

An important cardiac surgery milestone: The first known stopped-heart operation



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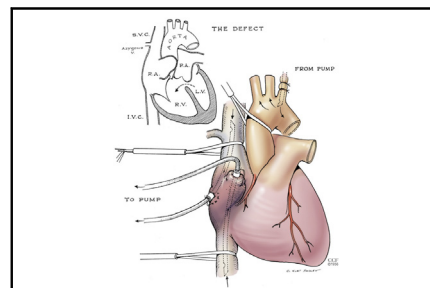
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Colored illustrations of the original drawings of the first cardioplegic arrest operation.

CENTRAL MESSAGE

The first known stopped-heart operation, performed by Donald Effler, MD, and Larry Groves, MD, was a precursor to what has become a major contribution to cardiovascular care of patients.

See Commentaries on pages 464 and 466.

▶ Video clip is available online.

On May 6, 1953, John Gibbon, MD, performed the first heart operation using a heart–lung machine without stopping the heart¹; afterward, various inflow occlusion types of operations continued to be performed, and C. Walton Lillehei was using cross-circulation for heart operations.² Meanwhile, Melrose and his team were experimenting in the laboratory on inducing cardiac arrest with potassium.³ On February 17, 1956, Donald Effler, MD, and Larry Groves, MD,⁴ performed the first documented operation in which the heart was stopped with aortic occlusion and potassium citrate infusion on a cardiopulmonary bypass pump (built by Willem Kolff, MD) with a 17-minute pump time. There is no indication from the report of the first 3 operations done with potassium arrest of the heart on cardiopulmonary bypass. In addition, there is no record of Effler and Groves previously doing ventricular septal defect (VSD) closures with either cross-circulation or cardiopulmonary bypass without stopping the heart.

CASE REPORT

The patient (who signed HIPAA [Health Insurance Portability and Accountability Act of 1996] forms and provided written consent to share his story and medical information with media, since institutional review board approval was not needed) was a 17-month-old child weighing 17 pounds when he underwent surgery. He suffered from failure to thrive, could not sleep lying flat, and had repeated episodes

of pulmonary edema and “pneumonia.” His parents had to pace with him at night to try to get him to sleep. F. Mason Sones, MD, who would perform the first coronary angiogram on October 30, 1958, performed a cardiac catheterization and documented a high VSD and pulmonary hypertension. The patient’s record notes that Dr Sones informed the parents of Dr Effler’s research on using the heart–lung machine to close heart defects, as well as Dr Effler’s caution that the operation carried a 25% to 30% risk of death. The patient’s family agreed to proceed, and the referring doctor was invited to observe. Dr Sones ordered “fresh whole blood” and to “start him on antibiotic” before surgery.

The operation report describes, “A transverse anterior thoracotomy incision was made through the right 4th interspace, the sternum was transected, and it was carried up the left 3rd anterior interspace. After exposure was obtained, the left subclavian was isolated, and it was ligated immediately proximal to its primary division and divided after securing the base with a Pott’s ductus clamp. An aortic cannula was then inserted and tied into the vessel; the tip of the cannula extended into the arch of the aorta” (reference [Figure E1, C and D](#), for images of typed operative notes,

as well as handwritten notes from Dr Sones [Figure E1, A]). Dr Effler noted during surgery that the pulmonary artery was significantly enlarged, under high pressure, and more anterior in the chest. A trans-right ventricular approach was used to close the VSD that was “about the size of a 5-cent piece which is a considerable defect for a heart of this size” with 4 interrupted silk sutures. After reperfusion the heart, spontaneous sinus rhythm returned. A lung biopsy was taken after weaning; otherwise, closure was uneventful. The patient’s postoperative period was normal other than a fever of 103°F, perhaps due to aspiration that was relieved with suction, but he was discharged shortly thereafter. The patient was asked to return 6 weeks postoperatively, and the patient’s doctor wrote to Dr. Sones to report on the patient’s remarkable recovery (Figure E1, B).

DISCUSSION

Time magazine⁵ and *Reader’s Digest* reported on the remarkable operation. Today, the patient is a 66-year-old retired trumpeter who was inspired by the great band leader Doc Severinsen. He decided to study music because Dr Sones did not think it was safe for him to play sports after having 2 ribs removed. The patient is also a grandfather and has never experienced any other cardiovascular events. In 1980, Dr Effler wrote to the patient, saying that the patient’s lucky number must be 17: 17th day operation, 17 months, 17 pounds, and 17-minute pump time.

This seminal patient with potassium-induced arrest and cardioplegia on a pump was a precursor to what has become a major contribution to the cardiovascular care of patients. The 3 illustrations accompanying this case report (in

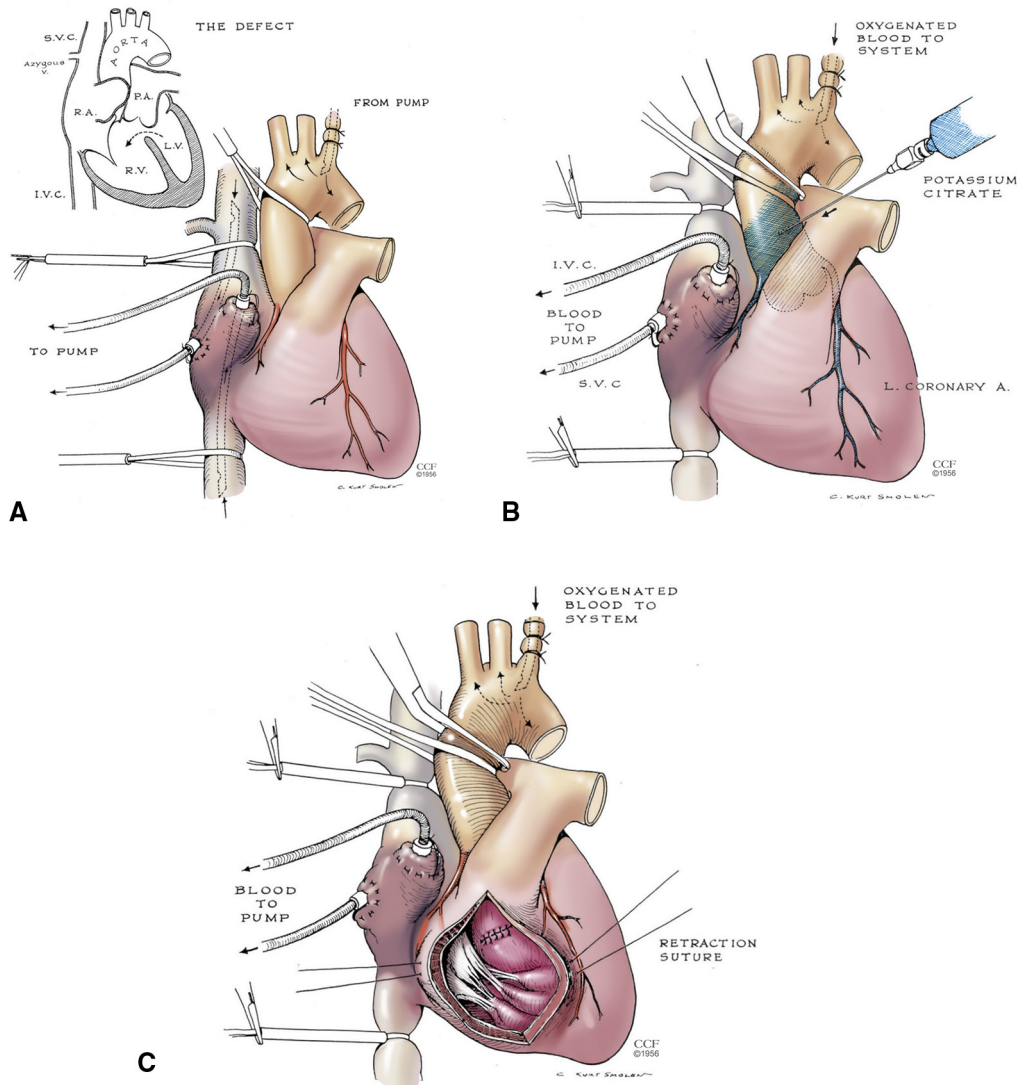
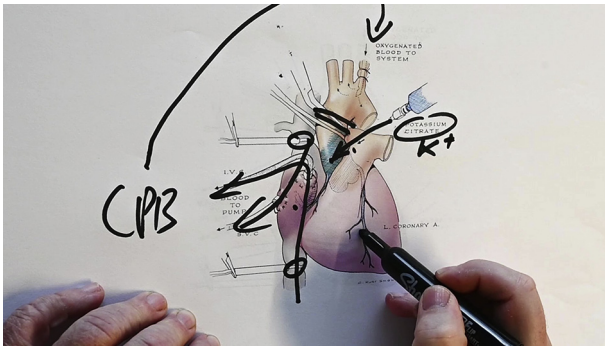


FIGURE 1. Colored illustrations of the original drawings of the first cardioplegic arrest operation. A, Illustration of the ventricular septal defect and cannulation via the left subclavian artery for cardiopulmonary bypass and venous drainage. B, Illustration of injection of potassium solution with the aorta crossclamped. C, Right ventriculotomy and closed ventricular septal defect. All images are reproduced with permission from Effler and colleagues.⁴ Copyright 2021 The Cleveland Clinic Foundation. All rights reserved.



VIDEO 1. Case Report. Lars G. Svensson, MD, PhD, discusses the milestone first stopped-heart operation to examine its significance for the evolution of heart surgery procedures. Video available at: [https://www.jtcvs.org/article/S2666-2507\(21\)00584-8/fulltext](https://www.jtcvs.org/article/S2666-2507(21)00584-8/fulltext).

Figure 1) depict colored versions of C. Kurt Smolen's original work.⁴ Additional explanation about this milestone operation appears in [Video 1](#).

Currently, about 500,000 heart operations are done annually in the United States—most still induced with potassium cardioplegia.⁶ This patient's story reminds us that the pioneers of cardiac surgery were great heroes for attempting operations with unknown outcomes. Thanks to their groundbreaking efforts, most heart operations have less than a 1% risk of death.

References

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OP Note
 2/17/56
 Closure of the inter-ventricular septal defect & extra coronary perfusion & Kardia.

THE CITIZENS BANK BUILDING
 ANDERSON, INDIANA
 March 30th, 1956
 Dear Dr. Sones:
 Mrs. B. called to-day inquiring if I had heard from you. She said you had indicated they should bring K. back in about 6 weeks.
 For nearly a week after returning home he sorely slept at night, and for the first few days behaved as though he was in a strange place. Finally I gave him a sedative enough to put him to sleep and since then everything has been Jacob.
 Wouldn't know why he should come back to Cleveland except to shake your hand and congratulate your entire team on an almost unbelievable performance.
 I know very well what the success of this case meant to you, and it certainly is a miracle. K. has not recovered from the operation completely but he is getting up more strength every day. No sign of a murmur is audible.
 Am most happy to have been privileged to see the care and surgery of this patient.
 Sincerely Yours, and many, many thanks

Name: [redacted] Age: [redacted] Case No. [redacted]
 Operation: [redacted] Date: [redacted]
 Anesthetic: [redacted] Room: [redacted] Time: [redacted]
 Surgeon: [redacted] Assistant: [redacted]
 Anesthetist: [redacted]
 PROBLEMS: With the patient under endotracheal anesthesia, a transverse anterior thoracotomy incision was made through the right 4th intercostal space. The sternum was transected, and it was carried up the left 3rd anterior intercostal space. Both intercostal spaces were divided and secured. At the exposure was obtained, the left subclavian artery was isolated and it was ligated immediately proximal to its primary division and divided after securing the base with a Bost's dactyl clamp. An aortic cannula was then inserted and tied into the vessel; the tip of the cannula extended into the arch of the aorta. The pericardium was then opened widely and the superior and inferior vena cava were ligated. Cannulas were then inserted through stab wounds in the muscular sheath and both vena were cannulated in this fashion. The cannulae were then sealed, an umbilical tape was placed around it at a point about 1 cm. distal to the aortic valve. The vena cannulae from the vena and the aortic cannula from the subclavian artery were then connected to the OHR oxygenator, and the patient was placed on the extracorporeal pump.
 With the use of the pump, the superior and inferior vena were then occluded around the cannulae by tightening down on the umbilical tape. The heart was allowed to empty itself and then a clamp was placed across the aorta at a point about 1 cm. distal to the valve, and a syringe solution was injected into the aorta in such a way that it would produce the anoxemia. The potassium citrate produced an artificial cardiac arrest and the patient's heart became completely flaccid and by electrocardiogram was completely flat. Four interrupted silk sutures were placed in the right ventricular wall and the ventricle was opened widely to expose the chamber. The residual blood was aspirated away but there was no significant bleeding from the heart itself and there was no coronary blood return. The septal defect could then be identified and accurately outlined. Four interrupted silk sutures were placed carefully to approximate the septal defect. After the sutures were tied and the defect was considered to be nearly closed, the aortic clamp was removed and almost immediately blood began to pour back through the coronary bed. Shortly after this, the heart began to resume its normal rhythm. The suture in the ventricular wall was then closed with a single silk suture, the first layer being a simple over-and-over suture, and a second layer being a mattress suture. The various cannulae were removed and the patient was returned to the OHR.

Name: Bryan Benson Age: 17 mos Case No. 159 124
 Operation: [redacted] Date: 2/17/56
 Anesthetic: [redacted] Room: [redacted] Time: [redacted]
 Surgeon: [redacted] Assistant: [redacted]
 Anesthetist: [redacted]
 Continued:
 and the pericardium was closed. The aortic cannula was removed from the subclavian vessel, the lungs were re-expanded, a lung biopsy was taken, the chest was then closed by approximating the ribs with pericostal cutgut on both sides, and approximating the cut edges of the sternum with two cutgut sutures through the soft bone and cartilage. Both pleural spaces were drained by simple Foley bag catheter drainage connected to waterseal suction. At the completion of the operative procedure, the child was reasonably active and seemed to be reacting very satisfactorily from the anesthesia.
 DICTATED BY: Donald B. Effler, M.D.
 D.B.E.
 2/17
 B

FIGURE E1. Original operative documents from first cardioplegic arrest operation. A, Handwritten operative notes with preprocedure instructions and notes about the procedure itself from Dr Sones. B, Letter written to Dr Sones from the patient's doctor with comments about the patient's recovery. C and D, Typed operative notes about the procedure. All images reproduced with the permission of the patient and Cleveland Clinic.