Claude Beck and Cardiac Resuscitation

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ABSTRACT **The problem of sudden death due to derangement of the cardiac mechanism remained poorly defined into the 20th century. The physiologist Carl J. Wiggers proposed maintenance of the circulation by manual massage of the heart, followed by electrical defibrillation at a suitable time. His surgical colleague Claude S. Beck, with several associates, defined a precise sequence of steps for management of cardiac arrest in the operating room and was able to apply them clinically with complete success. Subsequently, patients were resuscitated outside the operating room as well; and finally, massage and defibrillation across the intact chest have made cardiac resuscitation available at any place or time.**

Dr. Claude Beck, a large man physically but quiet and slow of speech, met his student group for a weekly seminar one day in the fall of 1949. Topic for the session was resuscitation from cardiac arrest, an activity regarded by many surgeons as unsound and vaguely reprehensible. Dr. Beck began by recounting an experience while a surgical intern at the Johns Hopkins Hospital in the early 1920s: "The operation was almost finished," he said, "when the anesthetist informed the surgeon that pulse and blood pressure were not obtainable, and the patient was blue. The surgeon removed his gloves, went to a telephone in the corner of the room, and called the Fire Department Rescue Squad. When the firemen arrived, perhaps 15 minutes later, the oxygen mask and the 'Pulmotor' were applied vigorously but without effect, and eventually the patient was pronounced dead." Later he added, "The experience left me with a conviction that we were not doing our best for the patient."

I was one of the students at the seminar; all of us were in awe of Dr. Beck as a renowned pioneer. Undoubtedly, he recounted the same episode to many audiences. Cardiac arrest was the principal hazard of anesthesia at the time, and cardiac monitors in the operating room were unknown. Aside from the specially shielded operating room lights, electrical equipment of any kind was a hazard to patient and surgical team because of the flammable anesthetics in daily use, ethyl ether and cyclopropane. Two years previously, for the first time, Dr. Beck had electrically defibrillated a patient's heart in the operating room.

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Historical Background

The French physiologists Prevost and Battelli [1] demonstrated in 1899 that fibrillation of the mammalian ventricles could be abolished by electric shock. Massage of the heart was used after countershock in the belief that it aided resumption of a normal rhythm [1]. Electrical induction and conversion of ventricular fibrillation (VF) were studied further in the early 1930s by Donald Hooker, a physiologist at Johns Hopkins University. By a happy chance, Hooker recruited to his studies two electrical engineers from the College of Engineering, William B. Kouwenhoven and O. R. Langworthy. Hooker confirmed that the canine heart essentially did not recover spontaneously from VF. Defibrillation by alternating-current countershock was possible, but it was ineffective after more than two minutes of fibrillation. Cardiac massage was regarded as dangerous: "The attempt to facilitate a reestablished circulation by cardiac massage was an unwise procedure, since it was all too likely to throw the ventricles into fibrillation again" [2, 3].

Carl J. Wiggers, professor of physiology at Western Reserve University (as it then was), saw that support of the circulation was necessary to maintain tissue oxygenation during VF, so as to permit defibrillation at a suitable time. He advocated cardiac massage to maintain circulation *prior* to countershock and again found that canine hearts could not be resuscitated after four to five minutes of VF if the circulation were not supported, or at all unless any coronary occluding ligatures were first removed [4]. In 1937, Claude Beck and his surgical associate Frederick R. Mautz [5], also at Western Reserve University and closely familiar with Wiggers' researches, outlined a systematic approach to cardiac arrest in the operating room (Fig 1). Their sequence ran in the following manner: (1) maintenance of pulmonary ventilation with 100% oxygen; (2) immediate surgical exposure of the heart, by nonsterile means if necessary; (3) manual cardiac massage to support the circulation; (4) defibrillation by countershock; and (5) topical and intracardiac application of procaine if the first shocks were ineffective. Their defibrillator applied a shock of 1.0 to 1.5 A, using 60-cycle alternating current at the standard potential difference of 110 V, for 0.5 to 2.0 seconds via two silver electrodes applied to the surface of the heart. Mautz [6] had demonstrated in 1935 that procaine, when applied to the surface of the heart or injected intracardially, markedly reduced irritability of the myocardium and facilitated electrical conversion.

Subsequently, two reports appeared of conversion of VF by massage alone or by massage plus intravenously administered procaine [7, 8]. Both reports cited Beck's principles of cardiac resuscitation, but in both cases no

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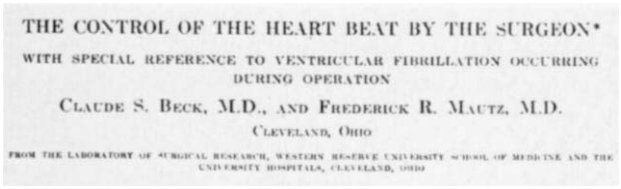

THE CONTROL OF THE HEART BEAT BY THE SURGEON*

WITH SPECIAL REFERENCE TO VENTRICULAR FIBRILLATION OCCURRING DURING OPERATION

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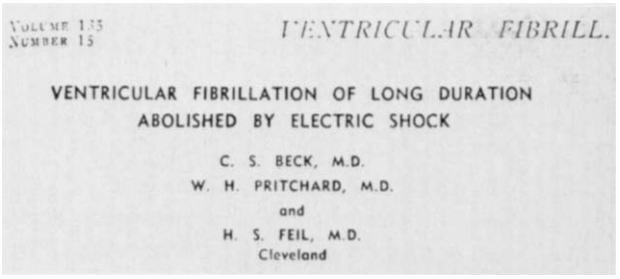
Fig 1. Title of paper by Beck and Mautz [5], 1937, advocating a precise standardized approach to management of cardiac arrest in the operating room.



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VENTRICULAR FIBRILL.

VENTRICULAR FIBRILLATION OF LONG DURATION ABOLISHED BY ELECTRIC SHOCK

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Fig 2. Title of article reporting the first successful electrical defibrillation of a human heart, 1947 [11].

defibrillator was available. Both patients had been receiving cyclopropane anesthesia; the agent may have been responsible in part for the arrhythmias, but it was also susceptible to rapid respiratory washout, allowing conversion.

During these years, Beck continually sought to gain acceptance for his views on cardiac resuscitation. His academic title, paradoxically, was Professor of Neurosurgery; he actually performed neurological surgery on a regular basis as well as such cardiac surgery as was then feasible. Throughout the 1930s and 1940s he was heavily occupied in the laboratory with his efforts, as he described them, to "bring a new blood supply to the heart." His studies reached clinical application, for a time, in the Beck II operation, arterialization of the coronary sinus by a vein graft from the descending aorta to the coronary sinus. At that time, without circulatory support, it was technically demanding and excessively hazardous. The alternative Beck I operation, while less hazardous, was not very effective; it sought to stimulate formation of intercoronary collaterals by abrasion and talc poudrage of the surface of the heart. Beck presided over the 25th annual meeting of the American Association for Thoracic Surgery at Detroit in 1946; his presidential address was entitled "The Direct Approach to Cardiovascular Diseases" [9]. One afternoon of the meeting was devoted to discussions of cardiovascular subjects by Drs. Helen Taussig ("by invitation"), Alfred Blalock, John Jones, Robert Gross, Clarence Crafoord, and Dwight Harken.

The Successful Achievement

In 1947, Dr. Beck operated on a 14-year-old boy to repair a pectus deformity. Rapid supraventricular tachycardia developed soon after induction of anesthesia and was treated by intravenous administration of lanatoside C, possibly in excessive dosages, as was pointed out in a later commentary [10]. Near the end of the operation, increasing cardiac irritability developed and rapidly progressed to VF. Without loss of time, cardiac massage was instituted and continued for 45 minutes before the fibrillation was abolished by countershock. The boy went on to make an apparently complete recovery (Fig 2) [11].

Aggressive treatment of cardiac standstill and VF in the operating room soon came to be regarded as mandatory. Many general surgeons found it difficult to pull back the drapes and do immediate precordial thoracotomy without sterile precautions, as was demanded by the drill. Application of the method outside the operating room was considered hardly feasible, but in 1953 a 55-year-old man was seen at the emergency room at the Burlington County Hospital in Mount Holly, NJ, complaining of recent onset of chest pain. While an electrocardiogram was being taken, VF developed. His chest was opened, the heart massaged, and fibrillation was successfully abolished by countershock after a defibrillator could be brought down from the operating rooms [12]. The case was not reported until 1956, but the report credited familiarity with Beck's resuscitation techniques for the successful outcome.

This apparently was the first case of successful defibrillation of the human heart after (probable) coronary occlusion, or in a location outside the operating room. Such an outcome had been thought unlikely, if not impossible, as Wiggers [4] had found that the canine heart could not be defibrillated unless any occluding ligatures on the coronary arteries had been removed.

On June 22, 1955, however, a 65-year-old practicing physician named Albert Ransone came in to University Hospital in Cleveland to have an electrocardiogram. The previous evening he had experienced persistent precordial distress, and subsequent review of the tracing showed evidence of early posterolateral myocardial infarction. Dressed once more in his street clothes, Dr. Ransone collapsed while leaving the hospital and was transported to the emergency ward without pulse or blood pressure. His chest was opened without removal of his vest or shirt, and cardiac massage plus ventilatory support were instituted. After 25 minutes of massage, the heart was successfully defibrillated by countershock [13]. He eventually left the hospital and resumed his practice for a time before retiring. A recent follow-up note by Dr. Elden C. Weckesser [14], one of the participants in the resuscitation, recorded that Dr. Ransone lived more than 28 years after the episode, dying at the age of 93.

Epilogue

Immediate nonsterile thoracotomy for cardiac massage was an awkward undertaking outside the operating room, virtually impossible outside the hospital, although a number of attempts were made. The technique was not suited to wide application, but it remained the

only feasible method of cardiac resuscitation from 1947 to 1960 [15, 16].

Conversion of cardiac arrhythmias by electric shock across the intact chest was studied by Zoll and associates [17] in 1956. Still using 60-cycle alternating current, they were able to terminate all varieties of arrhythmia, including ventricular tachycardia and VF. High energy levels were required, using potentials of 240 to 600 V. Cardiac pacing across the intact chest also was feasible, but unpleasant for the conscious patient.

Direct-current countershock had been studied in 1947 by the Soviet physiologists Gurvich and Yuniev [18], but subsequently it was noted that capacitance discharges sufficient to depolarize the heart involved an initial energy peak so high as to be injurious. Bernard Lown [19] showed that the most effective depolarization for all cardiac arrhythmias could be achieved by a modified capacitance discharge, which truncated the energy peak, prolonged the discharge, and was timed to avoid the vulnerable period at the apex of the T wave.

Finally, Dr. William B. Kouwenhoven had retired from his professorship of electrical engineering but had been granted facilities in the surgical laboratory at Johns Hopkins to continue pursuing his interest in cardiac resuscitation. Joined by G. Guy Knickerbocker and Dr. James R. Jude (then a resident in surgery), he noted that the pressure of the heavy external defibrillating electrodes on a dog's chest caused a momentary rise in the recorded arterial pressure [20]. First in animals, then in patients, the three investigators showed that adequate circulation could be maintained during cardiac arrest by external compression of the chest, allowing defibrillation when necessary by external countershock [20]. With this dramatic advance, cardiopulmonary resuscitation became applicable at any place or time and could be performed by trained lay people.

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