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Breakthrough: Arthur Blakemore and Arthur Voorhees, Jr

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In 1912, the Nobel Prize in medicine was given to Alexis Carrel, recognizing his research achievements in operations on blood vessels and the transplantation of organs. He was not a clinical surgeon and did not take care of patients. Benefits to mankind were postponed 5 decades. One challenge he could not solve was to replace the aorta with a functioning graft.

A suitable graft material was finally discovered in the early 1950s by Dr Arthur Blakemore (Fig 1) and Dr Arthur Voorhees (Fig 2), who successfully used Carrel's techniques in the experimental laboratory. Their breakthrough allowed the bypassing of diseased aortic segments and, by so doing, the development of a new field, vascular surgery. Who were these men?

In 1936, 39-year-old Dr Blakemore was brought to the surgical faculty of Columbia-Presbyterian Hospital in New York by Dr Allen Whipple, Chief of Surgery. Whipple's main interests were diseases of the pancreas and liver. He performed the first removal of cancer of the pancreas, an operation still referred to as "A Whipple." Blakemore was interested in cirrhosis of the liver and its deadly result, bleeding esophageal varices due to portal hypertension. He performed portacaval shunts to relieve the hemorrhage.[1] It was a tedious operation, with high mortality, especially when carried out when the patient was actively bleeding. He developed an ingenious triple-lumen esophageal balloon, which tamponaded the bleeding and could postpone the operation to a safer time.[2]

The Blakemore balloon was widely used in centers that dared tackle the complex disease. Blakemore was often referred patients with arterial problems. Severe ischemia of the legs had no effective treatment, and patients usually endured major leg amputations. He injected vasodilator drugs into the femoral arteries in a vain attempt to improve the outcome. He performed lumbar sympathetic nerve blocks, and if the limb warmed up, did lumbar sympathectomies. These were occasionally helpful. Patients with abdominal aortic aneurysms were particularly frustrating. The aneurysms invariably got larger until they ruptured, and the patients died. Blakemore tried implanting lengths of wire into aneurysms at open operations, with the hope that the blood inside the aneurysm would slowly clot, allowing time for collateral circulation to develop. Hopefully, the limbs would survive, and the aneurysm would not rupture.[3] The procedure proved to be a disappointment.

Blakemore was from Virginia, a tall and heavy-set man, who spoke with a slow drawl and moved slowly. When he was 19, an accident resulted in amputation of his right index finger at the proximal joint. In spite of the handicap, he mastered fine surgical technique. He maintained his composure exceptionally well, even when confronted with severe hemorrhage. He told me, "The only time I worry about bleedin' is when I can hear it." He was extremely patient as a teacher in the operating room. If a patient could not afford his surgical fee, the patient was placed on the clinical service, and he would assist the chief resident to perform the operation. This would take more time than his average, but he never became restless in the process.

Arthur Voorhees began his surgical internship at Columbia-Presbyterian in 1946. He was a Quaker; mild, soft-spoken, cool, and persistent. A year later, he was drafted by the army and served through 1948 in San Antonio, Texas. In 1949, he was back at Columbia to resume his residency. He had a close relationship with Dr Blakemore and worked in his laboratory. On a project to create a new mitral valve, a suture was inadvertently left inside the ventricle. When the animal was sacrificed, the thread was coated with a slick layer resembling endothelium. This surprising observation made Voorhees wonder whether a fabric in the bloodstream might develop a similar coating.

At that time, Dr James Blunt, an orthopedic resident at Columbia, became the recipient of a bolt of Vinyon-N cloth that failed to take a dye. Blunt tried using the material

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Fig 1. Dr Arthur Blakemore.

Fig 2. Dr Arthur Voorhees.

as a tendon replacement but was unsuccessful. He offered the material to Voorhees.

Using his wife's sewing machine, Voorhees constructed a tube of the Vinyon, which resembled silk. It was difficult to sew, and the ends of the tubes were folded back 3 mm for better purchase by the needle. Dogs that were to be euthanized by the pound were anesthetized and had segments of their aortas replaced by Vinyon. Early results were promising. The grafts stayed open![4]

On July 1, 1950, I began a surgical internship at Columbia-Presbyterian. During the first weeks, I was assigned to second-assist at a portacaval shunt by Dr. Blakemore. It started at 0800 hours and ended at 2200 hours. He was doing these operations about one every other week. One by one, my running mates requested not to be assigned to these long operations because of their leg swelling or back ache. I gradually became a regular assistant to Dr Blakemore.

My second year was given to research. I spoke with Dr Blakemore and Dr Voorhees about joining their team. Dr Jaretzki, a third-year resident, was already working with them, but there was room for me. Dr Voorhees was incredibly patient and spent a month teaching me how to sew in the Vinyon aortic grafts. Sewing arteries to Vinyon required painstaking technique. It was a marvelous learning experience, and I was finally able to operate on my own.

In 1951, an aorta bank was opened in New York, where human aortas were preserved and stored for use in surgery. That year, Dr Dubost, in Paris, reported the first successful replacement of an aortic aneurysm, utilizing such a graft.[5]

Late one night in February 1953, during my second year of residency, I was called to the emergency room. An elderly man was admitted with severe back pain. He had a pulsating mass in the abdomen and low blood pressure. The diagnosis was obvious. The patient had a ruptured abdominal aortic aneurysm. The chief resident was Dr Voorhees, and the professor on call was Dr Blakemore. It was serendipity, a perfect combination for the task ahead. I paged Dr Voorhees and placed a large bore needle for fluid replacement and called the blood bank. Dr Vorhees came quickly, confirmed my diagnosis and the need for immediate surgery. He called Dr Blakemore, the operating room, and the aorta bank.

In 30 minutes, the patient was in the operating room, with the team in place. The procedure was begun, and the aorta was clamped, slowing most of the bleeding. The aneurysm was large and extended into the iliac arteries. A nurse appeared and said, "I have bad news. The aorta bank just called. There isn't an aorta available in New York City." There was a sudden pause as we turned to Dr Blakemore. With his usual calm, he drawled, "Well, we'll just have to make one of our own."

Voorhees turned to me and said, "Come with me. We'll have to make a bifurcation graft, not a straight one." All our work in the laboratory involved constructing tube grafts. We had never made a forking graft. We both broke scrub, ran through the hall, entered the door connecting the hospital building to the medical school building, and entered the surgical research laboratory. It was dark and eerie, 0200 hours, and we couldn't find the light switch. The wind was shaking the windows, and we could hear the laboratory mice rattling their cages. We turned on the lights, went to the corner where the sewing machine was located, and put down two sheets of Vinyon. We sketched an upside down "Y" and sewed three lines, one in the crotch. Redundant Vinyon

was removed, and we raced back to the operating area. The graft was given to the float nurse, who flashed it, and we scrubbed back in. Meanwhile, Dr Blakemore was working to isolate the aneurysm. Finally, the aneurysm was removed, and the graft was sewn in place. The distal artery clamps were removed first, allowing blood to fill the graft. There was some bleeding from the graft, and the clamps were closed again. After 5 minutes, the distal clamps were reopened, and there was no more bleeding from the graft. Finally, the upper clamp was slowly opened, and pulsatile flow was resumed downstream. The aorta had been clamped for over 3 hours. When all clamps were removed, there was blood oozing from everywhere, except the graft. The graft worked well. Weak groin pulses were present. The abdomen was hurriedly closed. It was the first time a synthetic graft was used to replace the human aorta.

Dr Blakemore was so impressed with the performance of the Vinyon graft that from then on, it was his conduit of choice.

It was fortunate that synthetic grafts became available. The human aortic grafts did not fare well. After 1 or 2 years they degenerated, became aneurysmal, and had to be replaced. Aorta banks were closed.

Advances in textile manufacture led to the creation of Dacron grafts, which were easier to sew than Vinyon. Dacron grafts could be prepared in different sizes and were always available.

Hundreds of thousands of lives, limbs, and brains have been saved throughout the world by the development of vascular surgery, the field opened up by the pioneers, Dr Arthur Voorhees and Dr Arthur Blakemore.

Neither of these men sought recognition. It upset me in subsequent years to learn that surgical residents and vascular fellows knew little of the development of arterial grafts. When I asked who made the significant breakthrough to begin it all, many mentioned the name of a flamboyant Texan. I decided to clarify the issue in my presidential address to the Society for Clinical Vascular Surgery in 1987.[6] In preparation for writing the paper late in 1986, I spoke with Dr Voorhees by phone and told him I would describe details of the fateful evening of the first clinical use of a synthetic aortic graft. He mildly asked why I wanted to write the paper, and I told him to emphasize the importance of his and Dr Blakemore's achievement. I rhapsodized on the saving of the patient's life. He interjected, "Don't you remember? The patient died!"

One's memory can be faulty. I had not remembered. For more than 30 years, I had told my residents and students the story of the exciting evening and was frequently asked how the patient did after the operation. I answered that he survived. Voorhees reminded me the patient lived only 12 hours postoperatively, dying of shock and a bleeding problem. He reminded me that 3 weeks later he and I assisted Dr Blakemore to successfully replace a patient's aortic aneurysm.

After completing my surgical residency in 1956, I spent the following year as a fellow in Europe, working with surgeons who had achieved vascular "firsts." Felix Eastcott in London had performed the first carotid artery reconstruction to prevent strokes.[7] In Paris, I worked with Charles Dubost, who had done the first aortic aneurysm replacement, with a homograft. Also in Paris, I worked with Jean Kunlin,[8] who used a reversed saphenous vein as a femoral popliteal artery bypass for the first time. In Stockholm, I worked with Clarence Crafoord, who had done the first repair of coarctation of the aorta.[9]

In January 1958, I joined the surgical faculty of the University of California School of Medicine in San Francisco. In a few months, I made changes in techniques of two operations. Aortic aneurysms did not have to be totally removed. It was possible to leave the back wall of the aneurysm stuck to the vena cava, avoiding hazardous and unnecessary dissection, saving time and need for blood transfusions. I performed portacaval shunts through abdominal incisions, rather than through thoracoabdominal incisions, which were used by Dr Blakemore. This reduced the operating time by half, and, with use of an electrocoagulating unit, the Bovie, the operation could be done in 3 hours rather than 14 hours.

The University of California at San Francisco had an excellent vascular surgery unit, headed by Dr Jack Wylie, who developed the endarterectomy technique of peeling away localized plaque formations. This became the preferred method of carotid artery procedures. In 1960, Dr Wylie created the first vascular surgery fellowship in the country.

It was a privilege for me to be a member of the team of my mentors, Drs Voorhees and Blakemore, an experience that shaped my professional life. Pioneers of vascular surgery, both men died at age 70. I honor their memory.

REFERENCES

1. Blakemore AH. Portacaval anastomosis for portal hypertension. Surgery 1949;26:99-102.
2. Sengstaken RW, Blakemore AH. Balloon tamponage for the control of hemorrhage from esophageal varices. Ann Surg 1950;131:781-9.
3. Blakemore AH, King BG. Electrothermic coagulation of aortic aneurysms. JAMA 1938;111:1821-7.
4. Voorhees AB Jr, Jaretzki A 3rd, Blakemore AH. The use of tubes constructed from vinyon "N" cloth in bridging arterial defects. Ann Surg 1952;135:332-6.
5. Dubost C, Allary M, Oeconomos N. Resection of an aneurysm of the abdominal aorta: reestablishment of the continuity by a preserved human arterial graft, with result after five months. Arch Surg 1952;64:403-8.
6. Levin SM. Reminisces and ruminations, Vascular Surgery then and now. Am J Surg 1987;154:158-62.
7. Eastcott HH, Pickering GW, Rob CG. Reconstruction of internal carotid artery in a patient with intermittent attacks of hemiplegia. Lancet 1945; 2:994-6.
8. Kunlin J. [Long vein transplantation in treatment of ischemia caused by arteritis]. Rev Chir 1951;70:206-35.
9. Crafoord C, Nylin G. Congenital coarctation of the aorta and its surgical treatment. J Thorac Surg 1945;14:347-61.

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