

One Hundred Years of History at Stanford University: Thoracic and Cardiovascular Surgery

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The history of thoracic and cardiovascular surgery at Stanford spans a century long period, beginning not long after the founding of Stanford University. Pioneering Stanford surgeons have made landmark discoveries and innovations in pulmonary, transplantation, thoracic aortic, mechanical circulatory support, minimally invasive, valvular, and congenital heart surgery. Fundamental research formed the foundation underlying these and many other advances. Educating and training the subsequent leaders of cardiothoracic surgery has throughout this century-long history constituted a mission of the highest merit.

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PRE-STANFORD UNIVERSITY

Lineage tracing of the history of Stanford Cardiothoracic Surgery could be extended back to 1857, even before the founding of Stanford University. Elias Samuel Cooper, a San Francisco surgeon, authored “Report of an Operation to Remove a Foreign Body from Beneath the Heart” published by the San Francisco Medico Chirurgical Association. The following year in 1858, Cooper founded the first medical school in the western United States, named after himself, which then underwent a variety of name changes, moves, expansions, a “spin-off” that would later become University of California, San Francisco, and a reorganization to eventually become the Stanford School of Medicine.¹

EARLY STANFORD SCHOOL OF MEDICINE AND LEO ELOESSER

Stanford University was founded in 1891, and in 1908, acquired Cooper Medical College. By 1914, Stanford had reorganized this college into 10 divisions, including surgery, and renamed it the Stanford School of Medicine. Affiliations to a variety of hospitals in San Francisco existed over the subsequent 45 years (Fig. 1). Leo Eloesser, born in San Francisco in 1881, educated at the University of California and University of Heidelberg, trained in Europe and in San Francisco, joined the



New Stanford Adult Hospital

Central Message

Stanford: Upon a foundation of rigorous scientific investigation and dedicated teaching, Stanford thoracic and cardiovascular surgeons pioneered discoveries and innovations in pulmonary, transplantation, aortic, minimally invasive, and congenital heart surgery.

Stanford Faculty in 1914 and led the Stanford surgical service at the San Francisco General Hospital² (Fig. 2). Although he practiced a broad spectrum of surgery, much of his clinical and experimental work and scholarly publications were in the arena of chest surgery. He became renowned for innovative therapies for empyema.³ Eloesser served as the 19th President of the American Association for Thoracic Surgery (AATS) and as Editor-in-Chief of the Journal of Thoracic Surgery, predecessor of the Journal of Thoracic and Cardiovascular Surgery. He was highly regarded for his teaching and became a world traveler, working in China from 1945-1949.⁴ It is of particular importance to note that even 100 years ago, Stanford was acclaimed for its teaching of trainees.

EMILE HOLMAN AND FRANK GERBODE

In many respects, the rise of cardiovascular surgery at Stanford paralleled, with minimal lag, the developments eastward, of Gross (PDA Ligation), Crafoord (Coarctation Repair), Blalock (Blalock-Taussig Shunt), Bailey and Harken (Closed Mitral Commisurotomy or Valvuloplasty), and others. Emile Holman, educated at Stanford and Johns Hopkins and trained by Halsted and later Cushing, served as the head of surgery at Stanford from 1926-1955 and performed many of the extracardiac and closed heart procedures. Holman served as the 33rd AATS President.⁵ He was also instrumental in facilitating the career development of Frank L.A. Gerbode. Born in Placerville CA, Gerbode was educated at Stanford and trained in Europe and at Stanford. He had a close association with pathologist Max Borst and family in Germany and was instrumental in Hans Borst's brief training at Stanford

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Figure 1. Stanford Medical School circa 1914. Courtesy of Stanford Medical History Center.

(Fig. 3). As topical hypothermia, cross-circulation, and cardiopulmonary bypass, with bubble and disc oxygenators ushered in the era of direct intracardiac surgery, Gerbode was intricately involved clinically, performing the first open heart operation on the West Coast in 1954 and experimentally, in the research laboratory refining the membrane oxygenator.^{6,7} Active in many fields within cardiac surgery, his name is associated with the defect of a left



Figure 2. Leo Eloesser. Courtesy of Stanford Medical History Center.



Figure 3. Frank Gerbode. Adapted with permission from Bull.⁹

ventricular to right atrial fistula.⁸ Gerbode served as the 53rd AATS President.⁹

NORMAN SHUMWAY AND STANFORD CARDIOPULMONARY TRANSPLANTATION

Among these myriad connections with other cardiac surgery programs, the intersection with the University of Minnesota and C. Walton Lillehei would become the most important to Stanford's future—from here came Norman Shumway.

Norman Edward Shumway was born in Kalamazoo Michigan on February 9, 1923. He was known for his oratory skill and led his high school debate team. He completed a year of pre-law studies at the University of Michigan and was drafted into the Army in 1943. After basic training, he completed 6 months of engineering training followed by premedicine training. He then attended Vanderbilt University School of Medicine and graduated in 1949. Shumway served 2 years as a flight surgeon in the U. S. Air Force. He joined Owen Wangenstein's Department of Surgery at the University of Minnesota as a resident and was drawn to the work of F. John Lewis (Total Body Hypothermia) and C. Walton Lillehei (Cross Circulation). Shumway participated in Lillehei's original open heart surgeries in 1954 utilizing cross-circulation to repair more complex congenital defects. Shumway's research studies of hypothermia resulted in a PhD during training.¹⁰

Upon completing his training in 1957, Shumway joined an established surgeon in private practice in Santa Barbara, CA. It was an unhappy partnership, and in a few months, he was searching for a university position. When an interview with the Chairman at the University of California, San Francisco, did not go well, he decided to accept a position



Figure 4. Stanford Hospital Palo Alto, opened in 1959.

at Stanford, then at the Pacific Medical Center in San Francisco. When he joined the Stanford faculty in 1958, Shumway's clinical responsibility was to run the new hemodialysis program. However, he would spend most of his free time pursuing research into cardiac surgery techniques. Although the established Gerbode led the clinical cardiac surgery program, Shumway and his first resident Richard Lower studied selective cardiac ischemia, with hypothermia for protection, in canines on cardiopulmonary bypass. It was during these studies that Shumway and Lower first performed a cardiectomy and then reimplantation, the technique of which formed the foundation for cardiac transplantation. This work was ultimately presented at the Surgical Forum of the American College of Surgeons in 1960.¹¹

Fulfilling a long held desire to unite the School of Medicine with the University Main Campus, a new Stanford University Hospital was constructed in Palo Alto and opened in 1959 (Fig. 4). Many of the senior faculty chose to remain in San Francisco where they had established practices, Gerbode among them. This provided an opportunity for the young and gifted surgeon, Shumway, to move to Palo Alto and serve as the interim Chief of the Division of Cardiovascular Surgery, at least until “a big-name cardiac surgeon” could be recruited. Shumway rapidly developed a large clinical practice in adult and congenital cardiac surgery with superb results. In the laboratory, Shumway and Lower, with Eugene Dong, and Ray Stofer, perfected the surgical technique for and the myocardial preservation aspects of orthotopic cardiac allograft transplantation, and made progress in immunosuppression, achieving prolonged survival in dogs^{12,13} (Fig. 5).

Shumway and colleagues were ready to perform human heart transplantation by the fall of 1967 and like the rest of the world, were surprised in early December of 1967, when it was announced that Christian Barnard in Cape Town South Africa had in fact performed the

operation. Soon thereafter, on January 6, 1968, Shumway together with Edward Stinson, another of his trainees, performed the first adult human heart transplant in the United States¹⁴ (Fig. 6).

Over the next several years, despite multiple challenges, Shumway and Stinson with numerous colleagues of all clinical disciplines, and under the auspices of an NIH Program Project Grant for Cardiac Transplantation, made innumerable advances in the field. These included refinements in immunosuppression, management of complications such as infection and lymphoma, distant heart procurement, patient and donor selection criteria, and the diagnosis of rejection by transvenous endomyocardial biopsy.¹⁵ For all of his pioneering efforts, Shumway is considered to be the “father of cardiac transplantation” and is certainly the father of the Department of Cardiovascular Surgery which he established at Stanford in 1974.

Shumway's contributions to the world of cardiac surgery extend well beyond transplantation to innovations in thoracic aortic surgery, valvular prostheses, and corrective surgery for congenital heart disease, among many other discoveries. Shumway



Figure 5. Shumway, Lower, Stofer, and laboratory team circa 1958. Reprinted with permission from *J Thorac Cardiovasc Surg* 2009; 137:269-277.



Figure 6. Shumway and Donald C. Harrison, Chief of Cardiology, in a press conference after first adult heart transplant in the USA. Credit: Photograph by Chuck Painter/Stanford News Service.

also inspired and supported his faculty to explore widely and thereby the Stanford group contributed significantly to the advancement of all realms of cardiac surgery.

Likewise legendary was Shumway's dedication to education and training. By standardizing his surgical techniques and routinely utilizing topical hypothermia for myocardial protection, his operations were efficient, uncluttered, unhurried, and safe for virtually all cardiac conditions and thereby facilitated the training of residents. Dr Shumway was often referred to as the world's greatest first assistant, always insisting on the resident performing the operation from the right side of the table. It was also commented that, there were at the time, specific, famous cardiac surgeons at other institutions that made it appear as though they were the only person on the planet capable of doing a particular operation whereas Dr Shumway on the other hand, via his masterful assistance and teaching, made it appear as though every resident at Stanford could do every operation within cardiac surgery. Dr Shumway also selected many of his early residents directly out of medical school and often interspersed laboratory research and general surgery training in varying order. By no means all-inclusive, the [Table](#) lists many distinguished trainees of the Stanford program since Dr. Shumway's arrival. Shumway served as the 67th AATS President¹⁶ (Fig. 7).

Stanford's prominence in cardiovascular surgery was furthered by another of Shumway's early trainees, Dr Bruce A. Reitz. In the late 1970s, while a Stanford Assistant Professor, Reitz investigated the surgical, physiologic, and immunologic facets of combined heart-lung transplantation in a nonhuman primate model. When these studies introduced cyclosporin for immunosuppression of lung

transplants, long-term survival was achieved. On March 9, 1981, he performed the world's first successful heart-lung transplant on Mary Gohlke, a 45-year-old patient with primary pulmonary hypertension. She wrote an autobiography on the subject and survived over 5 years, succumbing to complications of internal hemorrhage after a traumatic fall¹⁷⁻¹⁹ (Fig. 8). Reitz was also actively involved in all other subspecialties within cardiac surgery. He was recruited in 1982 to head the Johns Hopkins Cardiac Surgery Division, which he did for the next decade. In 1992, following Shumway's retirement, Reitz was recruited back to Stanford to become the Chair of the Cardiothoracic Surgery Department and the Norman E. Shumway Professor.

Also during the 1980s, Stanford helped to advance the field of mechanical circulatory support. Again, fundamental research formed the core and was led by two other early trainees of Shumway's with very distinguished careers, Philip Oyer and Randall Griep, together with Departmental research scientist Peer Portner. Their investigation of chronic implants of early stage left ventricular assist devices (LVADs) into calves and sheep led to the world's first clinical use of an LVAD as a successful bridge-to-transplant at Stanford in 1984²⁰ (Fig. 9). The mechanical circulatory support (MCS) program, now led by Richard Ha, is implanting multiple commercially approved and experimental devices and is among national leaders in LVAD volume.

Yet another pioneering innovation in transplantation, in the early 1990s, lobar lung transplantation was developed at Stanford by Vaughn Starnes and the Shumway team to address issues of donor limitation and recipient size.²¹

THORACIC AORTIC SURGERY

Paralleling the vast successes in transplantation, Stanford also achieved many milestones in aortic surgery, building upon the insightful approach of differentiating the diagnosis and treatment of ascending and descending aortic dissections. The original 1970 Stanford classification system for aortic dissection is still used worldwide today²² (Fig. 10). Surgical reconstruction of complex aneurysms and dissections became a significant facet of the Stanford program. Several of Shumway's trainees also conducted and then provided formal training in vascular surgery. In the 1990s, many transformative innovations in thoracic aortic disease management emanated from Stanford. At the core was a trio comprised of D. Craig Miller and R. Scott Mitchell, both Shumway trainees, and interventional radiologist Michael Dake, who built in the laboratory and on July 20, 1992, clinically

ONE HUNDRED YEARS OF HISTORY AT STANFORD UNIVERSITY

Table. Distinguished Trainees of Stanford Cardiothoracic Surgery of the Shumway Era and Henceforth

Resident	Graduation Year	Career
Richard Lower	1961	Chief, Division of Cardiothoracic Surgery, Medical College of Virginia
Vincent Dor	1967	Chair, Cardiothoracic Center of Monaco
Edward Stinson	1968	Professor and Director of Cardiac Transplantation, Stanford University
Pat Daily	1969	Chief, Cardiac Surgery, University of California, San Diego
Thomas Fogarty	1970	Professor, Stanford University Founder, Fogarty Institute for Innovation
Lawrence Cohn	1971	Chief, Division of Cardiothoracic Surgery, Brigham and Women's Hospital, Harvard University
Randall Griepp	1972	Chief, Division of Cardiothoracic Surgery, Mount Sinai School of Medicine
Philip Oyer	1974	Professor and Director of Cardiac Transplantation, Stanford University
Jack Copeland	1975	Chief, Division of Cardiothoracic Surgery, University of Arizona
William Brody	*	President, Johns Hopkins University
Bruce Reitz	1976	Chair, Department of Cardiothoracic Surgery, Stanford University
D. Craig Miller	1977	Professor and Director of Thoracic Aortic Surgery, Stanford University
William Baumgartner	1978	Chief, Division of Cardiac Surgery, Johns Hopkins University
Donald Watson	1979	Chief, Division of Cardiothoracic Surgery, University of Tennessee
Stuart Jamieson	1980	Chief, Division of Cardiothoracic Surgery, University of California, San Diego
John Wallwork	1981	Chief, Division of Cardiothoracic Surgery, Cambridge University
R. Scott Mitchell	1982	Professor, Stanford University Chief of Cardiovascular Surgery, Palo Alto, VAMC
John Baldwin	1983	Dean, Dartmouth University School of Medicine
Vaughn Starnes	1986	Chair, Department of Cardiothoracic Surgery, University of Southern California
William Frist	1986	United States Senator and Majority Leader, Tennessee
Jeffrey Rich	1990	Director, Center for Medicare Management, CMS, United States Department of Health and Human Services
Patrick McCarthy	1990	Chief, Division of Cardiac Surgery, Northwestern University
Robert Robbins	1992	Chair, Department of Cardiothoracic Surgery, Stanford University
Thomas Burdon	1992	Professor, Stanford University Chief of Surgery, Palo Alto, VAMC
Hermann Reichensperner	1995	Chair, Department of Cardiovascular Surgery, University of Hamburg
James Fann	1996	Professor, Stanford University Board of Directors, ABTS
Marc Moon	1998	Chief, Section of Cardiac Surgery, Washington University
Joseph Schmoker	1998	Chief, Division of Cardiothoracic Surgery, University of Vermont
Abe DeAnda	2000	Chief, Division of Cardiothoracic Surgery, University of Texas Medical Branch at Galveston
John Ikonomidis	2000	Chief, Division of Cardiothoracic Surgery, Medical University of South Carolina
Francois Dagenais	2000	Chief, Division of Cardiac Surgery, Universite Laval
David Yuh	2001	Chief, Section of Cardiac Surgery, Yale University

*Dr Brody began his postgraduate training and completed several years in cardiovascular surgery with Dr Shumway and completed a residency in radiology at Stanford.

implanted the first aortic endograft in the United States (Fig. 11). This Stanford team pioneered the endovascular repair of thoracic aneurysms²³ and then aortic dissections.²⁴ In another aortic surgery arena, led by Miller, the Stanford surgeons have performed a very large series of valve-sparing aortic root replacements²⁵ and contributed to the evolution of Tirone David's operation with the Stanford—modification of a separate smaller ascending aortic graft to downsize

the sino-tubular junction.²⁶ Miller served as the 88th AATS President.²⁷

MINIMALLY INVASIVE SURGERY

Also in the 1990s, a team of entrepreneurial cardiac surgeons and engineers, led by Stanford member John Stevens, developed and commercialized the first specialized platform to facilitate minimally invasive heart surgery. The Heartport system

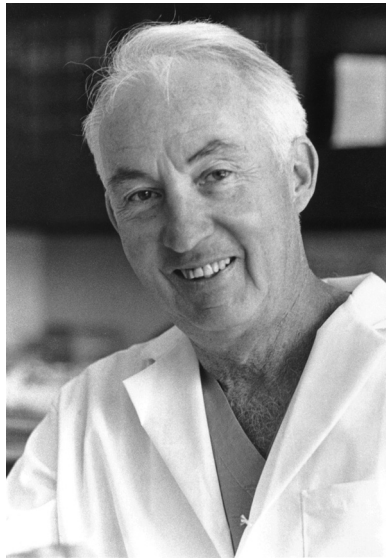


Figure 7. Norman E. Shumway. Reprinted with permission from Robbins.¹⁰

eventually comprised long-shafted, proximally-articulated instruments, peripherally-placed catheters that permitted cardiopulmonary bypass, aortic endoballoon occlusion with antegrade cardioplegia delivery, pulmonary artery venting, and coronary sinus retrograde cardioplegia administration. Coupled with endoscopic lighting and visualization technology, this system enabled experimental non-sternotomy approaches to coronary bypass grafting and valvular surgery.²⁸ The system was refined by

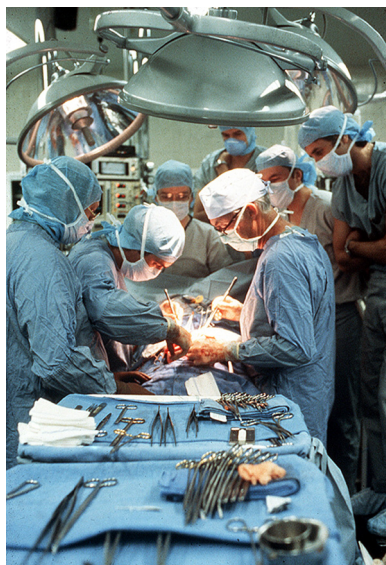


Figure 8. World's first successful combined adult heart-lung transplant performed by Bruce Reitz, Norman Shumway, and John Wallwork. Reprinted with permission from *J Thorac Cardiovasc Surg* 2009; 137:269-277

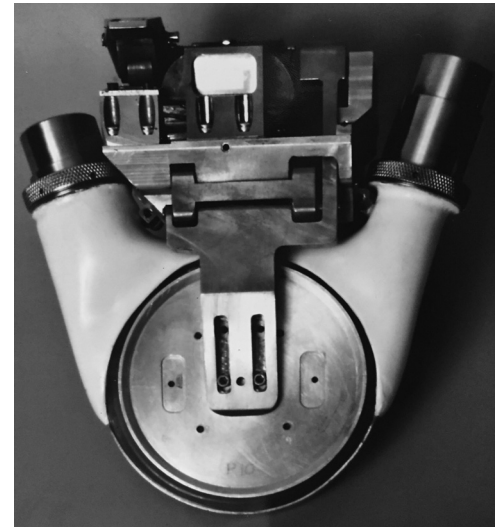


Figure 9. Novacor LVAD.

the Stanford team in the laboratory and then the first human clinical application was conducted in 1996 in Kuala Lumpur by Stanford surgeons, Thomas Burdon and Mario Pompili, in collaboration with Malaysian surgeons led by Azhari Yakub of the Malaysian National Heart Institute (Institut Jantung Negara)²⁹ (Fig. 12). Today, iterations of Stanford's original minimally invasive surgery technology and that of subsequent competitors are in active use worldwide. Minimally invasive surgery at Stanford now encompasses work in valvular disease, thoracic aortic disease, MCS, and adult congenital heart surgery, as well as a hybrid coronary revascularization and robotics program led by Jack Boyd.

PEDIATRIC CARDIAC SURGERY

To build upon the very strong foundation in congenital heart surgery created by Shumway and Reitz, in 2001, Frank Hanley was recruited to lead the Pediatric Cardiac Surgery Division. Most renowned for

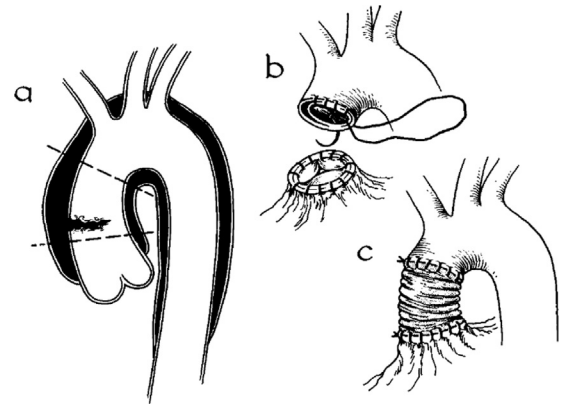


Figure 10. Original Stanford classification system depicting a type A aortic dissection.²²

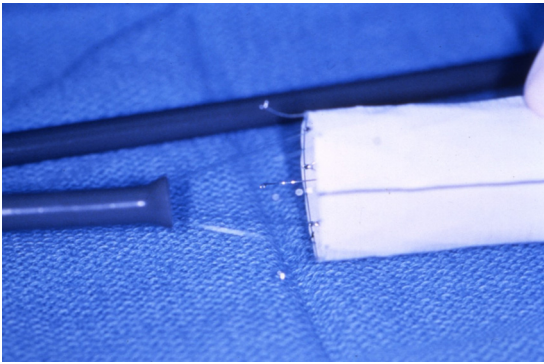


Figure 11. Original hand-made thoracic endograft.

developing and evolving the procedure of single stage unifocalization for pulmonary atresia with ventricular septal defect and major aortopulmonary collaterals, Hanley and his team also studied fetal surgery and made major advances in surgery in very low birth weight neonates³⁰ (Fig. 13). Laboratory research now delves into univentricular physiology and mechanical circulatory support strategies as well as alterations in gene expression in neonatal heart valves experimentally subjected to flow disturbances.³¹ Hanley's team has expanded the program's referral base across the nation and internationally for the unifocalization procedure, perhaps becoming the world's destination center. Most recently, the Stanford Adult Congenital Heart Disease Program was selected by the Adult Congenital Heart Association as one of the nation's 5 reference centers.

THORACIC SURGERY

The Thoracic Surgery Division remained within the Department of Surgery until 1990, when it was moved to the Department of Cardiovascular Surgery.

For decades since 1972, Thoracic Surgery was led by James Mark, who also served as acting Chair of the Department of Surgery from 1974-1977 and was elected the President of the American College of Chest Physicians in 1994. In the 1980s Mark was an early leader in the advancement of thoracoscopy beyond its known diagnostic utility into a therapeutic modality, and hence set the precedent for the development of VATS in the 1990s.³² Under the leadership of current chief Joseph Shrager, the Division of Thoracic Surgery has significantly increased clinical volume and most recently with Mark Berry leading the program in minimally invasive and robotic thoracic surgery, has expanded its expertise into video-assisted and robotic pulmonary, esophageal, and mediastinal surgery. The Division is also firmly grounded in research into lung cancer biology and diaphragm muscle pathophysiology.

BASIC SCIENCE RESEARCH

Fundamental laboratory investigation has comprised an integral feature of Stanford Cardiothoracic Surgery from its earliest days not only advancing the science but also clinical medicine. Norman Shumway and others were translating bench research to bedside care decades before this phrase became popular. In 2005, Robert Robbins, yet another of Shumway's stellar trainees, became the Chair of the Department after Reitz. An accomplished transplant surgeon, Robbins also led a National Institutes of Health-funded basic science laboratory, publishing ground-breaking investigation of stem cell biology and directed the Stanford Cardiovascular Institute.³³ Regenerative therapies for myocardial repair continue in Stanford Cardiothoracic Surgery at the basic,

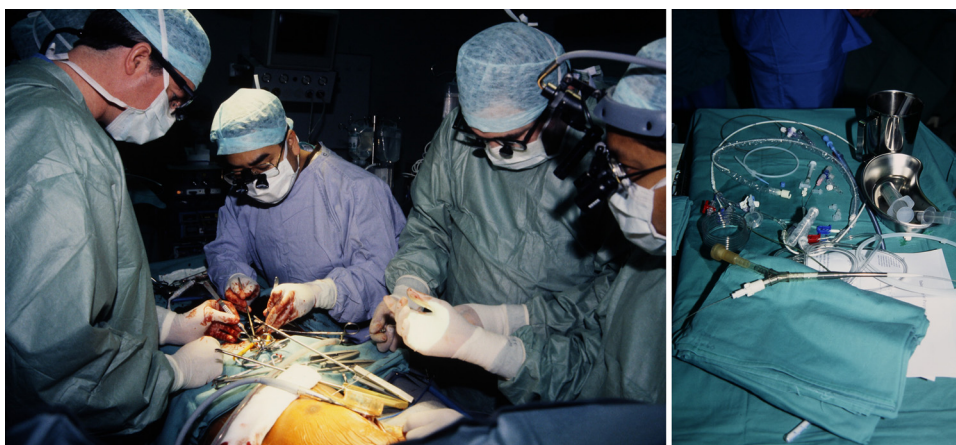


Figure 12. Heartport cannulas and instruments used during the Stanford and IJN surgeons performing the world's first-in-man port-access operation, Kuala Lumpur, 1996. Courtesy of Joseph Woo, MD. (Color version of figure is available online at <http://www.semthorcardiovascsurg.com>.)

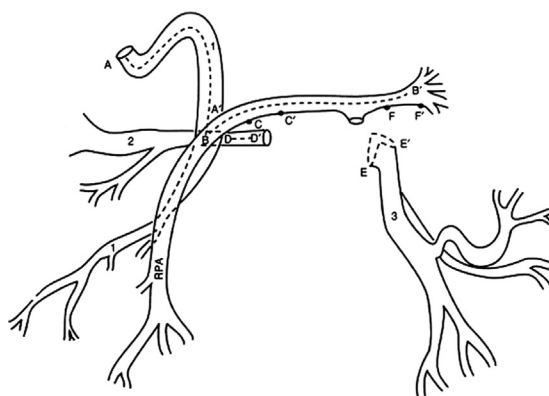


Figure 13. Original description of the single-stage unifocalization operation. Reprinted with permission from Reddy.³⁰

preclinical, and human clinical trial levels. Still expanding are the Department's collaborations with the Cardiovascular Institute, the School of Medicine, and across the University with Departments such as BioEngineering, Mechanical Engineering, Electrical Engineering, Materials Science, and Physics. Stanford University's rare attribute of having world-class Schools of Humanities and Sciences, Engineering, Medicine, Law, and Business all colocated on one central campus creates a unique environment highly conducive to collaborative discovery.

EDUCATION AND TRAINING

Residency training has been a prominent focus of the Stanford program for generations. Particularly notable is the Shumway approach to operative teaching whereby the faculty always stands on the left as the first assistant and the trainee on the right as the operating surgeon, a legacy that has endured through the decades. In a break from the standard pathway of general surgery training followed by cardiothoracic surgery training, in 2008, Robbins and Michael Fischbein, also trained at Stanford, created and implemented the nation's first formal integrated 6-year cardiothoracic surgery residency. Instead of general surgery residents, medical students would match directly into this program and spend their initial years in a moderate amount of general surgery and much more in cardiac surgery, thoracic surgery, vascular surgery, interventional cardiology, intensive care unit, echocardiography, radiology, and anesthesia. Most cardiothoracic surgery residency programs have now moved to a similar model. Ironically, this model actually resembles Shumway's original approach of training individuals without prior general surgery experience.

Stanford currently also offers accredited cardiac and thoracic track residencies for graduates of

general surgery training, as well as advanced super-specialty training programs in cardiopulmonary transplantation, MCS, and pediatric cardiac surgery. Fischbein now serves as overall Program Director for all of Stanford's multiple cardiothoracic surgery training programs. Also incorporated into the Stanford cardiothoracic residency is a formal simulation curriculum with annual videotaped technical examinations, a program of study developed by James Fann, another Stanford graduate.³⁴ Fann is a national leader in studying simulation in surgical training and his innovative educational tools are being widely adopted nationally³⁵ (Fig. 14).

CONCLUSION

Over its 100 plus year history, the program in thoracic and cardiovascular surgery at Stanford has produced epic scientific discoveries and clinical innovations in lung surgery, transplantation, MCS, thoracic aortic surgery, valvular surgery, minimally invasive surgery, and congenital heart surgery, improving untold numbers of patients lives at Stanford and beyond. Today, the delivery of cardiothoracic healthcare occurs across a growing network of Stanford-owned or affiliated hospitals and programs throughout Northern California and into neighboring states. On the main campus, Stanford is in the midst of the construction of a new \$2 billion adult hospital and \$1 billion pediatric hospital, which will significantly increase inpatient capacity and care delivery capability. In collaboration with the corporations of Silicon Valley, these new facilities, upon anticipated opening in 2017-2018, aim to be

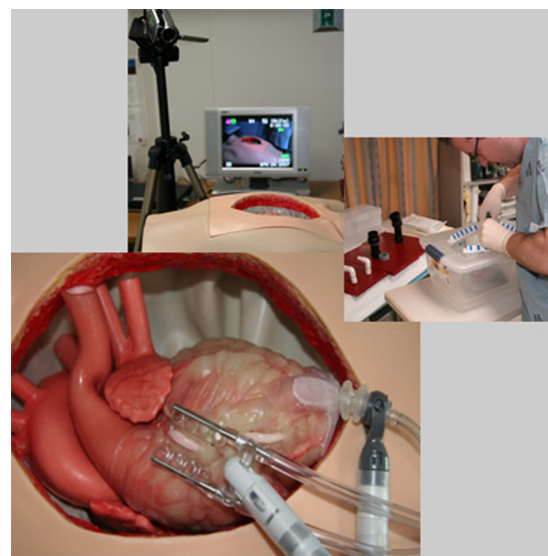


Figure 14. Simulators in Stanford Cardiothoracic Surgery.



Figure 15. New Stanford Adult Hospital opening in 2018, artist's rendition. Courtesy of Rafael Viñoly Architects.

among the most technologically advanced hospitals in the world (Fig. 15).

Advantageous co-location within the University among the Humanities & Sciences, Engineering, Law, and Business Schools affords unique opportunities for multidisciplinary collaborative research and development. Translating laboratory research into the care of patients has been and continues to serve as a fundamental principle of Stanford Cardiothoracic Surgery. Rigorous investigation of clinical results has guided continuous refinement of surgical treatments. Robust clinical device trials

abound. Steadfast commitment to resident teaching has always and continues to be of overarching importance. Basic and applied research, the breadth of diverse and pioneering clinical experiences, and a unique University environment comprise the abundantly rich platform for student education, resident training, and faculty career development. Created over these 100 years, is a storied institution that produced multiple presidents of major professional societies and leaders of American cardiothoracic surgery and will strive to train and develop the leaders of the future.

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