A Surprising Alliance: Two Giants of the 20th Century

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Alexis Carrel and Charles Lindbergh were among the most famous international figures in the 20th century: Carrel, the surgeon-scientist who won a Nobel prize as a young surgeon, and Lindbergh, the aviator-engineer who pioneered aviation and promoted commercial flight throughout his life. Surprisingly, these two amazing individuals came together to collaborate on the early development of extracorporeal circulation. Their work was interrupted by the onset of World War II, which destroyed one of them and nearly destroyed the other.

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Two of the best-known figures of the 20th century were a surgeon-scientist who had an enormous impact on the field of cardiovascular surgery and an aviator-engineer who was a catalyst for the growth of aviation and an architect of commercial air travel. Both had immense international reputations and, surprisingly, collaborated on the early development of extracorporeal circulation. They were Alexis Carrel and Charles Lindbergh.

Alexis Carrel

The popular president of France, Sadi Carnot, was assassinated by a knife-wielding anarchist in Lyon, France, in June 1894. He died of a vena cava laceration that the surgeons could not repair because vascular repair was not possible at that time. Alexis Carrel, a surgical resident in Lyon, decided that he would develop techniques for suturing blood vessels [1]. He found laboratory space and, working at odd hours, was able to do his experimental work without interfering with his clinical responsibilities. He attributed his manual dexterity, which was considerable, to instructions he received from an embroideress during his residency. He was able to find fine needles and threads in a local haberdashery. The technique that he used for suturing small blood vessels was triangulation, in which three guide sutures allowed the eversion of the suture line, allowing for an intima-to-intima closure, avoiding suture line thrombosis. In his laboratory, he was able to successfully suture the cut ends of femoral artery to saphenous vein and from carotid artery to jugular vein [2] (pp. 25-7) (Fig 1).

For a variety of reasons, he did not pass the extremely difficult surgical examinations, so he was unable to get a position at the University of Lyon. He went to Paris for 3 months in December 1903, where he reflected on his future. In May 1904 he sailed for Montréal, and in August he traveled by train to the west coast of Canada, then east across the United States to Chicago. He spent the next 2 years in the Hull laboratory of the University of Chicago, working with Dr Charles Guthrie. In Chicago, Carrel refined his suture technique further in a series of groundbreaking operations. He and Guthrie replaced a segment of carotid artery with jugular vein, demonstrating that venous walls could withstand arterial pressure; this was the first successful vascular homograft. They were also able to transplant kidneys, hearts, thyroid glands, and ovaries. The "Carrel patch," which used a piece of aortic wall containing the orifice of the renal artery, is still used today for kidney transplantation. Together, Carrel and Guthrie published 21 papers in 22 months [2] (pp. 24-35).

Carrel was disappointed with the level of financial support in Chicago, so in 1906 he accepted an invitation to work at the Rockefeller Institute for Medical Research in New York and began his work there, which lasted more than 30 years. He found ways to preserve and transplant arteries and veins, and he transplanted adrenal glands, spleen, intestine, and heart-lung blocks. He amputated and reimplanted the leg of a dog at the thigh successfully. He did operations inside the heart and on its surface, including coronary arteries, mitral valve, and ventricular septum. The operations he performed on dogs by 1910 were not repeated clinically for many decades: mitral valvotomy in 1948, kidney transplantation in 1954, limb replantation in 1962, heart transplantation in 1967, coronary artery bypass in 1968, and heart-lung transplantation in 1981. His work with vascular suturing and transplantation was half a century ahead of its clinical application. In 1912 Carrel became the first surgeon to be awarded the Nobel Prize for Medicine and Physiology specifically for surgical techniques. At the age of 39 years he was the youngest Nobelist

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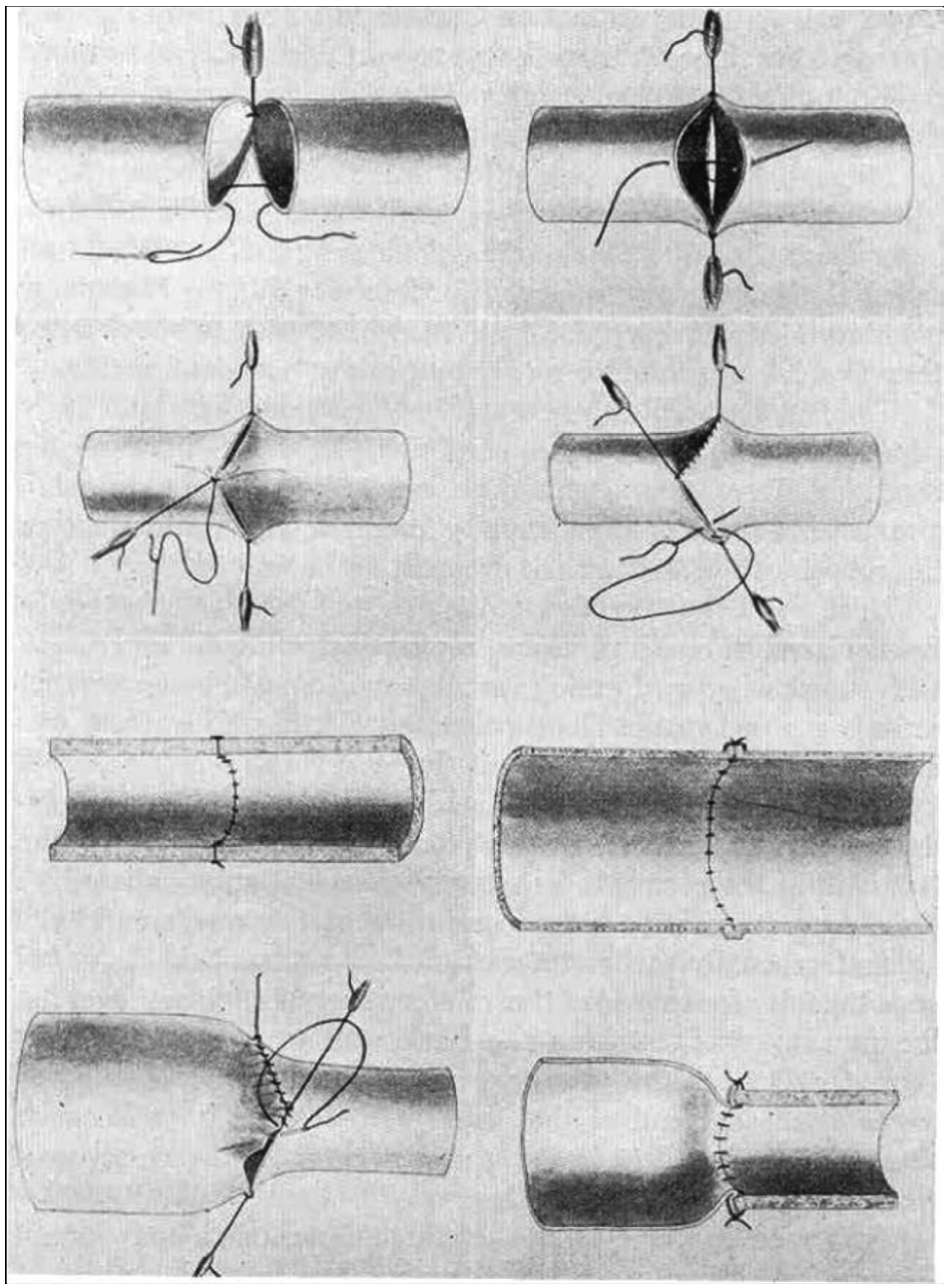

Fig 1. Upper four panels (left to right): The triangulation technique of small vessel anastomosis. Three fine stay sutures are placed at regular intervals around the circumference of a small vessel. Gentle traction on two of the sutures at a time allows the surgeon to achieve a smooth, everting anastomosis without touching the delicate vessel wall with forceps. Lower four panels: Anastomoses of a small vessel, a larger vessel, and a small vessel to a larger vessel. (Reprinted from Edwards and Edwards, Alexis Carrel: Visionary Surgeon, 1974:26, with permission of Charles C Thomas Publisher, Ltd, Springfield, Illinois.)

at that time, and the first scientist working in America to win the prize [2] (pp. 58-61).

During his time at the Rockefeller Institute he made many major contributions, such as the use of endotracheal anesthesia, treatment of wounds, and tissue culture. He and a chemist, Henry D. Dakin, developed the Carrel-Dakin solution for irrigating wounds in World War I; their solution is still used for treating infected wounds (Fig 2).

Charles Augustus Lindbergh

Charles Lindbergh was 20 years old in 1922, when he dropped out of the University of Wisconsin mechanical engineering school to pursue his dream of becoming a pilot. After brief training, he earned his living barnstorming across the Plains states as a wing walker and parachutist and by working as an airplane mechanic. In 1924, he underwent a year of military flight training with the United States Army Air Service Reserve Corps and was commissioned as a Second Lieutenant and later as a First Lieutenant. Continuing to serve in the reserves, he became an airmail pilot; he distinguished himself through his dedication to his responsibilities for mail delivery under highly adverse conditions [3] (pp. 84-9).

In 1919 the Raymond Orteig Prize offered $25,000 ($355,000 in 2016 dollars) to anyone who could fly from