HARVEY CUSHING AND ANAESTHESIA

DAVID A E SHEPHARD, M B , B S , D A *

For true philosophers, who are only eager for truth and knowledge, never regard themselves as already so thoroughly informed, but that they welcome further information from whomsoever and from whencesoever it may come

[William Harvey Dedication to "An Anatomical Disquisition on the Motion of the Heart and Blood in Animals," 1628]

THE WORDS OF WILLIAM HARVEY illuminate the nature of the great physician and neurosurgeon, Harvey Cushing "Author, educator, philosopher, and leader,"¹ Cushing lived between 1869 and 1939, and became the leading neurosurgeon of his day His influence reached far beyond his own field of neurosurgery, and many and lasting were his contributions to medicine "For a lifetime a student,"² he was always "eager for truth and knowledge," and ready to "welcome further information" wherever it might be found This was the greatness of the man He acquired knowledge of all fields related to neurosurgery, and his desire "to see all round his subject," to quote Kocher,³ was a mark of his genius One related specialty was that of anaesthesia, and here his contributions were original and valuable Through his work on anaesthetic records, blood-pressure measurement, monitoring, and regional anaesthesia, Cushing achieved a prominent place in the history of medicine His work has its own inherent interest, and through appreciation of it, one gains an insight into his personality It is the purpose of this essay to present the contributions of Cushing to anaesthesia in this light

EARLY ANAESTHETIC RECORDS

Harvey Cushing's experiences with the administration of anaesthesia began when he was a medical student He described his first experience vividly

My first giving of an anaesthetic was when, a third-year student, I was called down from the seats and sent in a little side room with a patient and an orderly and told to put the patient to sleep I knew nothing about the patient whatsoever, merely that a nurse came in and gave the patient a hypodermic injection I proceeded as best I could under the orderly's directions, and in view of the repeated urgent calls for the patient from the amphitheatre it seemed to be an interminable time for the old man, who kept gagging, to go to sleep We finally wheeled him in I can vividly recall just how he looked and the feel of his bedraggled whiskers The operation was started and at this juncture there was a sudden great gush of fluid from the patient's mouth, most of which was inhaled, and he died I stood aside, burning with chagrin and remorse No one paid the slightest attention to me, although I supposed that I had killed the patient To my perfect amazement I was told it was nothing at all, that I had nothing to do with the man's death, that he had a strangulated hernia and had

*From Department of Neurosurgery and Neurology, Montreal Neurological Institute and McGill University, Montreal

been vomiting all night anyway, and that sort of thing happened frequently and I had better forget about it and go on with the medical school. I went on with the medical school but I have never forgotten about it.⁴

This dramatic description illustrates the general condition of anaesthesia at the end of the nineteenth century, it was accepted as the nature of things by all but a few.⁵ Among these few was Cushing himself. He never forgot this initial depressing experience, and when, as a Junior House Pupil at Massachusetts General Hospital in 1895, his job was to anaesthetize for surgeons of his service, he wasted no time in improving the technique of administering ether. He joined in this with E. A. Codman, who was also appalled by the hazards of anaesthesia, in Cushing's words, "what an awful business it was and how many fatalities there were."⁴ The two interns competed to see who could give the most satisfactory anaesthetic.

Cushing wrote:

We determined to let the test of satisfactory anaesthesia rest with the patient's behavior in the ward and though I have forgotten just what was our scale of marking the cases, a perfect anaesthesia was supposed to be one in which the patient was sufficiently conscious to respond when left in the ward with the nurse and did not subsequently vomit.⁴

He also added

I think we both became very much more skilful in our jobs than we would otherwise have become, owing to this competition, but it was particularly due, I think, to the detailed attention which we had to put upon the patient by the careful recording of pulse rate throughout the operation.

Thus originated "ether charts," the first anaesthetic records.

As Cushing indicated,⁶ it was Codman who kept the first of such records. Beecher,⁷ in his valuable account of the contributions of Codman and Cushing, stated that the earliest of these was dated November 1894. The records included observations of pulse and respiration, comments on drugs previously administered, and notations of the amount of anaesthetic required and physical signs such as pupillary size and the presence of mucus. Cushing followed this plan, adding his own significant observations. A study of his records* illustrates Cushing's approach to them, and provides us with a glimpse of his personality.

The earliest record to be found is dated April 5, 1895 (Fig. 1), an ordinary ward chart was used, and the pulse and respiration were recorded at five-minute intervals. A record from June 1, 1895 (Fig. 2), gave more detail: note was made of premedicant drugs, pupillary size, and the rate of pulse and respiration. The amount of chloroform and its duration were shown, and a comparison was drawn between the effects of chloroform and ether, this patient having previously received ether. The latter record underlines Cushing's readiness to learn the essential signs of anaesthesia, and his ability "to see all round his subject." Significantly, the record concerned a patient suffering from a cerebellar tumour, a disease Cushing was later to study and treat so brilliantly, and we see the glimmerings of the future neurosurgeon: vivid and meaningful is his critical observation, "Was not radical enough."

*Preserved in the Treadwell Library of Massachusetts General Hospital, Boston

FIGURE 1. Treadmill record of Harvey Cushing's anaesthesia records dated April 5, 1895 (Treadmill record).

Another interesting record is one dated July 16 (Fig 3) The case was that of a patient with a cerebral tumour, one of the first Cushing had seen One senses from the sureness of the handwriting, characteristically neat and artistic, his excitement in placing on record his own observations of the physical signs and something of the surgical technique On the back of the record he added "No disturbance during op Did not have to hold up jaw nor stertor Elliot said never had less bleeding in opening No vomiting after operation" It is not surprising that he wrote emphatically across the record, "Best case ever had"

This record is interesting in another way The comment, "Quality of pulse changed tension diminished," while a significant observation, was also the most accurate indication Cushing could then give of the blood pressure, and it was not until 1901 that he was able to translate such observations into verifiable figures In that year Cushing became the first to add blood-pressure observations to anaesthetic records Here, Cushing was able to make his own individual contribution, for him, the anaesthetic record was part of a physiological study

Only in this way can we gain any idea of physiological disturbance—whether given manipulations are leading to shock, whether there is a fall of blood-pressure from loss of blood, whether the slowed pulse is due to compression, and so on ⁸

The readiness to learn from available data is apparent, and he could give advice which is valid today

I still feel that one of the most important elements in the giving of an anaesthetic is to have the anaesthetist keep during its administration a detailed chart of pulse, respiration, and blood-pressure ⁴

Such anaesthetic records were then, as they are today, of inestimable value In perspective, the merit of the early charts of Codman and Cushing has been indicated by Fulton "they stand historically as one of the principal American contributions to the technique of surgery" ⁹

BLOOD-PRESSURE MEASUREMENT

During 1900 and 1901, Harvey Cushing visited Europe, and this postgraduate year saw the development of Cushing the physiologist Methods of blood-pressure measurement were foremost in Cushing's thoughts, and when he visited Italy in 1901 he made a point of visiting Riva-Rocci, who had designed the cuff sphygmomanometer Simplicity and portability were advantages of this over other manometric devices Cushing recognized its value immediately, and by the end of 1901 he had introduced the new method of sphygmomanometry into the wards, as he was later to introduce it to the operating-rooms, of the Johns Hopkins Hospital ¹⁰ In this way Cushing was responsible for another important contribution to the field of anaesthesia

The understanding of the place of the sphygmomanometer was part of Cushing's foresight he saw beyond the horizons of his day and recognized the needs of the future Today the blood pressure is recorded as part of the routine care of patients, very different was the situation at the beginning of this century The climate of ignorance is epitomized in W T Councilman's nebulous invitation to

Cushing to address Bostonian surgeons on the subject of blood-pressure measurement, and to "speak of the advantages of knowing just what the heart is doing in surgical operations generally"¹¹ The climate of orthodoxy is indicated by the terse reaction of a Harvard Medical School committee set up to study the question of whether such measurements were necessary "The adoption of blood-pressure observations in surgical patients does not at present appear to be necessary as a routine measure"¹² However, an editorial in the Boston Medical and Surgical Journal was more promising

It may be that Dr Cushing takes an enthusiastic view of the matter in his prediction that in appropriate cases the routine observation upon blood-pressure will soon come to occupy the same position that pulse and temperature observations occupy at present, but enthusiasm is necessary to the introduction of any new procedure in medicine, and for this enthusiasm we are duly grateful¹³

Cushing himself could afford to be patient, and his attitude is amusingly illustrated by his apt quotation from Oliver Wendell Holmes' "Stethoscope Song"

Now such as hate new-fangled toys
Began to look extremely glum,
They said that rattles were made for boys,
And vowed that his buzzing was all a hum⁴

Cushing knew that the introduction of blood-pressure measurement would lead to an improvement in medical care, just as the introduction of anaesthetic records had led to improvement in the technique of administration of anaesthesia Now the "quality" and the "tension" of the pulse, which earlier could only be described in words, could be recorded by figures Incorporated into a more comprehensive anaesthetic record, they would permit the anaesthetist and surgeon to

obtain, graphically represented, data concerning the patient's condition in almost exact correspondence with that which the physiologist gains during an experiment by having an animal's carotid in connection with a mercury manometer whose level is being constantly recorded on a revolving drum⁶

Cushing's paper "On Routine Determination of Arterial Tension in Operating Room and Clinic"¹⁴ set out the advantages of routine sphygmomanometry For the *surgeon*, "procedures which tend to upset in any way the cardiovascular apparatus, whether directly by loss of blood, or indirectly through insults to its nervous mechanism, will be recorded with fidelity, and if harmful their continuance or repetition avoided" In neurosurgery, a rise in intracranial pressure, perhaps requiring operative intervention, might be signalled, while during an operation the extent to which manipulation could safely be carried out might be indicated In abdominal surgery, intra-abdominal manipulation was recognized as affecting the circulation Shock, too, might be anticipated and avoided, surgical mortality could be reduced

For the *anaesthetist*, advantages accrued from the study of the effects of anaesthetics on blood pressure Cushing himself knew that chloroform tended to lower blood pressure, ether having the opposite effect For anaesthesia in neurosurgery, he preferred his anaesthetist to use ether, although it tended to cause greater blood loss, ether was thought to be safer than chloroform, which produced a

useful, but dangerous, degree of hypotension. Similarly, for cases of shock, Cushing stressed the hypotensive danger of chloroform, again preferring ether. This is interesting in view of the current debate concerning choice of anaesthesia for cases of shock, in which similar arguments are put forth. In addition, routine sphygmomanometry put on record the fall in blood pressure owing to spinal anaesthesia.

Concerning the *medical student*, Cushing the teacher felt strongly that

If the introduction of some method of instrumental estimation of blood-pressure changes in clinical cases does nothing other than serve to keep the student's mind alive to the physiological principles of the circulation and to make clinical observations on the cardiovascular apparatus more nearly in accord with his earlier experiences in the physiological laboratory, its routine use needs no greater justification.

Thus did Cushing present sound and logical arguments for the introduction of routine measurement of blood pressure, as with anaesthetic records he anticipated the accepted practice in anaesthesia today.

MONITORING

With the introduction of sphygmomanometry into the operating-room, Cushing became the first to monitor the progress of a patient with instruments, as well as with the five senses. The hesitation of the majority to accept such "new-fangled toys" was explained by Cushing:

The belief is more or less prevalent that the powers of observation so markedly developed in our predecessors have, to a large extent, become blunted in us, owing to the employment of instrumental aids to exactness, and the art of medicine consequently has always adopted them with considerable reluctance.¹⁴

Cushing insisted that, for accurate interpretation of data, "the tactile and muscular sense, no matter how well trained, must give way to some method more precise."¹³ Sphygmomanometry was one such method.

Another form of monitoring advocated by Cushing was "the continuous auscultation of cardiac and respiratory rhythm during the entire course of anaesthesia."¹⁵ Concerning *precordial monitoring* he wrote:

We have, of late, in all our cerebral operations followed the custom of having the etherizer constantly auscultate the heart. This is accomplished by strapping the transmitter of a phonendoscope to the precordium. From this a long tube passes to the aural receiver which is held against the auricle. This is much more satisfactory than the usual supervision of cardiac action by the occasional palpation of the pulse for which a hand must be disengaged.⁸

Like the anaesthetic record and sphygmomanometry, this was an innovation which not only provided the anaesthetist with ready information, but which also led to greater safety of the patient. His "etherizer," Dr S. Griffith Davis, was complimented in this respect: "It is entirely due to his skill that in over three hundred cranial operations there has been a complete absence of the calamities usually ascribed to anaesthesia."¹⁵ The comment was typical of Cushing's respect for good anaesthesia and for expert anaesthetists, what progress had Cushing witnessed since the sad day when as a student he gave his first anaesthetic!

Precordial monitoring has an interesting origin. According to Cushing, "The

idea arose from a practice in the Hunterian Laboratory of auscultating the heart during the production of experimental valvular lesions"¹⁵ This laboratory, in the medical school of the Johns Hopkins Hospital, has, according to Fulton,⁹ been considered to be "one of Cushing's most significant contributions to American surgery" It was designed as part of a course to teach students the essentials of surgical management Cushing described the aims and philosophy of this instruction, something of which can be gleaned from the following remarks on what he hoped the students would achieve

They learn to keep records, to present and discuss case histories intelligently, to visualize from such a history the actual condition of the patient They learn to prepare all of the supplies necessary for an operation and by actual experience the way of conducting it They learn to appreciate the risks of anaesthesia, and the need of untiring concentration upon his task by the administrator thereof ¹⁶

All was directed towards the student's ultimate aim to "learn to care kindly and properly for a living patient"

It is interesting to note that in this laboratory another form of monitoring was used, namely the recording of temperature Again Cushing anticipated the methods of today

REGIONAL ANAESTHESIA

During his surgical residency, Cushing became interested in the possibilities of local anaesthesia Undoubtedly the memory of his first anaesthetic appalled him, and as he could do little to alter the pattern of administration of anaesthesia (still to a large extent the responsibility of students), he set himself to master the use of cocaine for infiltration of operative sites It is characteristic of Cushing that he did this well, and two of his early papers^{17 18} impress one with his knowledge of the subject The second of these is a masterly exposition of the use of local anaesthesia for herniorrhaphy, the paper was enhanced by his own excellent illustrations The advantages and disadvantages of local anaesthesia was clearly described, and contraindications to general anaesthesia were appreciated The selection of local anaesthesia for certain cases followed logically Compassion also contributed to the selection of local anaesthesia, he recognized its value in seriously ill patients, such as those suffering from intestinal perforation in typhoid fever¹⁹ Cushing could not agree with "experts" who advocated restraint from surgical intervention "It is hard to agree with the statement that a patient should be left to his fate, no matter how desperate the condition, provided surgical intervention offers any chance of relief, forlorn as it may be"¹⁹ Indeed Cushing understood and used the tools at his command

He became an authority in the field of local anaesthesia, it has been said that he "rediscovered the principle of nerve blocking"²⁰ This is an interesting reference to the fact that, although he had worked with W S Halsted, who had first used cocaine for nerve blocking in 1884, Cushing "was utterly unaware that his chief had ever made studies on cocaine of any sort—so reticent was Dr Halsted about this matter and so little did questions of priority interest him"²⁰

It does appear, however, that Cushing was the first person to use the term

"regional anaesthesia" He wrote in 1902 that the "principle of 'blocking' nerve-trunks has been utilized for a long time as a means of producing anaesthesia over proposed operative fields by thus throwing out of function the sensory nerves radiating from it"⁶ He added significantly, "I would suggest that this be called 'regional anaesthesia' in contradistinction to 'local anaesthesia'" His suggestion was accepted and the term is widely used today

COMMENTARY

When Harvey Cushing died in 1939 at the age of 70, many acclaimed him He was eulogized in one obituary as being the "greatest of the great"¹ He was famous in his lifetime, and he will be remembered "as a great physician, as the founder of a school of neurosurgery and a humanist of unusual literary attainment"²¹

His achievements were many and this is part of his genius How many fields he covered, apart from his own specialty of neurosurgery! His contributions to anaesthesia have been discussed, is it not remarkable that in roentgenology he was also a pioneer,²² and that once, "he held the key to endocrinology"²² And in his leisure this man was a fine water-colour artist, a dedicated bibliophile, and of such literary excellence that his biography of William Osler²³ was awarded a Pulitzer Prize

His work on anaesthetic records, blood-pressure measurement, monitoring, and regional anaesthesia has been discussed here because of its lasting value But in studying his work, one also learns something of his nature His refusal to accept matters as they stood, his desire to improve the condition of medicine and the care of patients, his ability as an educator, and his compassion as a physician are all evident, as are the clarity and precision of his thinking and writing Above all, it seems that his genius lay in thoroughness as Penfield has said,²⁴ "no one has ever excelled Cushing in fastidious care and devotion to detail" His thoroughness led to success in all that he did Thompson aptly quotes one relevant opinion concerning his genius "His distinction is—and it is a distinction which places him for all time in the front rank of scientific investigators—that he has regarded and studied his specialty from every conceivable angle"²⁵

In the vocation and profession of medicine, Harvey Cushing achieved greatness His patients never forgot him, one wrote to him that, "The observation of a forgotten sage truly applies in your case, 'As one lamp lighteth another, so knowledge is diffused throughout the world'"²⁶ Nor will he be forgotten by the medical profession, for he fulfilled his responsibility most nobly Well did Harvey Cushing live up to the words of Francis Bacon

I hold everyman a debtor to his profession; from the which as men of course do seek to receive countenance and profit, so ought they of duty to endeavour themselves by way of amends to be a help and ornament thereunto²⁷

SUMMARY

Harvey Cushing, the great American neurosurgeon, made four important contributions to the specialty of anaesthesia He was one of the first to introduce anaesthesia records, he was responsible for the introduction of blood-pressure

measurement into operating-room practice, he developed the technique of precordial monitoring of patients undergoing surgery, and he was an authority on local anaesthesia, coining the term "regional anaesthesia." These aspects of Cushing's career have been discussed because of their inherent value, and because they lead us to an understanding of the nature of a great physician. A mark of his genius was the thoroughness with which he approached his neurosurgical work. His desire to understand every aspect of it led to his making important contributions to specialties outside his own. Not only did Harvey Cushing make neurosurgery safe, but this master surgeon also did much to improve the conditions of anaesthesia in his day. His contributions to anaesthesia are of lasting value, and the practice of anaesthesia today owes much to him.

RÉSUMÉ

L'anesthésiologie est redevable à Harvey Cushing, le grand chirurgien américain de quatre innovations d'importance considérable. Le premier, il a rédigé des dossiers anesthésiques, le premier aussi, il a saisi l'importance de la mesure de la tension artérielle durant la chirurgie. On lui doit d'avoir introduit à cet effet l'usage du sphygmomanomètre, inventé en Italie par Riva-Rocci. De plus, il a été l'instigateur de l'auscultation précordiale continue durant l'anesthésie. Enfin, ses travaux en anesthésie locale et régionale sont bien connus. C'est lui qui a proposé le terme d'anesthésie "régionale," terme qui ne tarda pas à être universellement accepté.

La valeur intrinsèque de ces innovations suffit à motiver leur présentation dans cet article, mais cet exposé veut aussi nous faire connaître la véritable dimension de ce grand homme qui fut tout à la fois un médecin génial, un artiste délicat, un bibliophile averti et un auteur remarquable. L'intransigeante conception qu'il avait de la neurochirurgie signe l'ampleur de son génie. Le besoin qu'il avait de connaître toutes les facettes de sa spécialité a fait de lui un novateur dans des disciplines autres que la sienne.

Harvey Cushing a non seulement rendu la neurochirurgie moins dangereuse, mais il a aussi grandement relevé les standards de l'anesthésie de son temps. Il en a aussi sûrement relevé les statistiques. L'effet bénéfique de ses contributions se fait sentir encore aujourd'hui. La sécurité de l'anesthésie moderne nous vient en bonne partie de lui.

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