



History, Evolution, and Continuing Innovations of Intracranial Aneurysm Surgery

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Key words

- History
- Intracranial aneurysm
- Microsurgery
- Surgery

Abbreviations and Acronyms

ACoA: Anterior communicating artery

ICA: Internal carotid artery

ICG: Indocyanine green

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INTRODUCTION

Technological advancement has facilitated cerebrovascular neurosurgeons to address the broad spectrum of vascular disorders affecting the central nervous system. The development of intracranial aneurysm surgery has benefited from these innovations. The origin of modern aneurysm surgery was established when the first silver clip was placed on the neck of an intracranial aneurysm in 1936.¹⁻³ However, the foundations on which these operative principles were laid had been developed many generations back. The current study examined key historical landmarks that have shaped the way aneurysm surgery is practiced in the contemporary era.

THE HUNTERIAN PRINCIPLE OF CAROTID ARTERY LIGATION

The first transformative concept in the surgical treatment of intracranial aneurysms was based on the Hunterian principle of proximal ligation of the feeding artery. John Hunter (1728–1793), the Scottish scientist and surgeon, first

described this technique in 1748,^{4,5} when he induced thrombosis within the aneurysm in the peripheral arteries. When Astley Paston Cooper (1768–1841) of London applied this technique to treat a cervical aneurysm in 1805,⁶ the patient became hemiplegic and died a few weeks later. In 1808, Cooper⁷ persisted on a second attempt and “successfully treated” a pulsating tumor at the angle of the jaw. **Figure 1** outlines the key milestones in the surgical evolution of intracranial aneurysms since this period to the present day.

Early reports of aneurysm exposure were made only through serendipitous discovery during the surgical approach for other intracranial diseases. Victor Horsley (1857–1916) was among the first to report on these findings. In 1885, Horsley^{2,8,9} reported a giant internal carotid artery (ICA) aneurysm that was compressing the optic chiasm, which he treated using bilateral cervical carotid artery occlusion. Horsley later performed a carotid ligation procedure in 1902,¹⁰ when he operated on a presumed middle fossa tumor that was discovered to be an ICA aneurysm on surgical exposure.

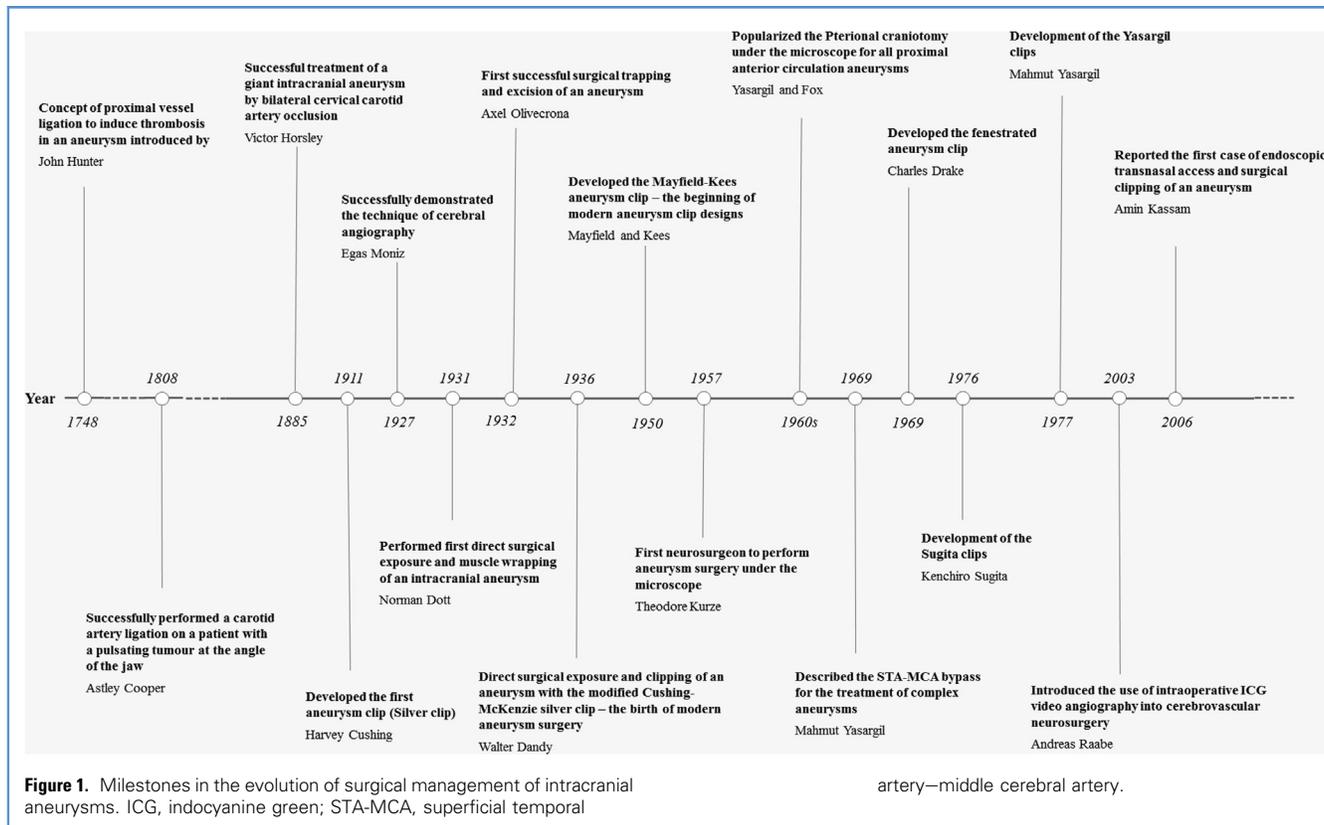
Despite the overall skepticism of many surgeons at the time, proximal carotid ligation gave the early cerebrovascular pioneers, for the first time, a treatment option for intracranial aneurysms.¹¹ Over time, this technique was refined. In 1905, William Halsted (1852–1922)¹² promoted

the idea of fractional ligation, in which “gradual” stricture of the carotid artery was performed to minimize surgical morbidity. This development gave rise to the invention of the Dott, Crutchfield, Selverstone, Kindt, and Drake vascular clamps or tourniquets (among others), which enabled surgeons to place the clamp across the artery and to gradually ligate them over a period of days.¹³⁻¹⁷

However, many surgeons remained doubtful of the therapeutic relevance of proximal carotid ligation for cerebral aneurysms. Throughout the mid-1900s, original research and reviews of the literature¹⁸⁻²⁰ showed that carotid ligation carried a high risk of operative morbidity and mortality. The rate of aneurysm obliteration was low, with success often limited to ICA aneurysms.¹⁸⁻²¹ Winn's report in 1977²² established no difference in the rate of rehemorrhage for those aneurysms that were treated by carotid ligation compared with those that were managed conservatively.

EXTENDING THE HUNTERIAN PRINCIPLE TO SURGICAL TRAPPING OF INTRACRANIAL ANEURYSMS

In 1932, Axel Herbert Olivecrona (1891–1980)^{23,24} performed the first successful unplanned surgical trapping and excision of a large posterior inferior cerebellar artery aneurysm. Based on this principle, Walter Edward Dandy (1886–1946)²⁵



successfully trapped a cavernous sinus aneurysm in 1935 by ligating the ICA within the neck, and then intracranially. Dandy²¹ was also credited for performing the first vertebral artery ligation beneath the atlas to treat a vertebral aneurysm in 1944. In 1948, Henry Schwartz²⁶ described his experience with a direct surgical approach to a large basilar artery aneurysm, which he successfully trapped using silver clips. Further, in 1956, Logue²⁷ ligated the proximal dominant anterior cerebral artery in patients with ruptured anterior communicating artery (ACoA) aneurysms. Later, Tindall et al.²⁸ described the ligation of the contralateral ICA in the neck to assist in aneurysm thrombosis in patients with ruptured ACoA aneurysms.

THE BEGINNING OF DIRECT SURGERY ON INTRACRANIAL ANEURYSMS

The technology available in the 1930s made direct surgery of intracranial aneurysms a significant undertaking. Ligatures and silver clips were the only devices developed at the time that were available in the

cerebrovascular neurosurgeon's armamentarium. The ability to maintain hemostasis in the event of aneurysm rupture was limited. Frustrated by the outcomes of Hunterian carotid ligation, Sir Norman McComish Dott (1897–1973) in 1931 planned and successfully treated a ruptured intracranial aneurysm by direct exposure and wrap reinforcement with muscle taken from the patient's thigh: a technique that he might have acquired from Harvey Williams Cushing (1869–1939) during his residency in 1923 and 1924.^{2,29,30} In a monograph published in 1925, Cushing³¹ had already reported the use of muscle to pack and wrap an intracranial aneurysm, combining this treatment with cervical carotid artery ligation during surgery for a suspected tumor in the region of the Gasserian ganglion.

Dott had already recognized that most aneurysms were located at arterial junction points and associated with vessel wall weakness.^{29,32} He advocated for conservative treatment for many anterior circulation aneurysms, but recommended carotid artery ligation for aneurysms located proximal to the circle of Willis, and “direct

operative exposure and application of muscle” for those distal to the circle of Willis.^{29,32}

During this period, other surgeons had also established their experience with direct surgery on aneurysms using muscle wrap reinforcement techniques.³³⁻³⁶ In 1934, Wilhelm Tonnis (1898–1978)³³ split the corpus callosum to cover the surface of an ACoA aneurysm with a piece of muscle. Similarly, in Ireland in 1936, Adams McConnell (1884–1972)³⁴ opened a subchiasmatal ICA aneurysm and packed it with muscle. The patient's vision was subsequently restored. Dutton³⁵ and Selverstone³⁶ introduced wrapping as a routine method for treating intracranial aneurysms that were difficult and not amenable to direct clip ligation.

THE BIRTH OF SURGICAL CLIPPING OF INTRACRANIAL ANEURYSMS

In 1911, Harvey Cushing³⁷ described the use of silver clips to occlude when a ligature could not be made to encircle the vessel. However, it was not until 1937

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