Srinivasa N. Raja, M.D., Editor

In this issue of ANESTHESIOLOGY, we are pleased to launch a new section entitled "Classic Papers Revisited." As the title suggests, this section will offer a retrospective on publications to the fields of anesthesiology, critical care medicine, and pain that have come to be regarded as classics because of the impact they have had on the growth of our field. The format will include the abstract of the "classic paper" (or, in the absence of an original abstract, a reconstructed one), followed by a commentary from the author(s) or an established investigator in the field. The concept is to provide a historical perspective on the background and significance of the paper to the science and practice of anesthesiology.

We inaugurate this section with a commentary by Dr. Peter Safar on his report in the *Journal of the American Medical Association* on resuscitation, a seminal paper that has led to major advances in cardiopulmonary resuscitation.

The first few classics have been selected based on suggestions by the members of the Editorial Board. We welcome your feedback and suggestions for future selections. We hope that this section will provide an interesting and revealing perspective on past studies and the investigators who have made the field of anesthesiology what it is today. In particular, we hope that our younger generation of clinicians and researchers will enjoy being introduced to these pioneers in our field.

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From Control of Airway and Breathing to Cardiopulmonary–Cerebral Resuscitation

Peter Safar, M.D., Dr.h.c., F.C.C.M., F.C.C.P.

Ventilatory efficacy of mouth-to-mouth artificial respiration: Airway obstruction during manual and mouth-to-mouth artificial respiration. By Peter Safar. JAMA 1958; 167:335–41.

Background: **For respiratory resuscitation without devices, the author hypothesized that providing upper airway patency requires lifting the base of the tongue off the posterior pharyngeal wall and that artificial ventilation with intermittent positive pressure using exhaled air, *i.e.*, direct mouth-to-mouth ventilation (MMV), is more effective than back or chest pressure with or without arm lift. MMV leaves the operator's hands free for backward tilt of the head, forward displacement of the mandible, or both.**

Methods: **The author studied 25 sedated, nonintubated adult human volunteers under neuromuscular blockade with succinylcholine for 1–3 h each. One hundred sixty-seven untrained lay persons performed various direct MMV methods after one demonstration. Eighteen trained ambulance rescuers performed back or chest pressure arm-lift methods. Ventilation volumes were recorded during MMV from a calibrated pneumograph and during the manual methods from a taped face mask on a spirometer. Arterial oxygen saturation was monitored by an ear oximeter, and end-tidal carbon dioxide was measured by an infrared analyzer.**

Results: **With the head in the mid position or flexed, airway obstruction occurred in all volunteers, equally in the supine or prone position. With the head tilted backward and the mouth held open, one half to two thirds of the volunteers had an open airway; the remaining volunteers required additional forward displacement of the mandible or a pharyngeal tube. Ninety percent of the lay persons performed MMV effectively. Moderate hyperventilation by the operator achieved normoxemia and normocapnia in the volunteer and moderate hypocapnia in the operator. Apnea-induced moderate hypoxemia was reversed with 5–9 MMVs. In the majority of volunteers, the manual methods caused no ventilation (mostly because of neck flexion), and in others, it caused progressive airway obstruction. In some volunteers, there was valve-like nasopharyngeal obstruction.**

Conclusions: In coma without a tracheal tube, direct MMV is effective because of the ability of the rescuer to support the head and jaw for upper airway patency and because of controllable high inflation pressures and volumes, whereas manual methods frequently fail to ventilate, mainly because of upper airway obstruction. The author recommends that backward tilt of the head plus exhaled air inflation methods be taught for general use in adults and children.

ANESTHESIOLOGY'S revisiting of our article in the *Journal of the American Medical Association*[1] of 1958 arouses memories. That study documented step A (airway control) and step B (breathing control by mouth-to-mouth ventilation) and the failure of the then-taught methods of back pressure (prone) or chest pressure (supine), with or without arm lift. The paper thereby initiated modern cardiopulmonary resuscitation (CPR) research. In October 1956, when I attended the American Society of Anesthesiologists meeting in Kansas City, Missouri, I was initiating chief of an academic department of anesthesiology at Baltimore City Hospital (now called Johns Hop-

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kins Bayview Medical Center), Baltimore, Maryland. At that meeting, I met anesthesiologist James Elam, M.D., then chief anesthesiologist at the Roswell Park Memorial Hospital in Buffalo, New York, and on duty at the US Army Chemical Center in Edgewood, Maryland. He told me that he had shown in apneic humans that intermittent positive-pressure ventilation by mouth-to-mask or mouth-to-tracheal tube could maintain normal blood gas values.[2] Elam's personality and data and the fact that his findings lay dormant motivated me to research resuscitation. Starting in December 1956, I studied and documented the failure of the manual methods and the superiority of direct mouth-to-mouth ventilation without devices.[3] Simultaneously, our team investigated patterns of upper airway obstruction.[4] I presented the data of this revisited 1958 article[1] for the first time at the American Society of Anesthesiologists meeting in Los Angeles, California, in October 1957 (during the week the Soviets launched Sputnik). There were two other articles invited simultaneously by the *Journal of the American Medical Association*: one by Elam regarding blood gas data and one by Archer Gordon, M.D., surgeon at the University of California in Los Angeles, California, regarding mouth-to-mouth ventilation *versus* manual ventilation in children (data obtained in 1957 after my first results became known).[3] Within 1 yr, this triumvirate convinced the world to switch from teaching the manual methods to teaching head tilt plus mouth-to-mouth ventilation.

Curarized and sedated adult volunteers without tracheal tubes were needed because in coma, the natural upper airway of humans is kinked, whereas most animals' airways are straight, and conscious humans cannot relax in apnea. There were no institutional review committees then. Volunteers were ultrainformed. I obtained approval from peers and from the US Army, which supported our research. Two courageous colleagues deserve special recognition for having volunteered several times, including the making of documentary movies by the US Army, which helped convince the world: Felix Steichen, M.D., then chief resident in surgery (he later became a professor), and Richard Fredricks, M.D., then resident in pathology, both at the Baltimore City Hospital.

We documented, with roentgenograms and ventilation volumes, what many anesthesiologists instinctively knew—providing airway patency with backward tilt (extension) of the head, forward displacement of the mandible ("jaw thrust"), or both. I called it step A, airway control. Some believe that backward tilt of the head for coma[3,4] has saved more lives inside and outside hospitals than standard external CPR for cardiac arrest. Epidemiologic outcome data for this are needed.

William Kouwenhoven, Ph.D., professor of electrical engineering at the Johns Hopkins University, Baltimore, Maryland, had conducted since the 1940s dog studies of electrical fibrillation and defibrillation. In 1957, he and I agreed that a closed-chest method for emergency artificial circulation is needed. In 1958, Guy Knickerbocker, Kouwenhoven's Ph.D. student, made the brilliant, serendipitous rediscovery that pressure (by paddles) on the chest caused an arterial pulse. That became step C. Kouwenhoven saw the importance of this and had it documented in dogs. Johns Hopkins' surgeon Henry Bahnson, M.D., and surgery resident James Jude, M.D., were the first to try it in patients.[5] Conveniently, the new potent inhalation anesthetic halothane, introduced without precision vaporizers, sometimes produced transient pulselessness. The anesthesia team of Donald Benson, M.D. (Johns Hopkins University), provided steps A and B while Jude performed step C.

Sternal compressions alone are not CPR. In 1960, at the Baltimore City Hospital, I questioned the ability of sternal compressions alone to ventilate the lungs. We documented in humans with or without cardiac arrest, with or without tracheal tube, that no reliable ventilation is produced by sternal compressions alone.[6] Recently, cardiology-based colleagues of the American Heart Association CPR Guidelines Committee, considering basic life support with step C only, have ignored these data[6] and those of this revisited paper.[1] Our results made me assemble and teach steps A, B, and C together as CPR basic life support since 1959.

In 1961, I added steps D, E, and F (drugs; external electrical countershock pioneered by Gurvich,[7] Kouwenhoven,[8] and Zoll[9]; and fluids) as advanced life support for restoration of spontaneous circulation and prolonged life support. For prolonged life support, G was for "gauged" (titrated), H was for "humanized" (brain-focused, with hypothermia), and I was for "intensive care." In 1958, we at Baltimore City Hospital had introduced America's first multidisciplinary, physician-staffed intensive care unit for patients with any acutely life-threatening vital organ system failure.[10] After 1961, I promoted the extension of CPR to cardiopulmonary–cerebral resuscitation (CPCR).[11] For the delivery of CPCR, we composed guidelines in the early 1960s for community-wide emergency medical services systems—from the site *via* transport to the most appropriate hospital's emergency room, operating room, and intensive care unit.[12] My associates and I also initiated CPR education research.

In the 1950s and '60s, postarrest moderate resuscitative hypothermia (30°C) was used sporadically but without controlled data. It was then given up for 25 yr, probably because of adverse effects and management problems. For cerebral resuscitation, we revived resuscitative hypothermia research in the mid 1980s because of disappointing pharmacologic strategies. We used our novel, clinically realistic cardiac arrest outcome models in dogs. With cerebral blood flow promotion (by hypertensive hemodilution) and mild hypothermia (34°C), the efficacy of which we discovered in dogs in 1987, we

could normalize cerebral outcome after normothermic cardiac arrest of 11 min without blood flow.[11] Also, compared with standard external CPR, open-chest CPR or emergency cardiopulmonary bypass proved more effective for the heart and brain.[11]

Dr. Raja asked me: "Which aspects of your research have become most satisfying to you?" I answered: (1) Having recognized in the 1950s the importance of resuscitation research and having seen our results on CPR steps A and B and the need for the CPCR system withstand the test of time; (2) having helped clarify the pathophysiology and reversibility of acute dying processes (inspired by Vladimir Negovsky, M.D., Ph.D., Institute for General Reanimatology, Russian Academy of Medical Sciences, Moscow, Russia); and (3) having helped many young colleagues to become creative clinician-scientists. Now, focusing on unresuscitable conditions, my associates and I are exploring "suspended animation for delayed resuscitation," for the rapid induction of preservation of the organism at the start of cardiac arrest, for transport and repair without pulse, to be followed 1–2 h later by resuscitation with emergency cardiopulmonary bypass.[13]

No single investigator "invented" CPCR. Much knowledge about resuscitation existed around 1900, but for half a century, there was no implementation. Currently, the implementation of knowledge in resuscitation is still suboptimal. In 2001, let us hope that increasingly more effective CPCR for "hearts too good to die" (a term coined first by Claude Beck, Case Western Reserve University, Cleveland, OH) and "brains too good to die" (a term coined first by the author) will be researched by multidisciplinary teams and implemented rapidly, without repeating the mistakes of 1900.

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