in 1931. The meetings occurred twice a year at different venues in the country, occasionally venturing onto the continent. In his history of the SBNS, King writes:

The discussion after each presentation was traditionally described as the most important thing but the social side, the opportunity to keep in touch with others struggling with clinical and administrative difficulties of introducing a new specialty must, at this time, have been the most important contribution of the society.<sup>32</sup>

Establishing these new units faced opposition from both neurologists and general surgeons. Dott struggled to get beds and though appointed in the mid-1920s he initially had to take his surgical patients to a private hospital. It was only in 1938 that the first neurosurgical unit was opened in Edinburgh.<sup>33</sup> Jefferson had similar problems being originally appointed to Salford with four beds and only the occasional access to an operating theatre. Although he was given beds on an orthopaedic ward at the Manchester Royal Infirmary in 1926, he had to wait until 1932 before getting his own theatre there.<sup>34</sup> Cairns was initially appointed to the London Hospital as a general surgeon in 1926 but after his year with Cushing sought to establish himself as a specialist neurosurgeon.<sup>35</sup> Despite publishing his first neurosurgical paper in 1928 for the Medical Research Council in which he set out neurosurgical principles, the London Hospital finally allowed him an operating list in 1933. At this time, Cairns:

... fought with immense courage and energy against general surgical orthodoxy to establish the first neurosurgical unit in a teaching hospital along the 'Cushing lines'. This marked the birth of neurosurgery as a distinct specialty in London.<sup>36</sup>

Cairns' difficulties with accessing beds were completely resolved with his move to Oxford in 1937 as the foundation Nuffield Professor of Surgery at the new clinical medical school, all of which was financed by the generosity of Lord Nuffield (1877-1963).<sup>37</sup>

The SBNS had begun as both a scientific and professional group of surgeons struggling in a new and difficult field: an individual doctor's financial survival was bound to be a risky prospect in the absence of a socialised health service where facilities were not easily provided or obtained and remuneration was for item of service. Neurosurgical operations tended to be longer than previously encountered in hospitals thus making difficult demands on theatre and anaesthetic time.<sup>38</sup> The war would highlight the inadequacy of Britain's neurological provision, both medical and

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<sup>32</sup> King. *History of the Society*, 2014 (Note 31). p.13.

<sup>33</sup> King. *History of the Society*, 2014 (Note 31). p.7.

<sup>34</sup> King. *History of the Society*, 2014 (Note 31). p.66.

<sup>35</sup> King. *History of the Society*, 2014 (Note 31). p.11.

<sup>36</sup> Taylor, Handa. Hugh Cairns, 2007 (Note 6). p.190.

<sup>37</sup> Boulton R, Handa A. From Motorcars to Surgery: A Historical Review of the Late Lord Nuffield. *Annals of the Royal College of Surgeons of England*. 2013; 95: 10-13.

<sup>38</sup> King. *History of the Society*, 2014 (Note 31). p.53.

surgical as well as psychiatric. As a close knit, co-operative group of surgeons the SBNS was able to provide activity figures for the war years from fourteen units which would go on to influence the development of neurosurgical service provision in the new NHS post-WW2.<sup>39</sup>

### **Establishing the specialty**

World War 2 would provide a considerable fillip for the development of neurosurgery as a specialty. At the forefront of developments were Cairns, Jefferson and Dott. Dott had been spared the horrors of WW1 as a road traffic accident had left him with a permanently injured leg thereby rendering him unfit for service. During those war years he had remained at medical school, graduating in 1919.<sup>40</sup> Jefferson qualified in Manchester and then moved to Canada in 1914 but, at the outbreak of WW1, he returned to Europe. He initially worked in the Anglo-Russian Hospital in Petrograd, Russia before joining the Royal Army Medical Corps in France.<sup>41</sup> Cairns, who had commenced medical school at the age of fifteen, joined the Australian Army Medical Corps in 1914 as a corporal midway through his fourth year. He served in support of the Gallipoli campaign and returned at the Australian government's behest to finish his medical studies in 1916, graduating the following year.<sup>42</sup> He would later compare the physical stress of being Cushing's resident to that of his experience of serving on the Gallipoli Peninsula.<sup>43</sup>

Since the early 1930s Cairns had been a civilian consultant neurosurgeon to the Queen Alexandra Military Hospital, Millbank but it was only in 1938 that he was appointed as advisor to the War Office on the care of head injuries in the armed forces.<sup>44</sup> Cairns' familiarity with and understanding of the military paved the way for him to influence the development of neurosurgical services during the war. Early in 1939, Jefferson and Cairns were appointed as consultant advisors to the Ministry of Health with the responsibility for the organisation of neurological services for the country during the impending war.<sup>45</sup> Jefferson was given the duty of providing a neurological service for the civilian population, thus becoming its sole organiser working with the Emergency Medical Service, which had taken charge of voluntary and local hospitals. This was a useful position for the specialty as it provided an opportunity to influence government health policy, especially as Jefferson continued in this role after the war.<sup>46</sup>

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<sup>39</sup> SBNS. *Notes on the Neurosurgical Needs of the Population and the Training of the Neurosurgeon*. Manchester: printed by Percy Brothers Ltd, The Hotspur Press; 1947. p.9.

<sup>40</sup> Anon. N. M. Dott. *British Medical Journal*. 1973; 4(5895): 787.

<sup>41</sup> Schurr PH. Sir Geoffrey Jefferson (1886-1961): A Founder of British Neurosurgery. *Journal of Medical Biography*. 2000; 8: 156-161.

<sup>42</sup> Attwood JE, De Luca GC, Hope T, Jeyaretna DS. Sir Hugh Cairns: a pioneering collaborator. *Acta Neurochirurgica*. 2019; 161: 1491-95.

<sup>43</sup> Tailor, Handa. Hugh Cairns, 2007 (Note 6). p.192.

<sup>44</sup> Stone, Patel, Bailes. Sir Hugh Cairns, 2016 (Note 25). p.1303.

<sup>45</sup> King. *History of the Society*, 2014 (Note 31). p.18.

<sup>46</sup> King. *History of the Society*, 2014 (Note 31). p.18.

## World War 2

Dott's role during WW2 was confined to ensuring the provision of neurosurgical services in Scotland, and to this end he established and became director of the Brain Injuries Unit at Bangour Emergency Medical Services Hospital near Edinburgh. His technical innovations included developing a special ventilation apparatus for his operating theatre. He also insisted on his department being fully equipped with staff and facilities for occupational therapy, speech therapy and social work, aiming to rehabilitate his patients and return them to civilian life, thereby taking a very holistic approach to his patients' care.<sup>47</sup> Rehabilitation for neurosurgical patients was essential but had previously been neglected. However, it would be expanded during the war and afterwards.

In his role as organiser of services for England, Jefferson created twelve new special head centres, situating them away from the towns where bombing was anticipated. These centres were designed to treat war casualties as well as providing a service for the normal civilian demands on a neurosurgical service and their activity figures would provide a yardstick for the future. He introduced two measures that were considered controversial at the time; firstly, head injuries needed to be notified to the local Medical Officer of Health. The second and more contentious measure he introduced was that all major head injuries should be transferred to a head centre. This was not popular but resulted in a beneficial outcome for the patients who did not come to any of the anticipated harm from being transferred.<sup>48</sup> He carried out 'pastoral visits' which amounted to inspections. The overall success of his actions is shown in Table 1 which summarises the total volume of neurosurgical activity undertaken by these units during WW2.

Total Admissions	32,491
Head Injuries (excluding Battle Casualties)	11,644
Brain Tumours	6,839
Brain Abscesses	706
Spinal Tumours	795
Neuralgias	1,827
Sciaticas	2,627

Table 1. Analysis of admissions to fourteen centres from 1 July 1940 to 30 June 1945. The units were: Birmingham, Bristol, Chase Farm (London Hospital), Derby, Farnborough (London Postgraduate Hospital), Hayward's Heath (National Hospital, Queen's Square), Hill End (St Bartholomew's), Manchester, Newcastle-upon-Tyne, Oxford, Sheffield, and Winwick (Lancashire), plus Glasgow and Bangour, Edinburgh. SBNS. *Notes on the Neurosurgical Needs*, 1947 (Note 39).

<sup>47</sup> Ah-See RCW, Wright D, Demetriades AK. Norman Dott: three vignettes on the making of a master neurosurgeon. *British Journal of Neurosurgery*. 2020; 34(3): 346-352.

<sup>48</sup> Schurr. Sir Geoffrey Jefferson, 2000 (Note 41). p.158.



By way of comparison, Table 2 is an analysis of neurosurgical cases undertaken in one institution, St Bartholomew’s Hospital, which relocated to Hill End, St Albans during the war. These figures are taken from their archival theatre registers.<sup>49</sup> Between July 1937 and August 1939, four theatres were in operation and neurosurgical procedures were divided between the visiting general surgeons. After the war, the surgery was undertaken by a dedicated neurosurgeon. The missing dates (June to August 1948) are due to the fact that the register at Hill End was poorly kept during that summer, especially in August, for no apparent reason except possibly the imminent commencement of the NHS. The activity in this table is grouped as per Cairns’ article for the Medical Research Council about neurosurgery with a miscellaneous category which included nerve repairs, sympathectomies, ventriculography, and other investigations including angiography.<sup>50</sup> It shows a dramatic increase in the number of cases undertaken after the war and after the inception of the NHS, highlighting the fact that neurosurgical problems were not as uncommon as previously thought.

Procedure	Jul 1937 to Aug 1939	Sep 1946 to May 1948	Sep 1948 to Feb 1950
Intracranial	6	35	82
Neuralgias	2	5	10
Head Injuries	0	2	14
Spinal Cord Operation	4	43	96
Miscellaneous	10	22	80

Table 2. Neurosurgical procedures undertaken at St Bartholomew’s Hospital and Hill End Hospital, St Albans. Surgery registers, Barts Health Archive (Note 49).

The contributions of Jefferson and Dott to neurosurgery during the war were concerned with the development of services on the home front which would be essential for post-war provision. The evidence of work volume in Table 1 meant that the days of the general surgeon ‘with an interest’ undertaking neurosurgical operations were over and service provision would inevitably have to change with obvious benefits to the patient. Cairns’ team used basic scientific and therapeutic research in their holistic approach to neurosurgical patient care looking at service provision, rehabilitation, and long-term follow-up.

<sup>49</sup> St Bartholomew’s Hospital. General Surgery registers. Barts Health Archives. SBHB/TH/3/4, SBHB/TH/4/4, SBHB/TH/5/4, SBHB/TH/6/4 (July 1937 to August 1939); Hill End Hospital. Surgery registers. Barts Health Archives. SBHB/TH/16/6-7 (September 1946 to May 1948 & September 1948 to February 1950).

<sup>50</sup> Cairns H. *A Study of Intracranial Surgery*. Medical Research Council. Special Report Series No. 125. London: HMSO; 1929.

## **The Oxford contribution**

The articles written about Cairns unanimously paint a picture of an energetic, driven, charismatic, organised and far-sighted individual. His move to Oxford allowed him to use those talents to make Oxford a world-class centre for neurosurgery and scientific medicine.<sup>51</sup> There were several factors that facilitated the development within these fields. Cairns gained the necessary political and military trust plus the considerable financial backing from Lord Nuffield to make his vision a reality and he had the skills to be able to carry out critical organisational planning and implementation.<sup>52</sup> This would culminate in the opening of St Hugh's College, Oxford as a Military Hospital in February 1940. It was this move that would influence the whole of post war British neurology and neurosurgery.

Initially, the hospital opened with 50 beds rising to 430 by the time of the D-Day landings in June 1944.<sup>53</sup> During the course of the war 13,000 head injury cases were treated there. This provided a rich source of clinical material, invaluable not only for training but also for research purposes. Cairns encouraged collaboration with different university departments, working with outstanding researchers (including Florey and Guttman, both discussed later) who in turn were delighted to have access to patients, leading to very fruitful collaborations.<sup>54</sup> He facilitated the collaboration of Peter Medawar (1915-87) who would win a Nobel Prize in 1960 and John Zachary Young (1907-97). Their work on nerve grafting and regeneration established immunological principles which underpin the modern field of organ transplant surgery.<sup>55</sup>

Cairns' influential wartime studies in prevention and treatment of traumatic brain injury (TBI) would eventually produce very practical results claiming the lowest fatality rates from TBI of any major army during WW2.<sup>56</sup> Initially the results at St Hugh's Military Hospital were poor due to delays in adequate definitive surgical treatment.<sup>57</sup> This led Cairns to establish Mobile Neurosurgical Units (MNSUs) in the various theatres of war. Though not exhaustive the areas that would have their outcomes improved for future neurosurgical patients can be divided into several broad groups: preventive, investigative, therapeutic and rehabilitative.

Probably the most significant preventive outcome was related to work on the design and subsequent mandatory wearing of crash helmets by despatch riders during the war and subsequently by all motorcyclists after the war.<sup>58</sup> This was an area that Cairns had been involved in since the untimely death of TE Lawrence (1888-1935) from a head injury due to a road traffic accident.<sup>59</sup> The results were an improvement in the outcome for head injuries and reduction in fatalities. On the investigative front,

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<sup>51</sup> Anon. Sir Hugh Cairns – An Appreciation. *The Manchester Guardian*, 21 July 1952. p.5.

<sup>52</sup> Stone, Patel, Bailes. Sir Hugh Cairns, 2016 (Note 25). p.1301.

<sup>53</sup> Stone, Patel, Bailes. Sir Hugh Cairns, 2016 (Note 25). p.1301.

<sup>54</sup> Weiner, Silver. St Hugh's Military Hospital, 2017 (Note 29). p.183.

<sup>55</sup> Attwood *et al.* Sir Hugh Cairns, 2019 (Note 42). p.1495.

<sup>56</sup> Lanska. Historical Perspective, 2009 (Note 10). p.449.

<sup>57</sup> Cairns H. Neurosurgery in the British Army 1939-1945. *British Journal of Surgery*. 1947; 55(Suppl 1): 9-26.

<sup>58</sup> Tailor, Handa. Hugh Cairns, 2007 (Note 6). p.195.

<sup>59</sup> Stone, Patel, Bailes. Sir Hugh Cairns, 2016 (Note 25). p.1303.

electro-encephalography was introduced as part of research into the management of post traumatic amnesia and epilepsy. There was also research on the side effects of antiseptic use and the development of acrylic resins for post-operative skull repair.<sup>60</sup>

There were two important areas of therapeutic intervention that would be transformational for the specialty. The first related to managing head injuries along Cushing's principles with the aim being to excise non-viable brain tissue and close the majority of head wounds within the first 24 hours after injury. Cairns' implementation of the MNSUs in each theatre of war provided the opportunity to achieve this important aim, in keeping with the principle that the first operation on the brain should be the definitive one with the consequence of improving outcomes. Any further operation carried much greater risks of complications.<sup>61</sup> One other major advantage of the MNSUs was related to the level of experience gained by those neurosurgeons involved.

The Gillingham papers covering neurosurgical practice during the war are archived at St Hugh's College, Oxford. They provide extensive details of the activity of various MNSUs and subsequent patient follow-up data. Table 3 gives a breakdown of cases seen in the North African MNSUs between December 1942 and March 1943. The striking features from this archive relating to MNSUs include the overall number of cases seen in such a short period of time, the level of clinical detail in each set of case notes (which were all typed up) and the fact that post-mortem examinations were undertaken very soon after death with the results being used as a reflective learning exercise. In all the operative cases, sulphonamide powder was used successfully to reduce infection.<sup>62</sup>

Combat cases	126
Non-combat cases	61
Psychiatric cases	6
Deaths	14
Cases requiring surgery	116

Table 3. Cases seen in MNSU No. 4, North Africa, December 1942 to March 1943. Gillingham Papers (Note 62).

The second major therapeutic breakthrough in infection prevention and control came from Cairns' collaboration with a fellow South Australian Howard Florey (1898-1968) on the use of penicillin intra- and post-operatively which would improve

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<sup>60</sup> Green FHK, Covell G. *Medical Research*. History of Second World War. London: HMSO; 1953. p.82.

<sup>61</sup> Hughes JT. Hugh Cairns (1896-1952) and the mobile neurosurgical units of World War II. *Journal of Medical Biography*. 2004; 12: 18-24.

<sup>62</sup> Gillingham Papers. Gillingham Case Notes – Loose, 1942-1944. St Hugh's College Archives, University of Oxford. HHA GIL 1/1/1.

outcomes for all surgical patients.<sup>63</sup> Florey was Professor of Pathology at Oxford and subsequently a Nobel Laureate for his antibiotic work. The penicillin programme was one of the largest wartime initiatives and is without doubt among the most successful research and development trials ever.<sup>64</sup> Cairns' insistence on the attention to detail in documentation of patients' condition, signs, symptoms and follow-up irrespective of location has been well documented. This would provide a useful resource for assessing the efficacy of the various management strategies used during the war as well as being a major source for reflection on clinical practice.

Physical rehabilitation had previously been relatively ignored but was key to long-term outcomes. Ludwig Guttman (1899-1980), a renowned German Jewish neurosurgeon, had joined Cairns' team as a refugee though was not allowed to operate. One could argue that this was a blessing in the long run as he undertook pivotal research on body temperature control and skin blood flow in paraplegics. His research on bedsores and bladder management would have a dramatic effect on the outcomes of spinal injury patients and their return to a useful life. His inception of regular two-hourly patient turning has had long term benefits not only for paraplegic patients but also for those chronically immobilised. The two hours related to the length of time it took to go from one end of the hospital to the other turning patients before starting again. In a WW1 study of 400 paraplegics, all were dead by twelve months. A follow-up study in WW2 of 2,500 combat paraplegics showed that three-quarters were alive twenty years later, emphasising the invaluable development of comprehensive rehabilitation.<sup>65</sup> As a result of his work at Stoke Mandeville, Guttman would set up games which would lead to the Paralympic Games. As Weiner wrote 'What Cairns and his team of gifted neurologists and neurosurgeons achieved in such a short period of time is extraordinary'.<sup>66</sup>

## **Conclusion**

It has been argued that war medicine is considered to be conservative in its practice with the main aim being to get soldiers back into combat in as little time as possible.<sup>67</sup> In WW1 medical specialisation had been encouraged as a way of using resources more economically and to get men back into combat as soon as possible. WW2 brought to light as never before the inadequacy of neurological services provision, both medical and surgical as well as psychiatric, in Britain. The wartime approach to head injuries, use of antibiotics, crash helmets, appropriate usage of beds and rehabilitation were changes that would not be reversed in the post-war era when the population's expectations in terms of medical care would become irrevocably changed. One of the most striking aspects that came to light in this study was the number of neurosurgical

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<sup>63</sup> Stone, Patel, Bailes. Sir Hugh Cairns, 2016 (Note 25). p.1308.

<sup>64</sup> Cooter R, Harrison M, Sturdy S. *War, Medicine and Modernity*. Stroud: Sutton; 1998. p.204.

<sup>65</sup> Lanska. Historical Perspective, 2009 (Note 10). p.455.

<sup>66</sup> Weiner, Silver. St Hugh's Military Hospital, 2017 (Note 29). p.189.

<sup>67</sup> Harrison M. Medicine and the management of modern warfare. *History of Science*. 1996; 34(4): 379-410.

beds in the country, which rose from 85 to 400 in London, 30 to 145 in the northwest, and 50 to 210 in Glasgow and Edinburgh during WW2.<sup>68</sup>

World War 2 highlighted the previously poor and haphazard provision of neurological services as a whole. Wartime experience had also shown that neurosurgical conditions were not as rare as previously thought. Cairns, Jefferson and Dott had laid the foundations during the war for modern neurosurgery to be accepted as a specialty. Jefferson's attention to detail and documentation produced figures which were subsequently incorporated into a SBNS document produced in 1947 assessing the post-war neurosurgical needs of the population and the training of future neurosurgeons.<sup>69</sup> These wartime achievements would be used to continue developing neurosurgical services in Britain and beyond to benefit all patients with neurosurgical problems.

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<sup>68</sup> King. *History of the Society*, 2014 (Note 31). p.20.

<sup>69</sup> SBNS. *Notes on the Neurosurgical Needs*, 1947 (Note 39). p.12.

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