

## A Window into the History of Resuscitation

### *Anesthesiology's Contribution to Artificial Respiration*

By Shawn Hicks

Imagine a black and white photograph. The date is 1957. The setting is an operating room at a Baltimore hospital. There is no operating table and a man lies on the floor. The man, a volunteer, is pharmacologically paralyzed and sedated. Several people are gathered around the room, some doctors, several boy scouts and other people from the community. Everyone's attention is focused on one of the first-ever demonstrations of mouth-to-mouth respiration.

This photograph hangs in the hallway outside a conference room at the Safar Center for Resuscitation Research in Pittsburgh. During my time in graduate school at the University of Pittsburgh, my advisor attended regular research meetings there and I was able to tag along to hear about current research news. Every time I walked down that hall, this particular photograph grabbed my attention. I just knew there had to be a great story behind that picture.

Not surprisingly, the discipline of anesthesia played a fundamental and pivotal role in the development of resuscitation medicine. This essay will briefly discuss the history of resuscitation and how the field of anesthesiology contributed to this knowledge. In particular, this paper provides an overview of the history of airway control and ventilation, from the early anatomy experiments of Galen and Vesalius; the (attempted) recovery of drowned persons in the eighteenth and nineteenth centuries; life support during general anesthesia in the late nineteenth and early twentieth centuries; and finally the development of artificial respiration of today.

References dating back a thousand years refer to artificial respiration in some form or another. The most credible reference approximating artificial respiration is from Galen, in 177 A.D. At the time, little was known about the heart and lung function of mammals. Galen had made attempts at examining the cardiopulmonary system in live animals. However, these experiments were impeded because the animal died from a pneumothorax caused by the chest wall dissection. He attempted without success, to remedy this problem by using bellows to inflate the lungs [1, 2]. Galen continued to believe that the spirit air, pneuma, lived inside all living things, a belief that was not challenged for hundreds of years. It is clear from Galen's thoughts on human physiology that he may not have appreciated the significance of his attempts at ventilation.

This insight into physiology would be largely forgotten until the time of the great anatomist,



**Baltimore City Hospital  
Department of Anesthesiology  
Resuscitation Experiment, July  
13, 1957  
Volunteer: Felix S Teichen, MD  
Resident in Surgery**

Andreas Vesalius in 1543. Vesalius performed tracheotomies on his experimental animals and blew air into their lungs through a reed, keeping the animal alive while he examined the cardiopulmonary system [1]. With this technique Vesalius initiated a chain of discoveries that would erode Galen's long-held superstitious theories. These observations in anatomy made it possible for the seventeenth century physician, William Harvey to describe the circulatory system for the first time [2].

Early attempts at reviving the non-breathing were unsuccessful. A society for the recovery of drowned persons was founded in Amsterdam [2] in the middle of the eighteenth century. This society made recommendations on the treatment of the recently drowned. The rescuer was advised to warm the victim, remove swallowed water, and use bellows, or perform mouth-to-mouth ventilation. Unfortunately, the rescuers were also advised to initiate blood letting and rectal stimulation using tobacco smoke. These rescue societies expanded to other parts of Europe, as did the number of rescue techniques. The importance of mouth-to-mouth (or device) ventilation in artificial respiration would not be realized for another two hundred years.

New techniques emerged, such as the "ready method" introduced by Hall in 1857. In an attempt to compress and expand the chest, the ready method called for repeatedly switching the victim's position from prone to the side. Soon thereafter, Henry Sylvester introduced his technique of raising the victim's arms above the head (causing inhalation), to replacing the arms on the chest and applying pressure (causing exhalation). Other methods advocated pulling and releasing the tongue at a rate of 15 times a minute. The Nielson method applied pressure on the shoulder blades and then lifted the arms above the head. Debate over the best technique raged on for years. From 1850 to 1950, over 108 methods of artificial respiration were described in the literature [3]. Many of these methods continued to be used well into the early 1900s, even in hospitals and in operating rooms.

The introduction of ether to surgical practice by Crawford Long [4] in 1842, and the first public demonstration of ether administration in 1846 by William Morton [5], indirectly led to our present-day practice of artificial respiration. Ether, as well as chloroform, was given by open drop administration with the risk of causing airway obstruction, apnea and pulselessness [6] - not very desirable outcomes. This spurred the development of airway control and ventilation in the operating room. At the time, crude airway instruments were being used during surgery, such as the tongue forceps. In 1880, Howard described how extension of the neck could open the airway [7]. In the early 1900s, Franz Kuhn made significant advances in airway control with tracheal intubation and positive pressure ventilation [8]. However, these valuable techniques were confined to the operating room. Several decades would pass before all the pieces would be rediscovered and fully realized.

The history of artificial respiration would take a new leap forward when James Elam was faced with treating a polio epidemic as an anesthesia resident at the University of Minnesota in 1946 [3]. Elam successfully applied mouth-to-mouth ventilation several times to a small number of patients suffering from bulbar polio. Elam was familiar with this technique from its use by midwives in Europe and from an account of its successful use by Tossach in 1744 [9]. At the time there were several references advocating this method over the manual methods [10, 11]. However, the medical community still did not accept this method. Some of Elam's colleagues thought that the acceptance of artificial respiration was delayed because of the introduction of germ theory, making it unsanitary to make mouth-to-mouth contact between victim and rescuer, and secondly, and by the thought that a hypoxic person could not be revived with exhaled air containing carbon dioxide (a newly discovered poisonous gas). This

did not deter Elam from investigating its potential.

In 1954, Elam documented the use of the mouth-to-mask method on patients recovering from general anesthesia [9]. By measuring expired CO<sub>2</sub>, tidal volume, and arterial blood gases, he was able to demonstrate conclusively that expired air was sufficient to maintain adequate ventilation. Unfortunately, convincing the world of the value of this approach would prove more difficult. Elam held seminars for rescue personnel and enlisted the help of a medical student, whom he sedated and paralyzed for demonstrations [3]. Despite this dramatic evidence of success, the Red Cross remained unconvinced and clung obstinately to the ineffective manual methods. It would take more experiments to finally convince the medical community and the general public.

These experiments arose from a chance encounter between James Elam and Peter Safar during a two-day car ride from Kansas to Baltimore [12]. Peter Safar was an anesthesiologist working at the Baltimore City hospital and, at the time was unaware of Elam's previous work. Safar's interest was kindled and redirected his career toward resuscitation research. This collaboration led to experiments demonstrating the definitive superiority of the mouth-to-mouth methods over the long-practiced manual methods [13, 14]. The first two steps of the ABCs of resuscitation were coined: "A" for airway, the head tilt; and "B" for breathing, direct mouth-to-mouth (or mask) ventilation by a rescuer.

Elam and Safar embarked on a multifaceted campaign to convince the public of their newly proven technique. Many demonstrations were given at medical conferences and on public television. During one such television demonstration, Elam was the announcer, Safar was the rescuer, and (amazingly) his wife, Eva Safar, was the victim [3]. The American Medical Association and American Red Cross officially sanctioned the use of the head-tilt and mouth-to-mouth technique in 1958 with the Canadian Red Cross following in 1959.

The photograph described at the beginning of this essay captures an exciting and very important moment in medical history, almost as if it were a window looking back through decades (and centuries) of research into the reversal of sudden death. This history also reflects the fundamental contribution of anesthesia in the development of modern resuscitation and life support.

## References

[1] Baker A., *Artificial respiration, the history of an idea*. Med History, 1971. 15(4): p. 336-51.

[2] Eisenberg M., *The quest to reverse sudden death: A history of cardiopulmonary resuscitation*, in *Cardiac Arrest: The science and practice of resuscitation medicine.*, H.H. Paradis NA, Nowak RM., Editor. 1996, Williams & Wilkins: Baltimore. p. 1-27.

[3] Eisenberg M., *Life in the Balance: emergency medicine and the quest to reverse sudden death*. 1st ed. 1997, New York: Oxford University Press.

[4] Hammonds WD, Steinhaus SE., *Crawford W. Long: Pioneer Physician in Anesthesia*. J Clin Anesth, 1993. 5(5): p. 163-167.

[5] Greene N., *Anesthesia and the development of surgery (1846-1896)*. Anesth Analg, 1979.

58(1): p. 5-12.

[6] Safar P., *On the history of modern resuscitation*. Crit Care Med, 1996. 24(2): p. S3-S11.

[7] McIntyre J., *History of Anesthesia: Oropharyngeal and nasopharyngeal airways: I (1880-1995)*. Can J Anaesth, 1996. 43(6): p. 629-35.

[8] Thierbach A., *The Resuscitation Greats: Franz Kuhn, his contribution to anesthesia and emergency medicine*. Resuscitation, 2001. 48: p. 193-197.

[9] Elam JO, Elder JD, *Artificial respiration by mouth-to-mask method*. NEJM, 1954. 250(18): p. 749-754.

[10] Waters RM, *Artificial respiration: comparison of manual maneuvers*. Anesth Analg, 1936. 15: p. 151-154.

[11] Waters R., *Simple methods for performing artificial respiration*. JAMA, 1943. 123(559-61).

[12] Safar P., *From Vienna to Pittsburgh, For Anesthesiology and Acute Medicine*. 1st ed. Careers in Anesthesiology, An Autobiographical Memoir., 1st ed. M.K. Fink BR. Vol. 5. 2000, Park Ridge: Wood Library-Museum of Anesthesiology.

[13] Safar P, Elam JO., *A comparison of the mouth-to-mouth and mouth-to-airway methods of artificial respiration with the chest-pressure arm-lift methods*. NEJM, 1958. 258(14): p. 671-677.

[14] Safar P., *From control of airway and breathing to cardiopulmonary-cerebral resuscitation*. Anesthesiology, 2001. 95(3): p. 789-91.