J Neurosurg 92:1056–1064, 2000

Historical vignette

Origin of the Drake fenestrated aneurysm clip

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The development of the Drake fenestrated aneurysm clip is a study in the history of ideas. This communication outlines the conception and solution of a surgical problem involved with the clipping of large basilar tip aneurysms. Dr. Charles G. Drake's ability to modify old ideas and experiment with new ones was instrumental to the conceptual idea of a fenestrated clip. Dr. Frank H. Mayfield and Mr. George Kees, Jr. played essential roles in bringing the idea to a reality. The development of the fenestrated clip has added substantially to the armamentarium of the aneurysm surgeon in dealing with large and complex aneurysms.

KEY WORDS • Dr. Charles G. Drake • fenestrated aneurysm clip • history of aneurysm surgery

WHAT a man leaves after him are the dreams that his name inspires and the works that make his name a symbol of admiration—Paul Valéry (French poet)

The Problem

BY 1969 Dr. Charles G. Drake had had extensive experience and a large international referral practice associated with the clipping of supratentorial[1,2,14,16–18,22] and infratentorial, predominantly basilar bifurcation,[2,4,7–9,12,13] aneurysms. In the spring of that year two similar patients were admitted to his neurosurgical service at Victoria Hospital in London, Ontario, Canada, with especially complex, large basilar bifurcation aneurysms. Both individuals were admitted within 2 weeks after suffering subarachnoid hemorrhages and were good-grade patients. At subtemporal exploration, the bulbous origins of both aneurysms were easily exposed and separated from perforating vessels located beside and behind the aneurysm necks in the interpeduncular fossa. At that time, the surgical approach that was used to place a clip on an upward-projecting bifurcation aneurysm was to separate the P_1 segment of the PCA from any adherence to the side of the aneurysm neck, with its perforating vessels lying behind. Then the opened posterior blade of the clip could be inserted underneath the P_1 segment anteriorly, so that it could slide across the back of the aneurysm neck, in front of the perforating vessels, and be allowed to close on the neck against the anterior blade, flush with the origin of the neck and the medial origin of the opposite P_1 segment.[8]

In each case, however, the ipsilateral P_1 segment was densely adherent to the transparently thin neck and waist of the aneurysm. In the first patient, who had been placed in a state of deep hypotension, gentle attempts to free the P_1 segment from its adherence resulted in a small tear in the aneurysm neck without serious bleeding. The exposed portion of the aneurysm was covered with gauze including some packed behind it in the interpeduncular fossa. The operative findings in the second patient were identical to those of the first patient, in that the adherent P_1 segment could not be separated safely and the aneurysm was encased in gauze. Both patients recovered uneventfully, but each died of rebleeding within 2 months of each other. These two cases demonstrated that the problem of how to clip a large basilar bifurcation aneurysm with a fragile neck and an adherent P_1 segment had not been solved.

A New Case: The Solution

On August 20, 1969, Mr. Lee Carlisle Mitchell, a 46-year-old production engineer suffered a subarachnoid hemorrhage while in a pool in Hawaii. Cerebral angiography demonstrated a giant basilar bifurcation aneurysm. The patient was initially referred and transferred to Dr. J. Lawrence Pool's service at Columbia Presbyterian Medical Center in New York City. Pool called Drake concern-

Abbreviation used in this paper: PCA = posterior cerebral artery.

ing the case and asked him to review the films. In the operative note (1969), Drake outlined his opinion:

> The more I looked at the aneurysm, the more I thought that the clip might be placed across the base of the sac above the origins of the two posterior cerebral arteries. This would leave a small amount of the fusiform enlargement of the basilar bifurcation but it might well spare him from the threat of rebleeding for years. If not for his life.

On reviewing the angiogram the aneurysm looked almost identical to the those of the other two patients mentioned previously, with both P_1 segments riding up the sides of the aneurysm sac.

Dr. David W. Rowed, Drake's junior resident at the time, comments:

> I do recall Dr. Drake deliberating about the angiograms that Dr. Poole had sent from New York and discussing them with John Alcock. I am sure you will recall Dr. Drake's habit of ruminating about clinical problems with his pipe clenched in his teeth, or with an Upman's No. 1 in his hand. In this instance the problem was that of a funnellike expansion of the terminal basilar artery with the P_1s effectively arising out of the proximal portion of the aneurysm sac. Dr. Drake felt that he could probably offer Mr. Mitchell significant protection from rebleeding if he could get a clip to sit across the proximal portion of the sac, maintaining patency of the P_1s even if the clip wasn't precisely flush with the "neck" of the aneurysm. To do this, particularly from his preferred subtemporal approach, made it very difficult to work around the proximal P_1 on the ipsilateral side . . . . (Rowed DW, personal communication, 1999)

Dr. A. Loren Amacher, Drake's chief resident, reminisces:

> . . . . at times he [Drake] would grumble about the danger of letting close the usual clips in just the situation demonstrated by this patient, and why couldn't he have a clip with an opening of some kind? We would talk about it, how it might be designed—whether it should be double or simple action (Dr. Drake felt that a double-action clip would be too hard to open easily) and whether the clip blades should be flat or round (the concern about a round clip was the risk of lateral twisting with the loop there, and torquing off the neck of the aneurysm). (Amacher AL, personal communication, 1999)

As Drake later commented:

> In brooding over the problem I knew I would be faced with, *it came to me while playing with a Mayfield clip, that [the] P_1 need not be dissected free at all if an opening could be made at the take off of the clip blades from their handle wherein [the] P_1 could be accommodated* [italics added] while remaining blade lengths fell upon the neck beyond, providing that length just crossed the closed neck of the aneurysm about 1.5 × its diameter. (Drake CG, personal communication, 1998)

At this time, Drake was using the Mayfield clip frequently when he believed a basilar bifurcation aneurysm could be clipped.[4,8] Drake attempted to bend a number of Mayfield clips, trying to make a suitable aperture and ruining several in the process. "On the spur of the moment," after reviewing the angiogram, Drake called Dr. Frank Mayfield in Cincinnati and outlined the problem to him. Drake asked if Mr. George Kees, Jr., the engineer who worked with Mayfield, could create a small aperture at the origin of the clip blades to contain the P_1 segment. He outlined the measurements of the aneurysm neck and the size of the aperture needed to contain, but not compress, the PCA. It was Drake's understanding that Mayfield and Kees focused their resources on the problem and, by the end of the week, three fenestrated clips arrived by express mail, differing in length by approximately 1 mm. No correspondence concerning the interaction between Mayfield and Drake exists related to the development of the fenestrated clip; all information was relayed by "telephone conversation and request" (Drake CG, personal communication, 1998).

With these three fenestrated clips in hand, arrangements were made to transfer the patient from the Columbia Presbyterian Hospital to Victoria Hospital. In the operative note (1969) Drake wrote:

> I discussed the whole problem carefully with the son and daughter and then with the family when they arrived, and it was elected to go ahead and explore the lesion. I thought this was quite a reasonable thing to do but I made no bones about the fact that we might have to back out, however, the situation might arise where our hands would be forced.

The patient, a professional engineer, was intrigued with the idea of being the first patient in whom this new clip would be used and was anxious to get on with it (Drake CG, personal communication, 1998).

The Operation

The patient was taken to the operating room on Monday September 8, 1969. Using a right temporal craniotomy with a lumbar drain and administration of mannitol, the brain fell away without difficulty and the aneurysm was explored. Drake described the technique used to dissect and clip the aneurysm in his operative note (1969):

> It was a simple matter to get around in front but the front aspect of the aneurysm looked thicker but it and the upper aspect of the basilar artery were yellow color, presumably with atheroma. One perforator was taken off the posterior aspect of the aneurysm quite easily, and another arising from the origin of the posterior cerebral artery came away fairly easily too. This left a single perforator running straight up the lateral aspect of the aneurysm for about 7–8 mm. Before it angled off into the brain area. This was the only perforator that lay between us and the possible application of the clip, and I thought it reasonable to attempt to free it. It freed fairly well at the base up for 3 or 4 mm. But then became more densely attached. There still wasn't enough of it free to get a clip laid beneath it so I persisted in an attempt to free this perforator and finally got a pinhole opening in the side of the aneurysm. This stopped up readily enough by simple packing with a small pattie while we continued the dissection. *I felt we were even more committed now and I tried the new clip for size which Mr. Kees had made for me and the largest one seemed to have blades which would cross the neck of the aneurysm. This clip has an opening at its base such that the posterior cerebral artery could lie in the opening and not be occluded by blades which lie beyond* [italics added]. After picking up the perforators as far as I could from the aneurysm where they arose from the base of the posterior cerebral artery, the blades of this clip were then gradually worked across the base of the aneurysm just above the origin of the right posterior cerebral artery. When I could see the posterior cerebral artery well within the circle of the opening the blades were allowed to close. In looking at the situation after, as far as I could tell the posterior cerebral artery lay within the opening and I have no question but that the blades are across the base of the aneurysm. The base of the aneurysm was large enough, of course, that I was blind on the far side although I had felt it with a blunt hook and I couldn't feel any obstruction. Our concerns are whether or not the perforators on the right side are free or whether unseen perforator on the far side was occluded or that the tip of the clip may possibly have encroached on the left posterior cerebral artery.

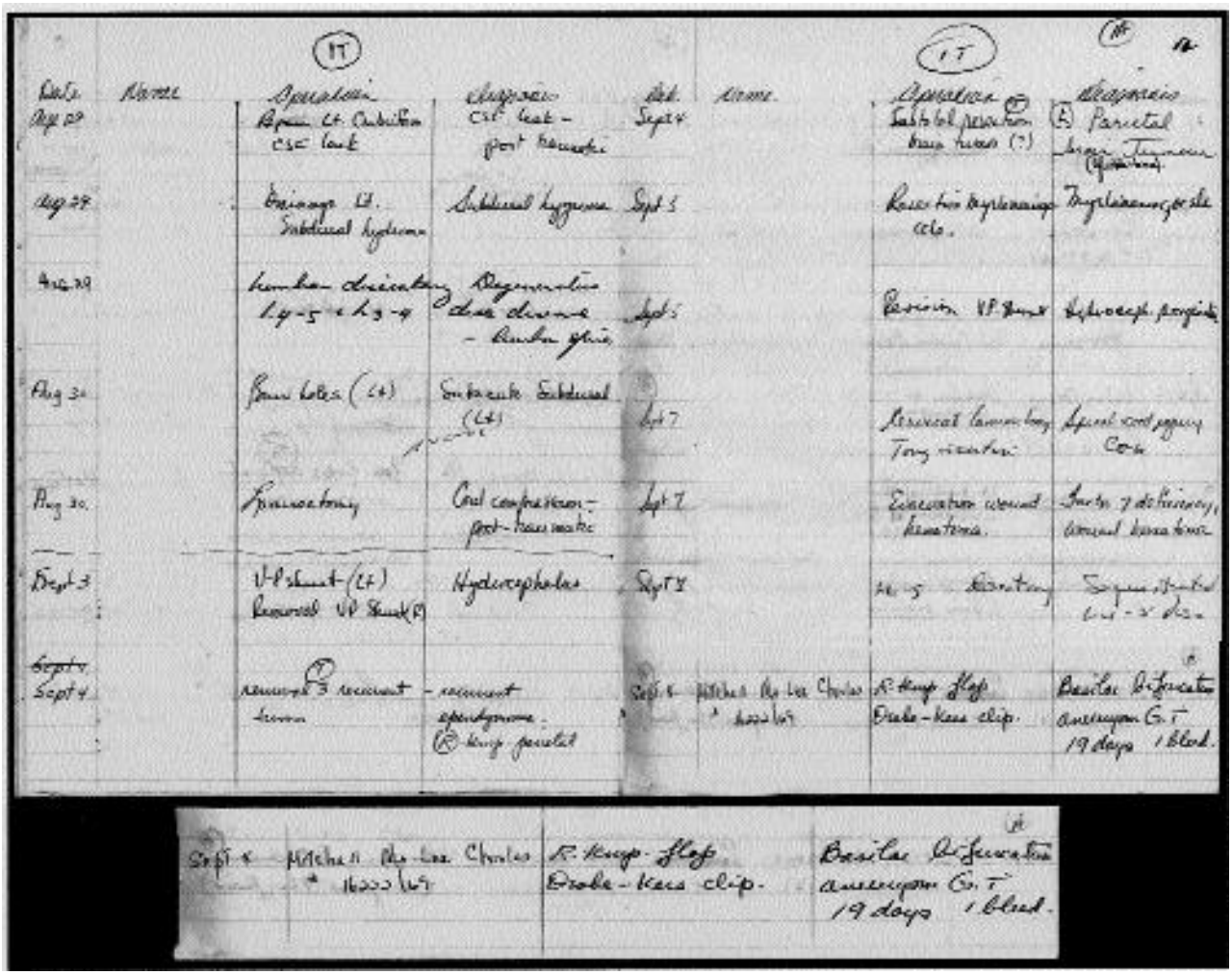

FIG. 1. Pages from Drake's operating room book (August 29–September 8, 1969). Beginning in 1951 Drake maintained operating room books containing records of the varied surgical cases with which he was involved. On September 8, 1969 he documented the first case in which the Drake–Kees clip was used.

The patient awakened in the recovery room bright, alert, and orientated with a third nerve palsy.

Beginning in 1951, Drake had a policy of recording all neurosurgically treated cases in hardcover books. On September 8, 1969 he documented the first case in which the "Drake–Kees clip" was used (Fig. 1). It was also his policy to keep personal written records of all his aneurysm cases. After the operation he would outline the lateral and anteroposterior view of the aneurysm and associated vessels directly from the angiogram in pencil and then outline the vessels in blue ink and the aneurysm sac in red ink. This would be followed by personal notes on the patient's history, the operative technique used, notes on the patient's postoperative progress, and subsequent follow-up data. This information was kept in three-ring binders and used extensively as the database for all his clinical studies, which culminated in a monograph on posterior circulation aneurysms.[15]

Drake's written records on the first case in which the fenestrated clip was used are revealing (Figs. 2 and 3). They outline the aneurysm's shape and size, neck width, and relationship to the posterior cerebral vessels. In red ink, Drake documented that deep hypotension (40 mm Hg for 10 seconds and 50 mm Hg for 20 seconds) had been used and that he "felt committed" to clip the aneurysm after a "tiny hole in side of aneurysm" was made. He underlined in red ink the comment, "Applied new Drake–Kees clip."

He included a small drawing of the clip and the mechanism of the clip's usage. The record outlines the simplicity of concept of the clip's design, the complexity of placing the ipsilateral PCA in the aperture, and the need not to include perforating vessels or the contralateral PCA with the clip blades.

Postoperative Course

The postoperative and subsequent course of this patient can be followed by reviewing Drake's notes (Figs. 2 and 3). The patient was confused on postoperative Day 2 and a paralysis of upward gaze was noted. On September 20,

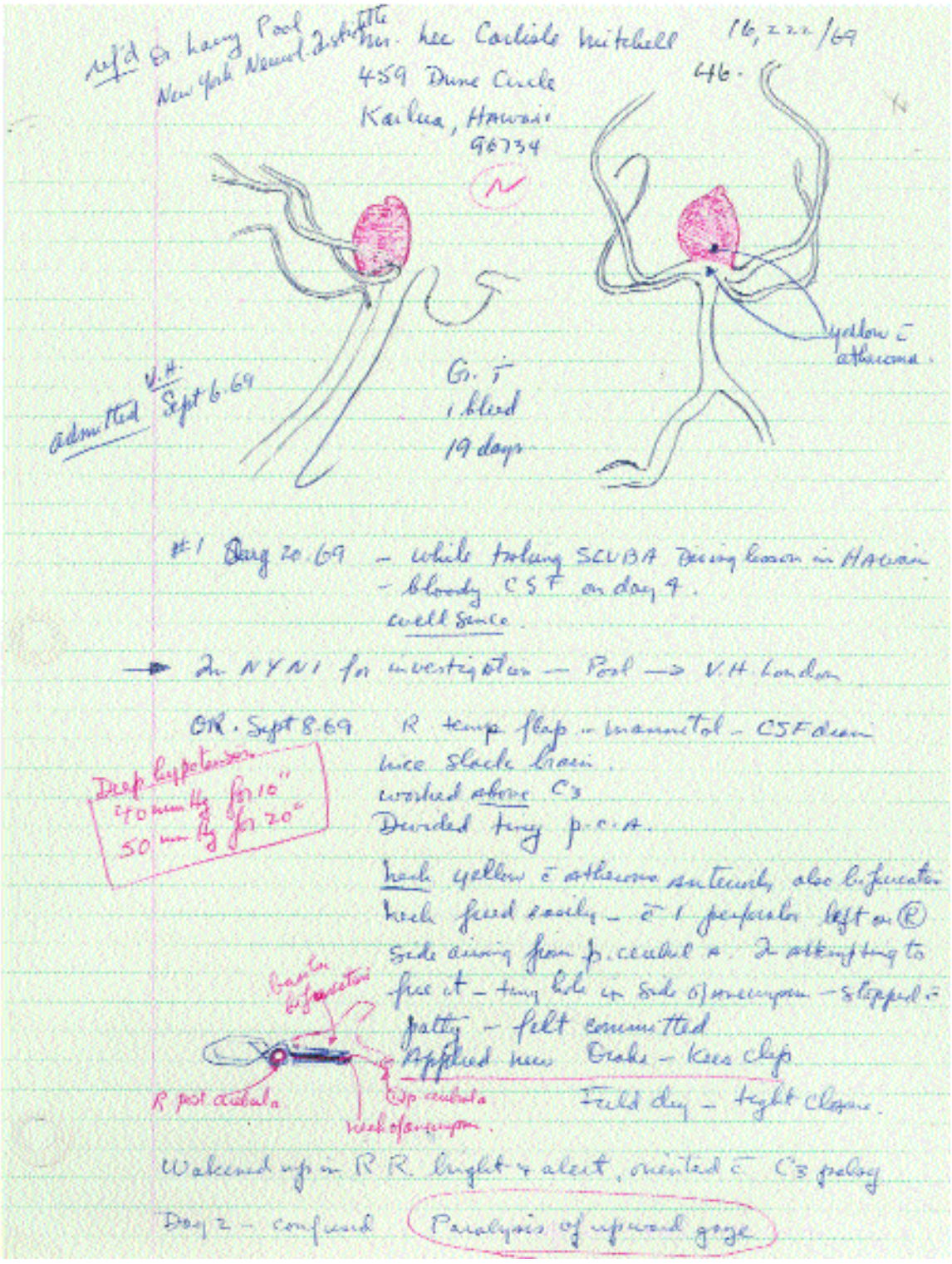

FIG. 2. Notes on the first patient in whom a fenestrated clip was used. Drake kept personal records of each aneurysm case. This page contains drawings that outline the shape and size of the aneurysm, as well as records on the patient's history, the operative technique used, and the patient's initial postoperative progress. In the *left lower* corner Drake outlined the mechanism of the clip's usage.

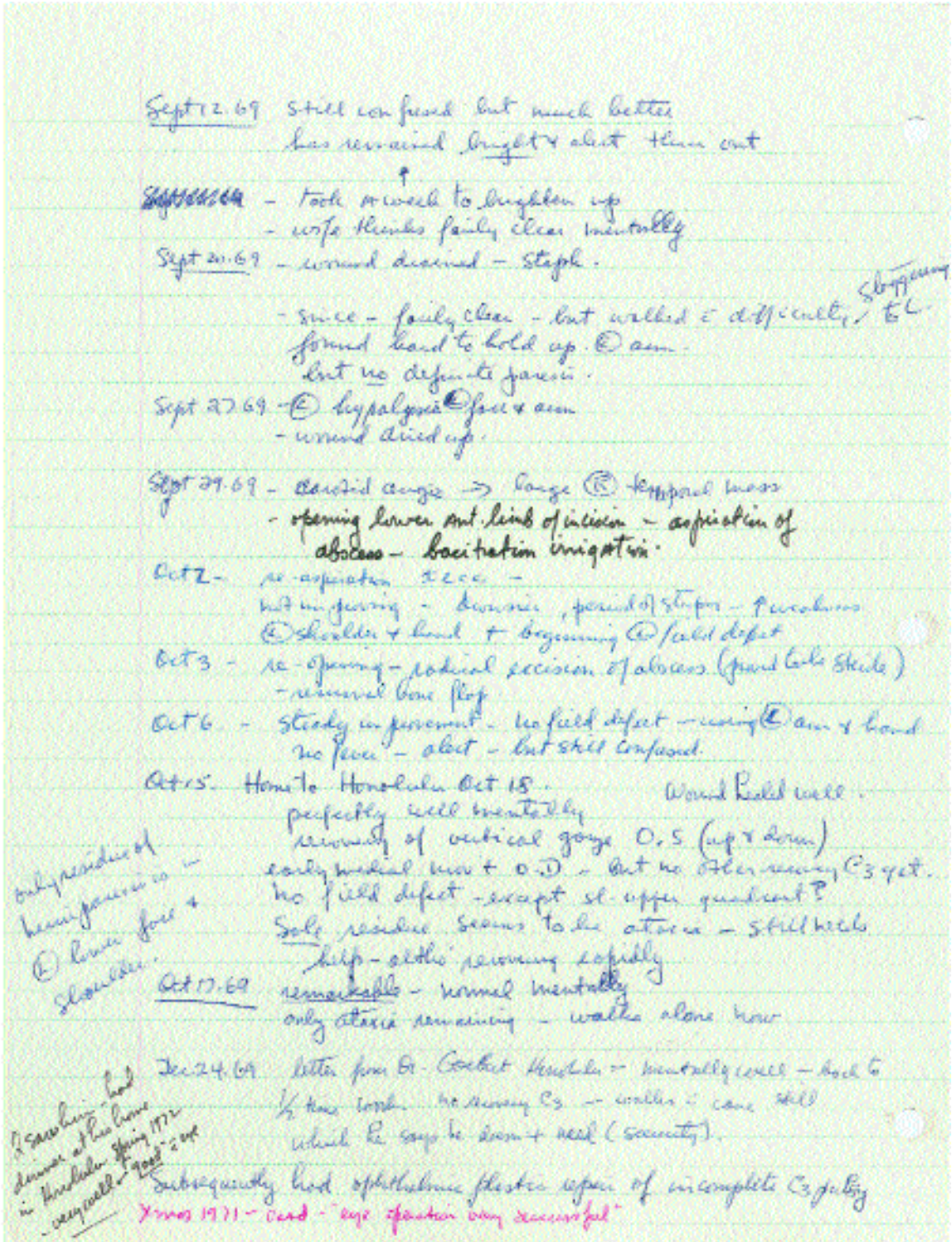

FIG. 3. Continuation of the notes shown in Fig. 2, providing the patient's postoperative course and follow-up data.

the patient's wound drained material from which *Staphylococcus aureus* was cultured. He experienced a left-sided weakness and underwent aspiration of a temporal lobe abscess on September 29 and October 2, and excision of the abscess and bone flap removal on October 3. The patient progressively improved and was discharged from the hospital on October 18.

Bilateral vertebral angiography was performed on September 17. In an operative note written on September 29, 1969, Drake comments:

FIG. 4. The first photograph of a fenestrated clip, which was referred to as a modified Mayfield clip, published by Drake in 1973. Reproduced with permission from Drake CG: Management of aneurysms of posterior circulation, in Youmans JR (ed): **Neurological Surgery.** Philadelphia: WB Saunders, 1973, Vol 2, p 792.

> The postoperative films done a week later showed the clip to be in very good position just above the base of the aneurysm and occluding the fundus entirely. The blades of the clip were about a millimeter short of completely occluding the far side and a tiny little stream of dye gets just by the end of the clip for about a millimeter or two but then stops. *I think to all intents and purposes the aneurysm has been obliterated and his [the patient's] future would be secure as far as rebleeding is concerned* [italics added].

Drake carefully followed the patient's progress. In December 1969, Mitchell had returned to work half time and, subsequently, underwent corrective surgery for a partial third nerve palsy. Dr. and Mrs. Drake "saw him—had dinner at his home in Honolulu, Spring 1972. Very well—'good' with eye." (Fig. 3, added note in *lower left*). Mitchell lived a full life and died of a heart condition in March 1995 at the age of 72 years.

Epilogue

The first picture of the fenestrated clip was published by Drake in a chapter entitled "Management of aneurysms of posterior circulation" in Volume 2 of *Neurological Surgery*, edited by Dr. Julian Youmans and published in 1973 (Fig. 4).[6] The preoperative and postoperative angiograms obtained in Mitchell were included, demonstrating the PCA passing intact through the fenestration in the clip (Fig. 5). In the chapter, Drake referred to the clip as a modified Mayfield clip. The first illustration demonstrating the technique of clipping a basilar bifurcation aneurysm by using a fenestrated clip was published by Drake in 1978, 9 years after its development (Fig. 6).[11]

It is interesting that in an historical article related to the Mayfield clip written by Mayfield and Kees in 1971, the Drake modification of the clip is not mentioned.[20] The clip was commercially available in lengths up to 24 mm from the Kees Surgical Specialty Co. (Alexandria, KY) and was known as the Drake–Kees clip. It was not long before Drake discovered that many intracerebral structures could be safely preserved within the fenestration.[5,10] Every major intracranial artery, small branches, perforating vessels, optic and third cranial nerves, even other clip blades found their way into the fenestration (Fig. 7). In these and other articles, the clip is referred to as the Drake–Kees clip or the Drake clip.[5,10,11,24,25]

Some giant aneurysms had necks that were impossible to obliterate. Drake commented:

> A few years later, I watched five long strong clips with a piggy back clip still opening and closing on the pulsations of the neck of a huge carotid ophthalmic aneurysm because the thickness of the neck at their fulcra kept the clips tips part. *While playing with a fenestrated clip on my thumb crease I realized all I had to do was move the fulcrum (at the outside of the fenestration) out on the neck where the blades could close completely, then that portion of the neck remaining open in the fenestration could easily be obliterated by adding a shorter straight clip over it* [italics added]. Within a few minutes the long clips were removed and replaced with only the two clips in tandem and the aneurysm could be collapsed by aspiration. This tandem technique largely solved the problem of many giant aneurysms whose necks were soft enough to be collapsed."[5] (Fig. 8) (Drake CG, personal communication, 1998)

The history of the Drake clip followed the old adage *Nihil simul inventum est et perfectum* (Nothing is invented and perfected at the same time). The clip had a number of problems. Drake demonstrated the clip's usage to Dr. Kenichiro Sugita when the latter visited London and outlined the problems with the clip:

> I used the clip for him when he visited here—showing him the problems with it—handles too wide—blades also (view obscuring)—and the need for maneuverable blades with many

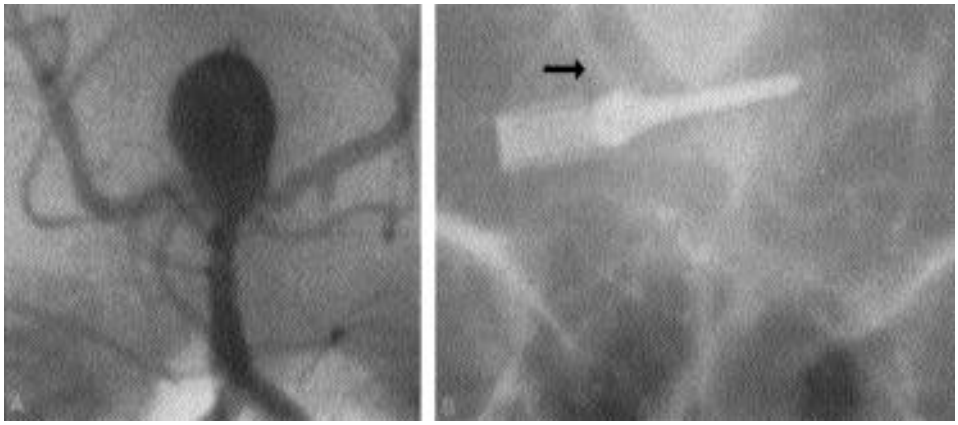

FIG. 5. Preoperative *(left)* and postoperative *(right)* angiograms obtained in the patient described in this article. The PCA *(arrow)* can be seen passing intact through the fenestration in the clip *(right)*, although the quality of the initial photograph was poor. Reproduced with permission from Drake CG: Management of aneurysms of posterior circulation, in Youmans JR (ed): **Neurological Surgery.** Philadelphia: WB Saunders, 1973, Vol 2, p 792.

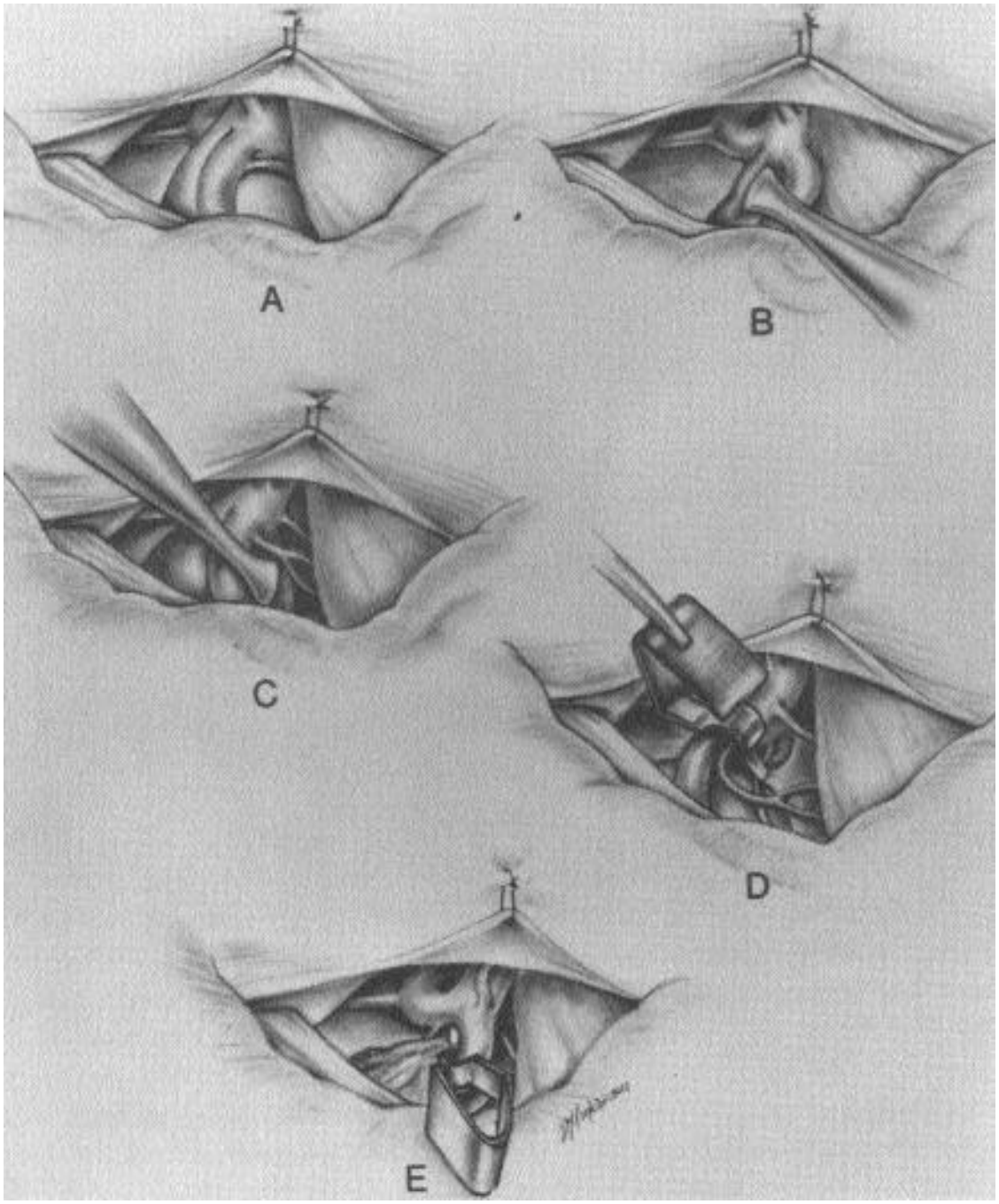

FIG. 6. The first illustration demonstrating the technique of clipping a basilar bifurcation aneurysm with a fenestrated clip. Reproduced with permission from Drake CG: Treatment of aneurysms of the posterior cranial fossa. **Prog Neurol Surg 9:**122–194, 1978.

angles and lengths. I had been unable to persuade Mr. Kees to modify it—he said it would cost $200,000. So Dr. Sugita went back to Japan and formed a manufacturing company who began work on the wonderful modifications of the Drake clip—turned out to be a 'best seller.' (Drake CG, personal communication, 1998)

Sugita's fenestrated clips, which were modified versions of the Drake clip, were soon widely available.[23,24]

Summary

The development of the Drake fenestrated aneurysm clip is a study in the history of ideas. Drake's experience with problems encountered in aneurysm surgery and, specifically, those encountered in treating large basilar tip aneurysms gave him the background needed to conceptualize the problem and to search for a solution. His ability to

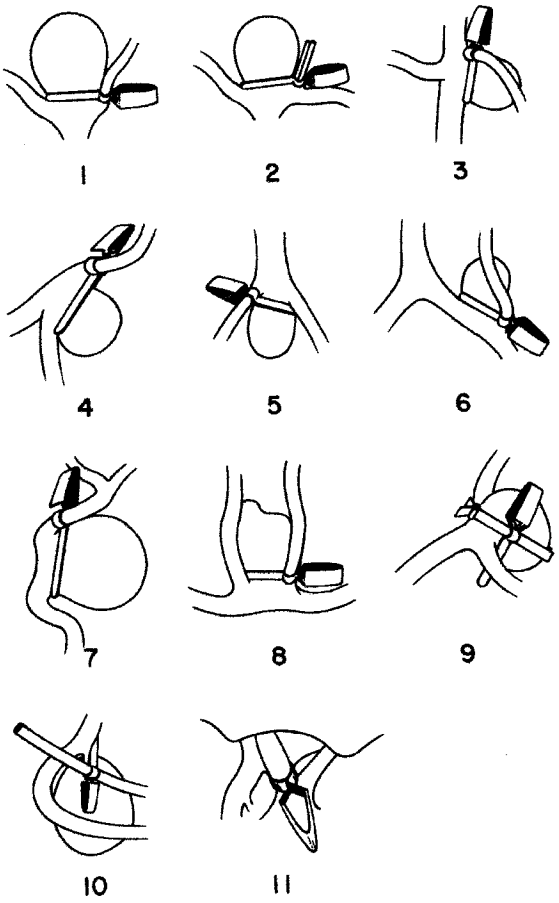

FIG. 7. Diagrams demonstrating the uses of the fenestration in the Drake clip to enclose vital structures. 1 = P_1 segment; 2 = perforating vessels; 3 = anterior inferior cerebellar artery; 4 = basilar artery; 5 = vertebral artery; 6 = posterior inferior cerebellar artery; 7 = carotid artery; 8 = A_2 arteries; 9 = blades of another clip; 10 = oculomotor nerve; 11 = optic nerve. Illustration reproduced with permission from p 110 of Drake CG: The treatment of aneurysms of the posterior circulation. **Clin Neurosurg 26:**96–144, 1979.

modify old ideas and experiment with new ones was instrumental in conceptualizing a fenestrated clip; Mayfield and Kees brought the idea to a reality. Multiple new uses of the clip were identified. Drake's publications and lectures disseminated information about the clip's usefulness and many students and surgeons visited the University of Western Ontario to watch him use it.[3,12,21] When technology appeared to limit the clip's adaptation, Drake convinced Sugita of the need for further modifications, which were realized under Sugita's guidance.

Dr. Charles George Drake made many contributions to medicine.[3,15,19,23] Every time a fenestrated clip is used to clip an aneurysm, it should remind us of the debt we owe to this man.

Acknowledgments

I would like to acknowledge Dr. Charles Drake's contributions to the article. Drake and I began working on this project in the fall of 1997, culminating in a poster presentation at the 33rd meeting of the Canadian Congress of Neurological Sciences in June 1998 in Montreal. Some of the material included in this communication was published in an abstract (**Can J Neurol Sci 25:**S47). Drake's illness precluded his active participation in the writing of this article, but I have endeavored to use his written recollections and those of others involved to provide a flavor of this time in the history of aneurysm surgery.

I would especially like to thank Mrs. Ruth Drake and family for allowing me to use Drake's notes, and Drs. Loren Amacher and David Rowed for allowing me to use their recollections of this time period. Mrs. Edith Mitchell and her family kindly allowed me to use Mr. Lee Carlisle Mitchell's name in the article, which made more information available to the reader, and they provided their memories of the events. I thank Sarah Murtagh for her secretarial assistance and Adrian Del Maestro for his aid with the figures.

Dedication

This article is dedicated to the memory of Dr. Charles George Drake (1920–1998).

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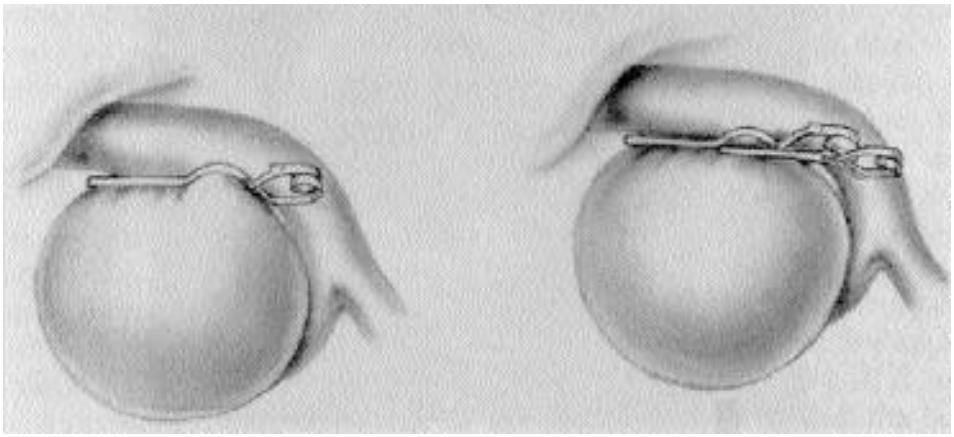

FIG. 8. Drawing showing the use of a tandem clip technique to occlude the thick neck of giant aneurysms. A fenestrated clip is applied first, allowing the blades to close on the far half of the neck *(left)*, as the near half is gathered into the aperture. A second clip of similar length is placed in tandem with the first to oclude the near half of the neck *(right)*. Illustration reproduced with permission from p 22 of Drake CG: Giant intracranial aneurysms: experience with surgical treatment in 174 patients. **Clin Neurosurg 26:**12–95, 1979.

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Manuscript received September 1, 1999.
Accepted in final form January 16, 2000.
This work was supported by the Boxter Corporation, Hyland/Immuno Division.

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