HEMOSTASIS IN NEUROSURGERY

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"The confidence gradually acquired from masterfulness in controlling hemorrhage gives to the surgeon the calm which is so essential for clear thinking and orderly procedure at the operating table." Halsted

INTRODUCTION

The purposes of this article are two: first to list and evaluate the several devices employed by neurosurgery in the control of hemorrhage and, second, to show how neurosurgery has been led inevitably to utilize the clotting functions of blood itself as an aid to hemostasis and to interpret the more recent innovations by reference to those functions. In discussing the whole range of the hemostatic procedures of neurosurgery, a larger purpose is also thereby served, namely, to acquaint general surgery, and its other sub-branches, with the details of modern hemostasis without ligature. For it is a curious and inviting thought that the feature that most aptly distinguishes neurosurgery as a specialty is the control of hemorrhage without the use of the ligature. The delicate and pulpy nature of the central nervous system, the fineness and indispensability of its structures, the close confinement of the avenues of approach, and the relative depth at which work is done, all combine to make hemostasis with the ligature virtually an impossibility. It has fallen upon neurosurgery, therefore, to devise methods of bleeding control that are workable under the peculiar circumstances of its several fields of activity, with the result that an impressive catalogue of methods has grown up during the three-score years by which neurosurgery counts its age, each one in turn resulting in a drop in the mortality rates, a strengthening of surgical courage, and a shortening of the time consumed by an operation.

It is a mistake, however, to presume that the principle of hemostasis without ligature is modern in origin. On the contrary we have but reverted to the practices of the ancients and in a sense have regressed from the pinnacle to which, after a long struggle, surgery rose when in 1876 Lister introduced the chromicized catgut suture and Halsted in 1879 turned the use of that ligature into a delicate and discriminative procedure by inventing the modern hemostat. One of the "musts" of any surgeon's library is the attractive little book, The History of Hemostasis, by Samuel C. Harvey (1929), 27 which acquaints us with the story of the control of bleeding from the earliest recorded medical times until the turn of the present century. It will be found there that many of the methods described in this paper are but refinements of practices employed during that incredibly long journey by which our scientific ancestors progressed toward the final adoption of the principle of ligation of vessels.
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This study is concerned only with methods for accomplishing permanent hemostasis, not with the temporary control of bleeding during the course of an operation.

HEMOSTATIC METHODS

1. BONE WAX

It is altogether fitting that the introduction of bone wax to surgery should have been accomplished in a laboratory experiment by Victor Horsley while he was preparing for his career in neurosurgery (1885), prior to his appointment at Queen Square, prior even to the first of those ten initial intracranial operations\textsuperscript{30} by which he established both his fame and the essential hopefulness of brain surgery. A little note in the \textit{British Medical Journal} for 1892,\textsuperscript{31} written in response to an inquiry, recalls the event. Some technique of Magendie had given him the idea, and he tried modelling wax worked soft in the fingers on the free bleeding cut surface of the cranial bones in dogs. As such a proceeding instantly arrested the bleeding, he attempted to make an antiseptic compound for operations on man, which, however, was not satisfactory. He then enlisted the aid of a Mr. P. W. Squire to make experiments so as to arrive nearly at the tenacity of modelling wax, and in this he succeeded with the following formula: beeswax, 7 parts; almond oil, 1 part; salicylic acid, 1 per cent. Horsley added that it is nearly always sterilized by boiling before use, and kept in covered stoppered bottles.

2. THE CUSHING CLIP

"The thought has doubtless occurred to many that much time and trouble would be saved in major operations could there be devised some form of haemostatic clamp, the mere placement of which would leave a fine, knotted ligature on the bleeding point so as to obviate the alternatives which we now possess, either of leaving a pendent instrument or taking the time necessary for ligation." Thus wrote Cushing\textsuperscript{11} in 1911, by way of introducing the tiny implantable metal clip that has come to bear his name. Improvements there have been in manipulation of sutures and ligatures, including a simple form of the Singer sewing machine, but thus far nothing has appeared that produces a knotted ligature without digital effort, and the Cushing clip meanwhile has been put to an increasing number of uses "in operations during which vessels are necessarily divided at depths easily reached by a clamp but in positions awkward for ligation," and it now does real service in the thoracic and retroperitoneal spaces, in addition to its primary domain of the brain and spinal cord. Whereas, however, the metal clip had formerly to be used upon vessels of all sizes, and consequently in large numbers, it is now possible to coagulate the smaller vessels with the electric cautery and reserve the use of the clip to the occasional larger artery or vein, with consequent reduction of the numbers of implanted metallic "ligatures" and a noticeable improvement in the radiographs taken subsequent to operation, if not for any demonstrable physiological gain. Further inroads upon the use of the metal clip are