BULLETIN OF ANESTHESIA HISTORY

VOLUME 13, NUMBER 3 JULY, 1995

John S. Lundy, Ralph Waters, Paul Wood: *The Founding of the American Board of Anesthesiology*

*by Douglas R. Bacon, M.D.**

The triumvirate of John Lundy, Ralph Waters and Paul Wood is critical to the history of anesthesiology. Long-time friends, Travel Club members and pioneers in the developing specialty of anesthesiology in the 1920s and '30s, these three men combined their unique talents to create the American Board of Anesthesiology. Theirs is not a fairy tale story; for in attempting to certify physician anesthetists as specialists Lundy, Waters and Wood had to defy the existing political power in anesthesiology, create a society, national in scope, acceptable to the American Medical Association (AMA), and devise certification criteria satisfactory to the AMA and themselves that insured qualified physician specialists' recognition.

Lundy, Waters and Wood each had individual talents. Lundy was friends with Dr. Olin West, secretary and general manager of the AMA, and other influential members of the AMA.[1] Waters, the eldest, was a consummate clinician and investigator. He developed the first true academic department of anesthesiology in the United States at the University of Wisconsin, Madison.[2] The New York City stalwart, Paul Wood, stands in contrast to the other two men. His genius was organization, and between 1930 and 1945 he ensured that several societies of anesthetists remained active and vital. Wood mimeographed minutes of the American Society of Regional Anesthesia and the New York Society of Anesthetists to permit members outside of cosmopolitan New York to maintain adequate involvement with the organization.[3]

John Silas Lundy, M.D.

John Lundy was born in Inkster, North Dakota, July 6, 1894. His father was a physician who had helped to organize the North Dakota Medical Society. Lundy's father died of pneumonia when John was a toddler, and he lived with his mother for most of his adult life. Lundy graduated from the University of North Dakota with a Bachelor of Arts degree in 1917, and received his Medical Doctorate from Rush Medical College in Chicago in 1920.[4]

Shortly after graduation, Lundy settled in Seattle, Washington, and began practicing anesthesia. He had Dr. Foregger build him a portable gas machine (nitrous oxide, oxygen, carbon dioxide and ethylene) with an etherizer in 1923. Lundy liked to use the newest anesthetic techniques, and in that same year he first used ethylene to produce general anesthesia.[1]

A year later, William Mayo was visiting Seattle prior to embarking on a transpacific voyage. At a dinner held in his honor by the Kings County Medical Society, Mayo wound up sitting next to Lundy. The brash young anesthetist inquired if the famed Mayo clinic used ethylene to produce general anesthesia. Mayo responded they did not, and in the course of the evening Lundy impressed Mayo sufficiently that the surgeon offered him a position at the Clinic, heading a newly created section on anesthetics.[5]

Lundy accepted. Safely installed at the Clinic, producing scientific papers[6] and anesthetizing the rich and famous[7], Lundy thrived. He was responsible for supervising the nurse anesthetists, a sore political point that would eventually lead to the unification of the triumvirate and the founding of the American Board of Anesthesiology. Using his political connections, on every visit to Chicago Lundy would call on Dr. West and lobby for the official recognition of anesthesiology as a specialty.

Ralph Milton Waters, M.D.

Ralph Milton Waters was the elder statesman of the triumvirate. Born October 9, 1883 in North Bloomfield, Ohio, he was a lad of eleven when Wood and Lundy entered the world. Waters attended the Western Reserve University and in 1912 received his Medical Doctorate. He initially opened a general practice in Sioux City, Iowa, but quickly began to specialize in obstetrics and anesthesia. Having been given a nitrous oxide apparatus by one of the surgeons in exchange for Waters anesthetizing all of his patients, Waters soon began to be recognized as an anesthetist in the local medical community. By 1915 he was a full time specialist.[8]

Four years later, in 1919, Waters opened the Downtown Anesthesia Clinic. It was an ambulatory surgery clinic, a concept pioneered by Waters. In 1923 Waters moved to Kansas City, Missouri, and replicated the clinic on a larger scale. He also began investigation into carbon dioxide elimination, and developed the Waters to-and-fro canister. In 1927, at the age of 43, he was recruited to the University of Wisconsin to direct the anesthesia section and develop an academic group. He was extremely successful, and his graduates have continued to dominate academic anesthesiology.[9]

Paul Meyer Wood, M.D.

Paul Meyer Wood was born on June 8, 1894, in Frankfort, Indiana, the son of school teachers. He began his college education at the University of Notre Dame in 1912, and transferred to Columbia University in New York when his family moved east for his father to accept a headmaster's job at a Biblical Seminary training missionaries. In 1917 Wood entered the College of Physicians and Surgeons, but interrupted his medical studies to organize an ambulance unit which saw action on the Italian front.[10]

Continued on Page 4

*Presented at the 1994 ASA meeting in San Francisco. Supported by a Wood Library-Museum Fellowship and by a Sonnecker Fellowship for the American Institute for the History of Pharmacy.

Anesthesia History Association Annual Meeting and Dinner

Thanks to the efforts of Dr. Bill Hammonds, Local Arrangements Chairman, and Dr. Ray Fink, President Elect, the annual meeting and dinner this year will be on Tuesday, October 24, in the Milan and Strasbourg Rooms on the third floor of the Atlanta Hilton and Tower Hotel.

A no-host Social Hour at 6:30 p.m. will be followed at 7:30 p.m. by the business meeting and a buffet dinner, at which wine will be served.

The lecture this year will be presented by Dr. Martin Moran, a distinguished physician and pediatrician. Recently, he has written a book on the history of medicine in Atlanta and at present he is President-Elect of the Medical Association of Atlanta. His topic will be: History of Medicine in Atlanta.

Those wishing to attend this meeting and renew friendships with members of the Association are urged to send their reservations and checks (total cost $55.00 per person) soon (not later than October 1) to: Dr. William D. Hammonds; Center for Pain Medicine, Emory Clinic; 1327 Clifton Road N.E.; Atlanta, GA 30322.

Please complete the insert in the Bulletin to facilitate handling the reservations. Everyone is welcome to bring guests.

A New Transformation

Beginning with this issue, it will be noted that there is a new name and a new masthead. The Newsletter is to be called the *Bulletin of Anesthesia History* and is sponsored jointly by the Anesthesia History Association and the Wood Library-Museum of Anesthesiology. For the present, the Editor will remain the same and the Associate Editors will be Dr. Doris K. Cope, representing the Anesthesia History Association, and Dr. Donald Caton, representing the Wood Library-Museum. The Editorial Staff, as in the past, will remain under the guidance of Mrs. Debra Lipscomb, who has done superb work and will continue to do so.

The contents of the *Bulletin* will not change radically and will attempt to bring to readers items of historical interest and value to which it has access. All readers of the *Bulletin* are invited to submit papers and articles of interest to our specialty and/or to make suggestions as to how the *Bulletin* may be improved.

Richard H. Ellis, M.B., B.S., F.F.A.R.C.S. (1937-1995)

A well-known and respected British colleague, Dr. Richard Ellis, died suddenly at 58 years of age in the postoperative period following an operation on May 10, 1995.

Dr. Ellis was a Consultant Anaesthetist and Senior Cardiothoracic Anaesthethetist in the Department of Anaesthesia at St. Bartholomew's Hospital in London.

From 1975-1977 he served on the Council of the Association of Anaesthetists of Great Britain and Ireland. Beginning in 1980, he edited the third volume of *Essays on the First Hundred Years of Anaesthesia*, which was published in 1982, along with a reprinting of Sykes' earlier two volumes. The completed works were sponsored in part by the Wood Library-Museum of the American Society of Anesthesiologists.

From 1983-1990 he was one of the Faculty of Anaesthetists' examiners for the final part of the F.F.A.R.C.S. examination. From 1985-1988 he was a member of the Council of the Section of Anaesthetists of the Royal Society of Medicine.

In 1985 he presented the Lewis H. Wright Memorial Lecture at the annual meeting of the American Society of Anesthesiologists and also was the guest lecturer at the annual meeting of the Anesthesia History Association.

He was the author of 36 papers, about half of which were concerned with the history of anesthesiology.

His most recent publication in 1994 was *The Case Books of Dr. John Snow*, a 567-page opus for which he wrote a comprehensive introduction and in which the case books themselves show careful editing. This volume was published by the Wellcome Institute for the History of Medicine, London.

Dr. Ellis will be sorely missed by his many friends, and particularly by his colleagues devoted to the study of the history and heritage of anesthesia. He is survived by his wife, Mrs. Elizabeth Ellis, and three children. Donations if desired may be sent to: The Missions to Seamen, St. Michael, Paternoster Row, London EC4 2RI.

President's Report

A busy spring calendar culminated in a versatile and enjoyable program for our third Spring Meeting, as organized again by Douglas Bacon. There were some excellent papers, and we hope to see some of them published during the coming year. One of the highlights was a pre-meeting reception for all participants on Wednesday, May 10th, hosted by the University of Pittsburgh Department of Anesthesia and its leaders, Peter Winter and Peter Safar.

On the evening of May 10th there was a called meeting of council for the purpose of exploring ways of implementing goals and missions of our society which are clearly and succinctly stated in the Constitution and original By-laws. Many useful ideas were proposed and discussed. It is now a matter of determining some realistic priorities for those projects which will be undertaken to increase both visibility and function of the Anesthesia History Association. One item, the importance of which has been agreed upon, is the establishment of a prize contest for the best Anesthesia History paper by a resident physician to begin in 1996.

In the last week of March your President had a quick trip to Hamburg, Germany, as the official representative of the Anesthesia History Association, invited for the purpose of planning the next International Symposium on the History of Anaesthesia, which will be held at the Conference Center in Hamburg, April 26 to 30th, 1997 immediately following the German Anaesthesia Congress (DAK). Put this on your calendar now for 1997.

—*Lucien E. Morris, M.D.*

Laureate of Anesthesia History

In the April, 1995, issue of the Newsletter, an announcement was made regarding nominations for the 1996 Laureate of the History of Anesthesia. One error was made in that account, namely, that all nominations for this honor should be forwarded not later than **July 31, 1995.**

The *Bulletin of Anesthesia History* is published four times a year as a joint effort of the Anesthesia History Association and the Wood-Library Museum of Anesthesiology.

C.R. Stephen, M.D., *Editor*
Doris K. Cope, M.D., *Associate Editor*
Donald Caton, M.D., *Associate Editor*
Debra Lipscomb, *Editorial Staff*

Roderick Kerns Calverley, M.D. (1938-1995)

The anesthesia fraternity of the world mourns the loss of Rod Calverley, cut down in his prime by a tragic automobile accident on April 1, 1995, just after his return from a military mission to war-torn Sarajevo. While attending a retreat of the Department of Anesthesiology of the University of California, San Diego (U.S.C.D.), on April 1, Rod took advantage of a three-hour break to go for a ride into the desert with his wife and daughter and her boy friend when the accident occurred. He was thrown out of the car and died a few minutes later.

Rod was born and reared in British Columbia and went to California in the early 1970s, where he became a naturalized U.S. citizen and a member of the U.S. Army Reserves, rising eventually to the rank of Colonel. At the time of his death he was a Clinical Professor of Anesthesiology at U.C.S.D.

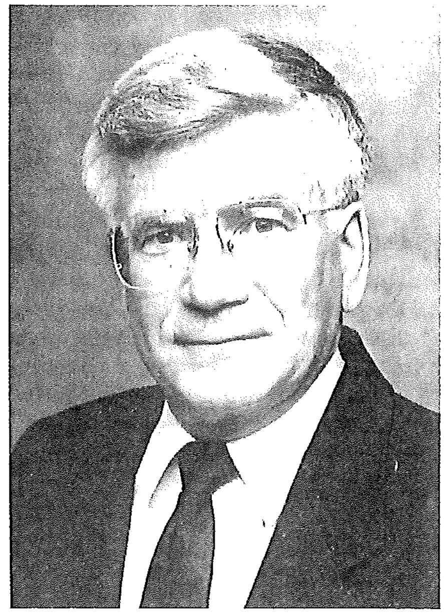
Dr. Calverley made his mark in the world on two fronts, as an outstanding historian of the progress in anesthesia and as a much traveled harbinger of good will throughout the world.

While attending the First International Symposium on the History of Anesthesia in Rotterdam in 1982, Drs. Calverley, Calmes and Mainzer were imbued with the idea that a historical society for anesthesiologists in America should be organized. Further work ensued and in October, 1983, the Anesthesia History Association was formed. This organization has thrived in the interim and much of the spark has been the constant enthusiasm of Dr. Calverley.

In 1989, recognizing his profound interest in the history of anesthesia, Rod was elected a Trustee of the Wood Library-Museum of Anesthesiology and until his untimely death he served as an outstanding and innovative force in promoting the heritage of our specialty.

Calverley's intensity of drive was also shared by the U.S. Army Reserve forces. Traveling under the aegis of the Department of State or the Army Reserve, he made trips over the years to Mexico, Ethiopia, Indonesia, Malaysia, Afghanistan and Russia. He served with a mobile medical unit during the Persian Gulf War with distinction.

A funeral and memorial service was held at St. Paul's Episcopal Cathedral in San Diego on April 7, 1995. Accompanied by full military honors, over 400 friends and admirers paid tribute to this tireless worker and



humanitarian. He is survived by his gracious wife, Janeen, a daughter Christine, and a son Grant. Memorial donations may be sent to a charity of one's choice.

DR. ROD K. CALVERLEY LAID TO REST

by Selma Harrison Calmes, MD

On a glorious California day, April 7, 1995, several hundred colleagues, family and friends gathered in St. Paul's Episcopal Cathedral in San Diego to honor the life of Dr. Rod Calverley, one of the leaders of anesthesia history. Rod was killed in a tragic car accident April 1, near Borrego Springs in the California desert. The beautiful day was a bitter contrast to the sadness all felt that day, as Rod had touched all our lives in a profoundly human way.

St. Paul's Episcopal Cathedral was the church Rod most frequently attended. It is Normandy-style, with simple grey mortar walls, a bank of lovely stained glass windows on the south wall and a Gothic-style carved wood pulpit to the right of the altar. Two simple bouquets flanked the altar (there was a request for no flowers). Music from the cathedral's magnificent organ filled the church as we gathered for the service.

Onward Christian Soldiers was the processional hymn. The flag-covered casket was brought in by the pall bearers from the 6252 US Army Hospital Section 1. They were led by Col. William Marshall; others were Col.s Garth Lee and Frank Lynch (Dr. Lynch is a pediatric surgeon in San Diego and was a close friend of Rod's), LTC Dan Meyer (he is a CRNA at the San Diego VA Hospital and accompanied Rod on military missions), Major David Schmidt, 1st Sgt. Dan McManus and Sgt. 1st Class Raymon Flores. Dean Carroll, previous Rector of St. Paul's and a long-time friend of Rod's, came out of retirement to officiate at the service.

Rod's University of California at San Diego (UCSD) colleague and well-known academic anesthesiologist Dr. N. Ty Smith gave a remembrance of Rod's professional life at UCSD and the Veteran's Administration Hospital. It included vignettes of a "stolen" Resusci-Annie which Rod really borrowed for an outside CPR course; this led to a run-in with the VA's security soon after he arrived. After interrogating Rod, the VA security officer realized what a special person Rod was. Convinced that Rod could not commit a crime, he dropped the case. Other stories noted the older anesthesia and lab equipment items that seemed to find their way to his crowded office (otherwise known as the Wood Library-Museum West), his love of his British heritage, his devotion to the people he served as a samaritan, and examples of Rod's enthusiasm for anesthesia history and, especially, for people.

A reading from Isaiah 35 was followed by the hymn, *Crown of Many Thorns*. Chaplain Henry L. Pereson, LTC USAR, spoke on Rod's service to his country, which began in 1983. He joined the Army Reserve that year. He was responsible for introduction of the mini-vaporizer system to the United States Armed Forces. This was a distinct technical improvement from previously available mobile anesthesia machines. Rod participated in many Reserve missions and served in the Gulf War.

The 23rd Psalm and a flute solo led to a remembrance of Rod's service to humanity

Continued on Page 16

ABA Founding. . . *From Page 1*

Wood was a war hero, receiving the *Croce d'Guerra* and the *Medalie Di Valore* in 1918. After returning from the front, Wood resumed his medical studies, graduating from Columbia in 1922. He then spent eight months as a surgical house officer at Bellevue. In 1923 Wood was a house officer at Roosevelt Hospital. He spent nine months on the anesthesia service, working with men like Thomas Drysdale Buchanan, James Gwathmey and Paluel Flagg. Of the triumvirate, Wood was the only one to have any formal postgraduate training in anesthesiology. On completion of his training Wood was appointed a junior attending Anesthetist at Roosevelt Hospital.[11]

The Quest for Specialty Status

In the early 1930s, two trends in anesthesiology collided, making specialty certification for physicians critical. The first, an outgrowth of physician research into the scientific foundations of clinical anesthesiology, resulted in a new and somewhat complex technology for the administration of anesthetics. Gas machines were sprouting new and different agents, regional anesthesia was beginning to grow in importance, and intravenous techniques of inducing anesthesia were beginning. Case reports concerning the management of chronic painful conditions were among the cutting edge topics in the literature. Postgraduate training programs in the specialty were being established, and the non-specialist had tremendous amounts of new technology with which to cope.[12]

At the same time, the world was in the midst of a strong economic depression. Hospitals looked to anesthesia as a source of income. By hiring nurses for a few dollars a day, or using housestaff, hospitals could charge an anesthetic fee far in excess of the hospital cost. Surgeons too had reasons to balk at the full-time physician anesthetist. The surgeon could also hire a nurse to administer anesthetics and charge a fee in excess of cost for her services. Or, to keep referrals flowing, the surgeon could ask the general practitioner to administer the anesthetic.[13]

Physician specialists in anesthesia looked to their national organizations to help weed out these "interlopers". Francis Hoeffer McMechan, the tireless arthritic cripple and recognized leader of organized anesthesia, had been trying from 1912 to secure physician-only anesthesia in AMA-approved hospitals in the United States. He had become, in the eyes of the AMA, a pest. Likewise, McMechan had become convinced that the AMA wanted nothing to do with the physician anesthetists.[14] Thus, as the 1930s opened, the relationship between organized anesthesia and the AMA could best be characterized as a virtual impasse.

McMechan, however, believed that he could certify specialist practitioners in anesthesiology on a world-wide basis. His organization proposed that a college should be established along the lines of the American College of Surgery and the American College of Physicians, totally independent from the AMA. At the Congress of Anesthetists in 1932, a committee was established to study the possibility of certification.[15] McMechan's group sought to establish the criteria upon which certification could be granted. In the first formal proposal, the group requested that an applicant submit the records for three thousand patient administrations, be endorsed by two surgeons and two physician anesthetists, be a member in good standing with the local, state and national medical societies, and not work with nurses or other technicians in the delivery of anesthesia.[15]

It was this latter proviso, against the nurse anesthetists, that nearly split organized anesthesia in two. Ralph Waters, as a friend of McMechan, wrote offering his opinion that the specialty was too small, and that there were too many other issues before them to split the physician anesthetists into two camps. He cited the example of Lundy, who had done great things for anesthesia, but supervised nurses. Excluding him from the certification process would, in essence, invalidate it.[16]

McMechan responded quickly, both personally and through his trusted associate Frederick Clement. Both chided Waters, and told him that if he didn't like the proposed certification criteria, he could disassociate himself from the process.[17] The year 1933 provided Waters with an opportunity to explore alternative forms of certification, attempting to link them with the American Medical Association, and along the way to forge a successful political triumvirate with Lundy and Wood.

The International College of Anesthetists came into being in 1935. McMechan and his associates kept the proviso concerning the training of nurse anesthetists, but weakened the clinical requirements. They requested only ten case reports for certification and thus crippled the process.[15] As Wood would later remark, the College granted an intern with only one month's training a certificate as a specialist based on his ten case reports. In another instance, a surgeon who rarely anesthetized patients, but had presented a paper at the New York Academy of Medicine on Anesthesia, was awarded a certificate. The surgeon then attempted to use these qualifications to assume the chairmanship of a university training program.[18]

The Great Triumvirate

In the Spring of 1933, Wood took a trip to see the "Century of Progress" exhibition in Chicago. It was a family excursion, his wife and children visiting the fair while Paul attended the AMA meetings held in conjunction with the exposition. After the meetings were over, Wood traveled first to Madison to visit with Ralph Waters, and later to Rochester, Minnesota, to see Lundy. Certification was a lead item on the agenda.[19]

McMechan's initial certification proposal had just been announced. Wood and Lundy agreed with Waters concerning the nurse anesthesia proposal. While Wood never supported nurse anesthetists, he understood the need to put the physician's house in order first, and then, united, to tackle the "technicians". Wood expressed these thoughts in a letter to Waters:

> Yes, I felt that you were not in sympathy with the plan but that you belong in the "interested" group. I have read and reread your letter many times and I am convinced that I can communicate freely with you... I planned to come up to Madison (and since recently meeting John Lundy) to go on to Rochester... This is all in a way educational in the right direction, and eventually may lead some surgeons to see the light...[19]

Wood's trip helped to strengthen the bonds of friendship between the men. As they searched for an alternative proposal during the lengthy hiatus in the founding of the International College (between proposal in 1931 and first induction in 1935), Lundy visited the headquarters of the American Medical Association with great frequency. Overtures for a section, a necessary prerequisite to an independent specialty board, were favorably received. Yet, Waters feared that AMA involvement would cause McMechan to pull away and split the anesthetists.[20] The AMA feared McMechan would control the section and likewise pulled back.

Waters and Wood began to explore, however, the AMA criteria for specialization. Wood was secretary of the New York Society of Anesthetists, a New York City based organization with membership spread across New York state, Pennsylvania and the New England states. The society moved to create a new class of membership, Fellows, that strictly adhered to AMA criteria. Fellows were required to present evidence of 2,500 administered anesthetics, or 500 and an advanced postgraduate training in anesthesiology. Each candidate also had to be a member in good standing of the AMA.[21]

Thus, the goal of the New York Society's Fellowship was to meet the criteria of the AMA's Advisory Council of Medical Specialties. Using the influence of Frank Lahey and other prominent, sympathetic surgeons, the physician anesthetists' proposal was placed before the AMA.[22]

Frank McMechan, however, was not happy with this development. The International College was something of a failure, and applications for fellowship were not numerous. Other physician anesthetists across the country responded as Waters did to the New York Society program.[23] It was strict, well organized and held the promise of approval one day by the AMA. McMechan and his close associates tried to torpedo the program. In a letter to Ralph Waters, Paul Wood stated:

> Of course we are having the dickens of a time with some of the old International and Associated hold-outs. For example, Long and Stewart had both shown keen interest in what we were doing, but neither have officially applied. Dr. Herb very definitely turned us down in a letter received today. Evans and Wells have not replied to any of my communications in any shape, manner or form and Miller is a definite stand-out together with McCarthy and Clement.[24]

In February of 1936, the New York Society changed its name to the American Society of Anesthetists, partly to reflect the national nature of membership, and partially to make the name more acceptable to the AMA.[25] Shortly thereafter, Erwin Schmidt, Waters' Surgical Chief at Wisconsin, visited New York with a plan that met with Waters' approval. Rather than independence, Schmidt was offering AMA recognition as a sub-board of the American Board of Surgery.[26]

Wood and the ASA jumped at the chance for certification. Schmidt, Waters and Wood set about arranging to make the sub-board a reality. Schmidt urged Waters to make a formal application to Everts Graham, the chairman of the proposed American Board of Surgery.[27] Graham was receptive to the idea, and invited Waters and Wood to speak at the Palmer House in Chicago on January 10, 1937. In what was supposed to be a twenty-minute presentation, Waters and Wood spoke for over two hours. They sufficiently impressed the American Board of Surgery (ABS) that it was agreed to take on the physician anesthetists as a sub-board.[28] Final arrangements were concluded at the April 1937 ABS meeting.[29] Meaningful certification in anesthesiology had arrived.

Waters' close professional relationship with Schmidt permitted them to make an effective political team for anesthesia.

> I think Erwin had done a most remarkable piece of political skirmishing in our behalf, and I am sure he will never know the full extent of my appreciation for the time and effort he has spent in helping us attain a position of recognition in medicine to which we are rightly entitled.[30]

Wood's role had been to create an effective political organization acceptable to the AMA. Lundy undoubtedly had helped the physician's cause at AMA headquarters, but as long as McMechan lived the AMA would not grant the ABA independence.

The Death of McMechan

On June 26, 1939, the tireless organizer of American Anesthesiology, F.H. McMechan died. Lundy acted in the context of a vacuum in leadership within the physician anesthetists' community. He furthered the political ambitions of the physician anesthetists late that July when Morris Fishbien, President of the AMA, came to Rochester for the funeral of Dr. William Mayo. On August fourth, Lundy wrote and asked for a Section of Anesthesiology. Apparently Fishbien referred him to James E. Pallin, Chairman of the Council on Scientific Assembly. Lundy requested a Section on Anesthesiology, the necessary prerequisite for independence:

> I called on Dr. Olin West and Dr. W. D. Cutter at AMA Headquarters and asked their advice about the situation that had arisen since the death of Dr. F.H. McMechan ... while he lived, AMA was unwilling to do much for fear that he would come into control of it. ... Dr. West felt that if you knew about the urgency of the situation now to make a home for the anesthetists in the AMA...[31]

Lundy was successful. The 1940 House of Delegates of the AMA approved a section on anesthesia for the 1941 meeting. Lundy was appointed secretary, and for the next 15 years ensured that there would be an excellent series of scientific papers presented. The American Board of Anesthesiology likewise gained its independence in 1940.

Conclusions

It took the efforts of three men, working in concert, to create an acceptable certification process for physician anesthetists. Associating with the AMA was critical, for the number of anesthetists in the United States was small, and the umbrella of the larger organization was necessary to add legitimacy to the proceedings. Also, these three men defied the conventional politics of their day when they believed that McMechan was wrong. By attempting to avoid splitting anesthesia over the "technician" issue, Waters, Wood and Lundy eventually seceded from McMechan, but only when they were sure that a majority of their colleagues would follow them.

Waters, the thoughtful academic working as a liaison with the surgeons, helped to create the possibility of a Board acceptable to anesthetists, surgeons and the AMA. Wood assured that the political organization of the anesthetists was in order. Lundy at first reassured the AMA that McMechan would not control the board, and after McMechan's death provided the opportunity within the AMA to gain independence from the surgeons. All of us owe this triumvirate a debt of gratitude for their astute, concerted political action.

The author would like to thank Mr. Patrick Sim, librarian extraordinaire for his kind assistance at the Wood Library-Museum of Anesthesiology and Mr. Bernard Schermetzler for his help with the Waters Collection at the Steenbock Library, University of Wisconsin, Madison.

References

1. Eckman J: John Silas Lundy, *The Genesis of Contemporary American Anesthesiology*. Edited by Volpitto PP and Vandam LD. Springfield, Charles C Thomas, 1982, pp 35-48

2. Bamforth BJ, Siebecker KL: Ralph M. Waters, *The Genesis of Contemporary American Anesthesiology*. Edited by Volpitto PP and Vandam LD. Springfield, Charles C Thomas, 1982, pp 51-68

3. Letter from Ralph M. Waters to Paul M. Wood, March 8, 1933. *The Collected Papers of Ralph M. Waters, M.D.*, Steenbock library collection, University of Wisconsin, Madison

4. Myers JA: John Silas Lundy, M.D. *Lancet* 80:134-135, 1960.

5. Letter from Lenore Lundy to Ralph M. Tovell, December 2, 1957. *The Collected Papers of Ralph M. Tovell, M.D.* The Wood Library-Museum of Anesthesiology, Park Ridge, Illinois.

6. Lundy JS: Memories of 30 years of group experience in anesthesia. *Minnesota Medicine* 51:867-873, 1968

Continued on Page 15

History of Cardiovascular Monitoring

An Historical Backdrop to Cardiovascular Monitoring

by George Stephen Bause, MD, MPH

We conclude this fascinating history of cardiovascular monitoring in this issue of the Bulletin. First published in Anesthesiology Clinics of North America, *Volume 6, December, 1988, we are indebted to Dr. Bause and to the W.B. Saunders Company for permission to reprint this penetrating account here.*

Western Theories of Circulation

A Spanish physiologist-theologian, Miguel Serveto (1509 to 1553) of Villanueva de Sigena (Michael Servetus Villanovanus) sought the nature of God as revealed through man's soul and man's body. As the Spanish Inquisition terrorized his homeland, Serveto escaped to Paris and subsequently to tutorials under Gunther, Sylvius, and Vesalius.[23] Serveto developed his own theories on the pulmonary circulation, realizing that:

> a crimson color ... is generated, as said, by the mingling of the inspired air with the more subtle portion of the blood which the right ventricle of the heart communicates to the left. This communication, however, does not take place through the septum, partition, or mid-wall of the heart, as commonly believed, but by another admirable contrivance, the blood being transmitted from the pulmonary artery (vena arteriosa) to the pulmonary vein (arteria venosa) by a long passage through the lungs, in the course of which it is elaborated, and becomes of a crimson color.[40,89]

Serveto was burned at the stake for his critical views on the pulmonary circulation.

Coining the term "circulation" (1569), Andrea Cesalpino (c. 1519 to 1603) of Arezzo, Tuscany, Italy, actually published his descriptions of the pulmonary and the systemic circulations some 57 years before William Harvey did so.[3] His anatomic dissections led him to conclude that:

> The circulation of the blood, which takes place from the right ventricle to the left ventricle, in passing through the lungs, agrees quite exactly with the following facts.... There are two vessels which end in the right ventricle, two in the left. One of the two is afferent, the other efferent.... The blood is conducted to the heart by the veins ... is carried by the arteries throughout the body ... the veins are engorged below a ligature, not above. Those who bleed patients are familiar with this experiment.[19,86]

Cesalpino also recognized the role of venous valves in maintaining circulation:

> The passages of the heart are so arranged by nature that from the vena cava a flow takes place into the right ventricle, whence the way is open into the lungs. From the lungs, moreover, there is another entrance into the left ventricle of the heart, from which then a way is open into the aorta artery, certain membranes being so placed at the mouths of the vessels that they prevent return. There is a kind of perpetual movement through the heart and lungs into the aorta artery, as I have explained in my 'Quaestiones Peripateticae.'[19,20]

William Harvey (1578 to 1657) of Folkestone, Kent, received his Doctor of Physic in 1602 from the foremost medical school of the day, the University of Padua. He received his Doctor of Medicine degree from the University of Cambridge that same year and began practice in London. From Harvey's first Lumleian Lectures to the College of Physicians in Surgery and Anatomy, manuscript notes reveal that Harvey had already formulated by 1616 his theory on the circulation:

> It is plain from the structure of the heart that the blood is passed continuously through the lungs to the aorta as by the two clacks of a water bellows to raise water.
>
> It is shown by the application of a ligature that the passage of the blood is from the arteries into the veins.
>
> Whence it follows that the movement of the blood is constantly in a circle, and is brought about by the beat of the heart. It is a question, therefore, whether this is for the sake of nourishment or rather for the preservation of the blood and the limbs by the communication of the heat, the blood cooled by warming the limbs being in turn warmed by the heart.[57]

International acclaim followed his formal publication of *De Motu Cordis* in 1628.

Stethoscopy

Exactly 200 years after Harvey's initial Lumleian Lecture, a French physician:

> walking in the court of the Louvre ... saw some children, who, with their ears glued to the two ends of some long pieces of wood which transmitted the sound of the little blows of the pins, struck at the opposite end.... He conceived instantly the thought of applying this to the study of diseases of the heart. On the morrow, at his clinic at the Necker Hospital, he took a sheet of paper, rolled it up, tied it with a string, making a central canal which he then placed on a diseased heart. This was the first stethoscope.[73]

The Frenchman, of course, was Rene-Theophile-Hyacinthe Laennec (1781 to 1826). Laennec recalled fondly that:

> In 1816, I was consulted by a young woman labouring under general symptoms of diseased heart, and in whose case percussion and application of the hand were of little avail on account of the great degree of fatness.... I rolled a quire of paper into a sort of cylinder and applied one end of it to the region of the heart and the other to my ear, and was not a little surprised and pleased, to find that I could thereby perceive the action of the heart in a manner much more clear and distinct that I had ever been able to do by the immediate application of the ear. From this moment I imagined that the circumstance might furnish means of enabling us to ascertain the character, not only of the action of the heart, but of every species of sound produced by motion of all the thoracic viscera.[63,103]

A myriad of modifications were made on Laennec's stethoscope. Pierre-Adolphe Piorry (1794 to 1879) of Poitiers designed a more slender stem and attached a pleximeter in 1826.[80] This was followed 3 years later at Edinburgh Royal Infirmary by Nicholas P. Comins' invention of the first flexible stethoscope.[22] The physician who first completely described the murmurs of mitral stenosis,[101] Charles J. B. Williams (1805 to 1889) of London created a lead-tubed binaural stethoscope in 1843.[102] Dr. Arthur Leared of London gave the first public exhibition of a binaural stethoscope at the 1851 World Fair.[66] That same year, Dr. Nathan B. Marsh received his US patent for stethoscopes having a "double branch connected with the main trunk, so as to enable persons to use both ears simultaneously."[75] A distant forerunner of the phonendoscope,[77] Marsh's stethoscope was inconvenient. One critic observed:

> Over the pectoral end of the instrument was stretched a membrane; two elastic tubes led from this to the ear. It is said that the ear pieces were inconvenient, and to use the instrument required both hands. It gave a muffled but loud sound caused by reverberation inside the instrument, due to the presence of the drum and the unequal bore.[77]

Better control of reverberation was achieved by Aurelio Bianchi of Florence, who devised the phonendoscope in 1894. Bianchi published details of this new instrument with Eugenio Bazzi the following year.[8] "The phonendoscope as it later appeared consisted of a heavy metallic cup with low margins, in which a light elastic hard-rubber diaphragm was made to vibrate both by sound waves and body movements. The instrument was made somewhat on the principle of the telephone.... Two long rubber tubes with ear-pieces connect[ed] with the cavity of the instrument."[77] A final modification in 1896 by Dr. H. B. Baruch of New York City affixed stethoscopic ear pieces to the ends of the rubber tubes of the phonendoscope.[4]

A year in the wake of the Baruch-Bianchi phonendoscope, in December of 1897, Robert C. M. Bowles of Brookline, Massachusetts, filed for design and utility patents on the Bowles stethoscope.[13] Not until 1901 did Bowles receive the latter US patent for:

> a stethoscopic instrument provided with an exposed diaphragm adapted to make contact with the body of a person, and with a back having a concaved front face ... to form an air-chamber, and a substantially small curved sound delivery tube or pipe of substantially non-compressible material attached to said back near its center and extended toward the outer edge ... to afford a smooth and unobstructed outlet for the sound-vibrations.[14]

Widely quoted in a report on the Bowles stethoscope in the *Johns Hopkins Bulletin,* Dr. Richard Clarke Cabot (1868 to 1939) characterized the Bowles stethoscope as "a simple diaphragm like that of the telephone, connected with the chamber into which the tube of the stethoscope enters. With it one can hear sounds deeper in the chest than those heard with any other stethoscope.... One can hear as much of the heart sounds through the clothes with this instrument as with any other instrument next to the skin."[2] As a leading Boston physician, Cabot helped lead a discussion of Harvey Cushing's "blood pressure observations"[26] at the program entitled "Consideration of Blood Pressure" held January 19, 1903.[56] As both an authority in auscultation and a leading proponent of the recently marketed Bowles stethoscope, Cabot acquainted Cushing with Bowles' instrument. Cabot's enthusiasm about "the Bowles" was not lost on Harvey Cushing during the conference in Boston.

Cushing returned to Baltimore, and within 28 months construction was completed on his Hunterian Laboratory for Experimental Medicine.[56] Named after anatomist John Hunter, the "old Hunterian" was America's first experimental surgical laboratory and also the veterinary hospital for Baltimore. However, the Hunterian's name "mystified Baltimoreans who thought the term had reference to pointers, retrievers, and setters."[56]

First on dogs in the Hunterian[27] and then on patients at Johns Hopkins Hospital, Harvey Cushing employed his personal Bowles stethoscope in 1907 as the first intraoperative precordial monitor. His Bowles stethoscope was rather bulky at 2 inches in diameter and was used predominantly as a respiratory monitor during induction of general anesthesia. Particularly on the dogs, the Bowles would often need to be removed as the chest was opened. Removing the monitor after induction (that is, during maintenance of anesthesia) was unsatisfactory, because both Cushing and surgeon-anesthetist S. Griffith Davis were anxious to avoid the "dread stage of respiratory paralysis ... [and promote] quiet [respiration], with perhaps a very slight snore."[29] The binaural component of the Bowles stethoscope was not especially helpful in the operating room, because the anesthesiologist needed one ear free for communications from operating room personnel. In fact, within a year, the Bowles would be relegated to detecting Korotkoff sounds under Riva-Rocci's cuff.[61]

Over the next 12 months, Davis and Cushing sought to bring "a simple device ... into general use—namely, the *continuous auscultation of cardiac and respiratory rhythm during the entire course of anesthesia.*"[28] This monitoring device would have to be useful in the prone and other awkward positionings of the neurosurgical patient. Cushing wrote:

> With a patient in this prone position it is difficult for the anesthetist to gauge fully the variations in cardiac action, and during the past six months Dr. Davis has employed in these, as in all other operations, [a very simple device].
>
> The idea arose from a practice in the Hunterian Laboratory of auscultating the heart during the production of experimental valvular lesions, and like other things has been carried from laboratory to clinic. The transmitter of a phonendoscope is secured by adhesive strips over the precordium and connects by a long tube with the anesthetist's ear, where the receiver is held by a device similar to a telephone operator's headgear.
>
> Uninterrupted information of the patient's condition is thus given, and the anesthetist need not disengage a hand for the occasional palpation of the pulse, which is all that he is usually expected to do. On several occasions, by the prompt appreciation of change in the heart-beat or respiration thus acquired, it has been possible to avert what otherwise might have been surgical disasters.[28]

Future monitors would avert intraoperative disasters by assessing changes in blood circulation by means of continuous modalities like sonic accumulation, phono-cardiography, and esophageal stethoscopy and echocardiography. Cushing's intraoperative auscultation with the Bowles stethoscope and Davis' more practical precordial monitoring with the phonendoscope were harbingers of sound

Continued on Page 8

Cardiovascular. . . *From Page 7*

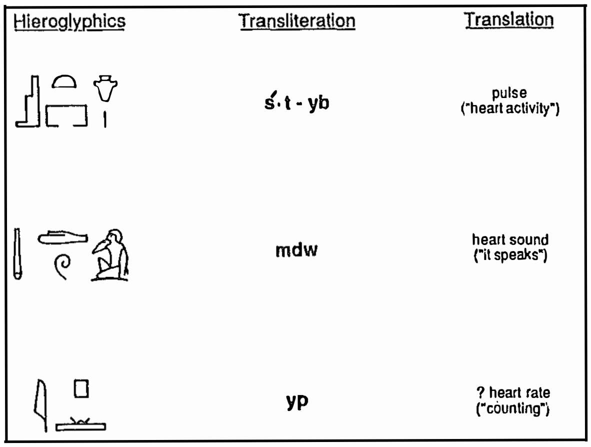


Figure 1. Referring to the heart and the pulse, these Egyptian hieroglyphics were gleaned from The Secret Book of the Physician.

(and ultrasound!) monitoring practices to come.

PULSATION

The pulse is the rhythm of life. The radial pulse has predominated as a diagnostic site for cardiovascular monitoring.

Egyptian: The Heart Speaks

As early as the "Old Kingdom" or "Pyramid Age" of the 30th to 26th centuries BC, the Egyptians valued the pulse as a measure or monitor of health in the present life.[1] Hieroglyphic phrases like "heart activity" and "the heart speaks" suggest the action of the pulse, and "counting" and "measuring" point to the likelihood that Egyptians counted pulse rate (Fig. 1). The 17th century BC saw the transcription of the first surgical textbook, the Edwin Smith Papyrus. This papyrus gave instructions on cardiovascularly assessing the neurologically injured patient:

> 'Thou examinest a man,' [it means] counting any one—— [like cou]nting things with a bushel. (For) examining (measuring) is [like] one's [counting] a certain quantity with a bushel, (or) counting something with the fingers, in order to [know]——. It is measuring things with a bushel which—— one in whom an ailment is [cou]nted, like measuring the ailment of a man; [in order to know the action] of the heart. There are canals (or vessels) in it (the heart) to [every] member. Now if the priests of Sekhmet or any physician put his hands (or) his fingers [upon the head, upon the the back of the] head, upon the two hands, upon the pulse, upon the two feet, [he] measures [to] the heart, because its vessels are in the back of the head and in the pulse; and because [its pulsation is in] every vessel of every member. He says 'measure' regarding his [wound] because of the vessels to his head and to the back of his head and to his two feet—— his heart in order to recognize the indications which have arisen therein; meaning [to meas]ure it in order to know what is befalling therein.[15]

Chinese: The 12 Pulses

The ancient Chinese elevated the taking of the pulse to an art. According to the *Nei Ching*, very early in the morning was the best time of day for taking the pulse "when the breath of Yin has not yet begun to stir and when the breath of Yang has not yet begun to diffuse...."[92] Generally, only the radial pulses were examined. The pulse diagnostician would examine a male patient's left radial pulses prior to the right ones and a female's right ones before her left. Each hand's radial pulsation was divided into inch, bar and cubit regions, each of which could be palpated deeply (the internal or Yin pulse) or superficially (the external or yang pulse).[104] Thus a total of 12 pulses, six on each hand, required monitoring (Fig. 4). Note that the *Nei Ching* and the European acupuncturists agree on the meridians or organ systems represented by the six deep or yin pulses; however, these sources disagree on the organs represented by the superficial pulses (Fig. 2).

Acupuncture and moxibustion were developed as treatment modalities for ministering to imbalances perceived in the 12 organ systems or meridians. Modern European and Chinese acupuncture reflects the evolution of Chinese pulse diagnosis after the dissemination of *Mei Ching ("The Classic of the Pulse")*, a ten-volume reference written by Wang Shu Ho (265 to 317 BC).[41]

Indian: The Ayurvedic Tridoshas

In order to be in Tridhatus or a state of balance, the three life forces Vayu, Kapha, and Pitha must be in perfect balance. When they are imbalanced, these are referred to as the three faults or Tridoshas. To monitor a patient's health, the physician merely needs to palpate the radial pulse, the "Witness to the Soul."

Pulse anthologists Amber and Babey-Brooke summarize Ayurvedic pulse monitoring as follows:

> First, the pulse at the wrist or the radial pulse is the one that is usually preferred and is examined with three fingers.
>
> The male patient extends his right hand for his pulse to be taken, but the female extends her left hand. This practice is reversed in the Chinese technique.
>
> The examiner uses the three fingers of his right hand: the index, the middle, and the ring finger or otherwise described as the second, third, and fourth fingers, and he places these three in a position two fingers in width below the root of the thumb. The physician uses his left hand to press the artery of the elbow and holds the patient's hand in a slanting manner while he places his right hand in the manner described above.... A heavy pulse to the index finger shows air; to

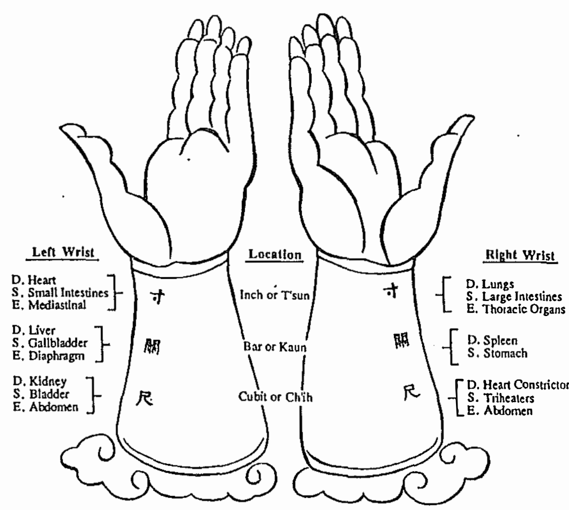


Figure 2. The 12 Chinese pulses included 6 yang or deep (D.) pulses and 6 yen or superficial ones. The original meridians represented by the superficial pulses have evolved from those of the Nei Ching *(S.) to those of the modern European acupuncturists (E.).*

RESERVATION FORM

Annual Meeting and Dinner
Anesthesia History Association

TUESDAY, OCTOBER 24, 1995

Milan and Strasbourg Rooms
Third Floor
Atlanta Hilton and Tower Hotel

6:30 p.m. — No-Host Social Hour
7:30 p.m. — Business Meeting and Buffet Dinner
8:15 p.m. — Lecture: *History of Medicine in Atlanta*
Martin Moran, M.D. — Pediatrician and Author

Name ______________________________

Address ______________________________

Number of Reservations ______________________________

Names of Guests ______________________________

Amount Enclosed (Cost: $55.00/person) ______________________________

Make your check payable to the Anesthesia History Association. Please mail promptly (no later than October 1) to:

Dr. William D. Hammonds
Center for Pain Medicine, Emory Clinic
1327 Clifton Road N.E.
Atlanta, GA 30322

the middle finger shows fire; and to the ring finger shows water.... The pulse becomes fast with air, jumpy with fire, and slow with water.[1]

Greek: Observation of Pulse

Praxagoras' disciple, Herophilus (f. 315 BC) of Chalcedon used a clepsydra, an Egyptian water clock, to measure pulse rate in Alexandria. He also delineated four cardinal properties of the pulse: frequency, rhythm, size, and strength. With his phrase *"pulsus caprizans,"* Herophilus likened the forcible pulse following an extrasystole to the leaping of a goat. Nearly 2,000 years would pass before man would again monitor the pulse as accurately as Herophilus had done.

Venous Access and Pulsations

Forsaking Herophilus' goat, Sir Christopher Wren experimented on dogs in 1656. Combining opium, wine, and ale inside a pig's bladder, Sir Christopher Wren infused the mixture through a goose quill into a dog's vein. Venous access was born!

Fifty years later, public anxiety over a rash of sudden deaths in Rome prompted still further investigations of the venous system, its distention, and its pulsations. The following year, in 1707, Giovanni Maria Lancisi (1654 to 1720) published his observations on the association of cardiomegaly with sudden death.[64] The brilliant Lancisi differentiated between cardiac dilatation and hypertrophy. By 1728 he had correlated jugular venous distention with right heart dilatation.[65] Lancisi's careful examination of the jugular venous pulsation and distention formed the basis for his discussion of tricuspid regurgitation.

Direct Measurement of Pulsation

Geddes has classified major early investigations of direct blood pressure measurement into mechanical, mechano-optical, electrolytic, and strain-gauge manometry.[50]

The Rector of Farringdon, Hampshire, and Minister of Teddington, Middlesex, Reverend Stephen Hales began informal blood pressure investigations on the crural (femoral) arteries of dogs in 1708. Hales reported that "about six years afterwards I repeated the like Experiments on two horses, and a fallow Doe." In his 1733 publication *Statical Essays,* Hales renders "An *Account* of some Hydraulick and Hydrostatical *Experiments* made on the Blood and Blood-Vessels of Animals" with the following as "Experiment I":

> In *December* I caused a Mare to be tied down alive on her Back, she was fourteen Hands high (56 inches), and about fourteen Years of Age, had a *fistula* on her Withers (shoulders), was neither very lean, nor yet lusty: Having laid open the crural Artery about three Inches from her Belly, I inserted into it a brass Pipe whose Bore was one sixth of an Inch in Diameter; and to that, by means of another brass Pipe which was fitly adapted to it, I fixed a glass Tube, of nearly the same Diameter, which was nine Feet in Length: Then untying the Ligature on the Artery, the Blood rose in the Tube eight Feet three Inches perpendicular above the Level of the left Ventricle of the Heart: But it did not attain to its full Height at once; it rushed up about half way in an Instant, and afterwards gradually at each Pulse twelve, eight, six, four, two and sometimes one Inch: When it was at its full Height, it would rise and fall at and after each Pulse two, three, or four Inches; and sometimes it would fall twelve or fourteen Inches, and have there for a time the same Vibrations up and down at and after each Pulse, as it had, when it was at its full Height; to which it would rise again, after forty or fifty Pulses.[55]

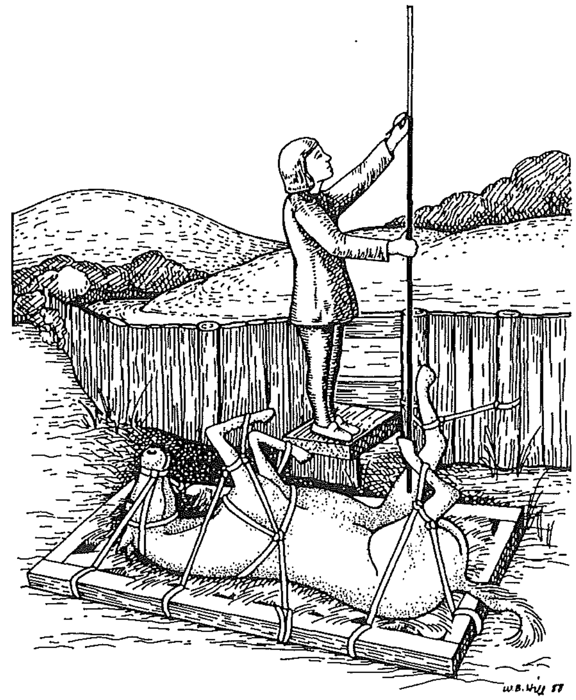


Figure 3. Experiment I from Reverend Hales' Statical Essays: *the first direct measurement of blood pressure.*

Unwieldy as this long manometer was, Hales' achievement was a landmark in cardiovascular monitoring (Fig. 3).

As part of his 1828 graduation dissertation, medical student Jean-Leonard-Marie Poiseuille (1799 to 1869), characterized his "hemodynamometer," a compact, mercury-filled U-tube manometer whose hollow lead end contained potassium carbonate as an anticoagulant. While measuring canine blood pressure with his hemodynamometer, Poiseuille demonstrated variation of blood pressure with respiration. It was Poiseuille's work that popularized mm Hg as units for measuring blood pressure.[81]

In order to disprove theories of a right-to-left heart temperature difference, Claude Bernard resurrected Hales' long rod approach to vascular access in 1844. However, Bernard employed a long mercury thermometer to cannulate first the equine carotid artery and left ventricle and then the internal jugular vein and right ventricle. At the horse's autopsy, Bernard learned that he had caused pericardial tamponade secondary to right ventricular perforation.[6] Thus Bernard was the first to demonstrate a major complication from central venous monitoring.[79]

A professor of anatomy, anatomy and physiology, and physiology at, respectively, Marburg, Zurich, and then Leipzig, Carl F. W. Ludwig (1816 to 1895) pioneered the graphic method of investigation in 1847. Sketching his new method of using the recording mercury manometer with a smoked drum kymograph, Ludwig wrote that "In order to secure a good value from Poiseuille's mercury manometer, and in order to get the time relations of the changes in pressure, put a staff-like float on the mercury at the upper end of which is a pointer. Let the fluctuations be written on a surface which passes by the pointer with uniform speed. In this way one secures curves, the height of which is an expression of the blood pressure and the duration of which is an expression of time."[69]

Clinical and laboratory research continued with the manometer. During a surgical procedure in 1856, Faivre connected a patient's femoral artery to a mercury manometer and found a direct arterial pressure of 120 mm Hg.[37] By 1878 Golz and Gaule had added a double check valve to the manometer in order to obtain maximum and

Continued on Page 10

Cardiovascular. . . *From Page 9*

minimum blood pressure.[52]

A different mechanical system for measuring pressures involved air transmissions through a double-lumen tube. Following work near Paris at the School of Veterinary Medicine at Alfort, Etienne-Jules Marey (1830 to 1904) and Chaveau crafted in 1861 this more rapidly responding pneumatic system. They observed, "One can be reassured of the innocuity of this method by examining the horse, who is scarcely disturbed, walks and eats as usual. In only a few instances is the pulse rate slightly increased, especially at the time of the catheter's introduction within the heart cavities."[21] These two investigators have been credited with reporting the first dysrhythmic complications of central venous access.[79] Note that neither scientist extended this catheterization to man.

Fick published details in 1864 of yet another mechanical system, his C-spring recorder for blood pressure measurement,[38] almost 15 years after its basic principle had been elucidated. Back in 1849, a railway engineer, R. E. Schinz of Switzerland had designed a C-shaped, thin-walled, hollow metal tube which uncoiled as a gauge of increasing pressure.[88] Bourdon popularized the gauge of Schinz at the Academy of Science in 1853, and thereafter this coiled pressure gauge was known as the Bourdon gauge.[11] The Bourdon gauge is still employed today to register pressure from compressed gas cylinders. The biphasic wave resulting from Fick's C-spring was disappointing, especially in light of Landois' work. In 1872 Landois demonstrated that a moving paper surface could be sprayed by the stream of blood pulsing from a fine needle that Landois placed in the tibial artery of a large dog. Recording not only systolic and diastolic pressures, Landois' hemautogram demonstrated the existence of the dicrotic notch.[68] Four years after Landois' hemautogram, Fick built a straight-spring recorder for measuring blood pressure.[39]

A tremendous advance came in 1906, when Sir James Mackenzie (1853 to 1925) created the ink polygraph with the technical help of a watchmaker.[71] Mackenzie recalled:

> In my early days when investigating the action of the heart, I attached a tambour to the upright stem of a Dudgeon sphygmograph in such a manner that I was able to obtain, at the same time as the radial pulse was being recorded, some other movement, as the jugular pulse, apex beat, or carotid. As, however, there was a good deal of inconvenience in the blackening and varnishing the papers, and as it was not possible to get a long tracing upon the heart's rhythm, I discarded this for the ink polygraph.[103]

Progress was also being made in the field of human central vascular catheterization. Following his research on cirrhosis,[9] Bleichroeder reported having passed ureteral catheters into arteries and veins of both dogs and humans as early as 1905. He obtained inferior vena caval blood specimens near the hepatic vein for his cirrhosis research. Nonetheless, he "did not believe the experiments to be of any practical value and left them unpublished."[79] Bleichroeder's catheterization experiments appear to have preceded the published reports of Werner Forssmann who catheterized his own right heart with a 4 French ureteral catheter in 1929.[42]

Meanwhile, a host of new technologies emerged. Mechano-optical systems were investigated first by Otto Frank[43-45] and then by Wiggers.[99,100] Electrolytic manometry was explored by Grunbaum in 1897[53] and eventually by Garten in 1916.49 As early as 1876, Tomlinson had published that stretching a wire produced a change in its electrical resistance.[91] This basic principle behind strain-gauge manometry remained available but unutilized for 66 years. Geddes has thoroughly and thoughtfully reviewed the complicated evolution of direct gauges of blood pressure.[50]

By the end of the Great War, man had successfully cannulated arteries and central veins. Man had also begun to appreciate pulsations on both sides of the heart. A grand frontier of discovery lay ahead and still lies ahead for invasive waveform monitoring.

Indirect Measurement of Pulsation

Having briefly examined direct gauges of pulsation, step back now to explore the more clinically applicable world of indirect gauges of pulse. Indirect measurement of blood pressure evolved from solid- to liquid- to gas-filled devices and eventually vacillated back and forth between liquid and gas. A professor of physiology at the University of Tubingen, Karl Vierordt (1818 to 1884) determined in 1855 the counterweight required to obliterate the human radial pulse.[93]

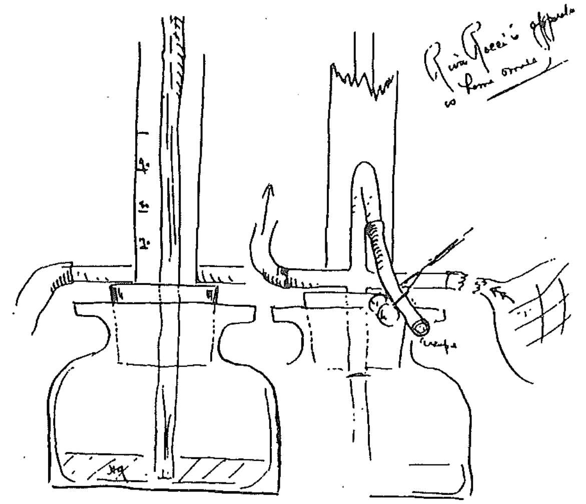


Figure 4. Harvey Cushing's rough sketch of Riva-Rocci's "sfigmomanometro." (Courtesy of Yale University.)

Not until 1876 was the first practical arterial occluder, a water-filled bag or pelotte, devised by Ritter Samuel Siegfried K. von Basch of Germany (1837 to 1905).[95] Von Basch studied only systolic pressure. Pierre-Carl-Edouard Potain of Paris (1825 to 1901) employed an air-filled pelotte.[82] By 1876 Etienne-Jules Marey of Paris (1830 to 1904) had reverted back to hydraulic counterpressure on the forearm.[74] In a final victory for pneumatics, Scipione Riva-Rocci designed his sphygmomanometer in 1896 at the University of Pavia in Italy. The Riva-Rocci apparatus employed an air-inflated, arm-occluding cuff that was only 5 cm wide.[84]

That same year, 1896, Harvey Williams Cushing began his surgical residency at Johns Hopkins Hospital. After completing, "in the house," his 4 years under Halsted, Cushing travelled throughout Europe during 1900 and 1901 to gain experience in clinical and experimental neurosurgery. While ice-skating and mountain climbing for recreation during his Swiss winter with Kocher in Berne, Cushing developed a cough that nagged him through the spring. Hoping a warmer climate would improve his health, a reluctant Cushing boarded a train for Italy.[30,47]

Mankind was blessed indirectly by that nagging cough. After arriving in Pavia, Italy, Cushing recorded the following entry in his 1901 diary:

> *Pavia* May 6 . . . Ospidale di St. Matteo. Just back of the University. Riva-Rocci at his [Osstaidi] in Vargese. Rarely comes to hospital. Dali Edmondo *Orlandi* at present is first assistant. Very kind. Speaks German. Also next door

Giovanni Grassi. Saw an O.P.D. Clinic in A.M. with a row of cherubic Pavia girls with their fore arms bared having injections of iron. Blood pressure apparatus at all hands. Many of them in each ward. Orlandi has made a very simple one. Riva-Rocci's apparatus is *home made.*[24]

An excellent artist, Cushing sketched Riva-Rocci's "sfigmomanometro" in his diary for future reference (Fig. 4). Upon returning to Baltimore in September 1901, Cushing began insisting that blood pressures be measured and recorded intraoperatively.[25] That same month witnessed Cushing's addition of blood pressure to the pulse/respiration anesthetic record that Amory Codman and he had pioneered while medical students at Harvard.[5,59,90]

Thus by the close of 1901, Cushing had transported the Riva-Rocci sphygmomanometer from Italy, Einthoven had reported his string galvanometer, and Bowles had received a patent for his stethoscope. The stage was now set for adding continuous modalities like precordial and electrocardiographic monitoring to Cushing's modern anesthetic record.

The history of cardiovascular monitoring has walked hand in hand with man's need through the centuries to assess patients with head injuries. Who but the neurotraumatized patient can bear such mute testimony to cardiovascular instability? It was no accident that ancient Egypt's *Secret Book of the Physician* was gleaned from the neurosurgical section of the Edwin Smith Papyrus almost 37 centuries ago. Nor was it accidental that the first physician to incorporate precordial and sphygmomanometric monitoring into anesthetic practice was none other than the consummate neurosurgeon, Harvey Williams Cushing.

ACKNOWLEDGMENT

I am indebted to Ferenc Gyorgyey and Susan Alon of the Yale Medical History Library for their valuable advice. I am grateful for the medical illustrations executed by Wendolyn B. Hill, Carol Porter, and Virginia Simon.

REFERENCES

1. Amber BB, Babey-Brooke AM: The Pulse in Occident and Orient: Its Philosophy and Practice in India, China, Iran, and the West. New York, Dunshaw Press, 1966
2. Anonymous: Surgical and Orthopaedic Apparatus, Invalids Articles, Circular 77. Boston, Codman & Shurtleff, undated
3. Arcieri JP: The Circulation of the Blood and Andrea Cesalpino of Arezzo. New York, SF Vanni, 1945, p 193
4. Baruch HB: Med Record (New York) 50:624, 1896
5. Beecher HK: The first anesthesia records (Codman, Cushing). Surg Gynecol Obstet 71:689-693, 1940
6. Bernard C: Leqons sur la Chaleur Animale. Paris, Librairie J.-B. Bailliere et Fils, 1876, pp 42-81
7. Bernstein J: Uber den zeitlichen Verlauf der negativen Schwankung des Nervenstroms. Pflugers Arch 1:173, 1868
8. Bianchi A, Bazzi E: Clinica Moderna (Florence) 1:421, 1895
9. Bleichroeder F: Virchow Arch Pathol 177:435, 1904
10. Bleichroeder F: Berl Klin Wochenschr 49:1503, 1912
11. Bourdon E: Note sur les tubes A section transversale non circulaire. Compt Rend Acad Sci 37:636-637, 1853
12. Bousfield G: Angina pectoris. Lancet 2:457, 1918
13. Bowles RCM: Stethoscopic instrument, U.S. Design Patent No. 28,307. In Official Gazette of U.S. Patent Office 82:1201, 1898
14. Bowles RCM: Stethoscope, U.S. Patent No. 677,172. In Official Gazette of U.S. Patent Office 95:2604, 1901
15. Breasted JH: The Edwin Smith Surgical Papyrus, vol. 1. Chicago, University of Chicago Press, 1930, pp 102-114
16. Burch GE, DePasquale NP: A History of Electrocardiography. Chicago, Year Book Medical, 1964
17. Burnett J: The origins of the electrocardiograph as a clinical instrument. Med History S5:53-76, 1985
18. Castiglioni A: A History of Medicine, ed 2. Translated by E. B. Krumbhaar. New York, Alfred A. Knopf, 1947
19. Cesalpino A: Quaestionum Peripateticarum. Venice, 1571, p 125
20. Cesalpino A: Quaestionum Medicarum, vol. 2, ed 2. Venice, 1593, p 234
21. Chauveau A, Marey E-J: Appareits et Experiences Cardiographiques Demonstration Nouvelle du Mecanisme des Mouvements du Coeur par l'emploi des Instruments Enregistreurs A Indications Continues. Mem Acad Mede 26:268, 1863
22. Comins NP: Lancet ii:685, 1828-1829
23. Cumston CG: The biography of Michel Servetus, the discoverer of the pulmonary circulation: to which is appended the text of that passage of his work relating to that discovery, followed by an English translation of the same and notes. Boston Med Sci J 156:451-461, 1907
24. Cushing HW: European Notes: 1900-1901, vol. 3. New Haven, Yale Medical History Library, diary entry for May 6, 1901
25. Cushing HW: On the avoidance of shock in major amputation by cocainization of large nerve trunks preliminary to their division. With observations on blood pressure changes in surgical cases. Ann Surg 36:321-345, 1902
26. Cushing HW: On routine determinations of arterial tension in operating room and clinic. Boston Med Surg J 148:250-256, 1903
27. Cushing HW: Experimental and clinical notes on chronic valvular lesions in the dog and their possible relation to a future surgery of the cardiac valves. J Med Res 12:471-486, 1908
28. Cushing HW: Some principles of cerebral surgery. JAMA 52:184-192, 1909
29. Davis SG: The administration of ether by the drop method. Md Med J (May) 1907
30. Denzel JF: Genius with a Scalpel: Harvey Cushing. New York, Julian Messner, 1971
31. DuBois-Reymond E: Vorlaufiger Abriss einer Untersuchung uber den sogenannten Froschstrom und uber die elektromotorischen Fische. Ann Phys Chem 58:1, 1843
32. DuBois-Reymond E: Aire et sur la modification qu'eprouve cette loi par l'effet de la contraction. Ann Chim Phys 30:119, 1850
33. Ebbell B: The Papyrus Ebers: The Greatest Egyptian Medical Document. Copenhagen, Levin and Munksgaard, 1937
34. Einthoven W: Un nouveau galvanometre. Arch néerl Sci exactes nat 6:625, 1901
35. Einthoven W: Die galvanometrische Registrirung des Menschlichen elektrokardiogramms, Zugleich eine Beurtheilung der Amvendung des Cupillar elektrometers in der Physiologie. Pflugers Arch 99:472, 1903
36. Elgood C: Medicine in Persia. In Krumbhaar EB (ed): Clio Medica, A Series of Primers on the History of Medicine. New York, Paul B. Hoeber, 1934
37. Faivre J: Etudes experimentales sur les lesions organiques du coeur. Gaz Med Paris, 1856, p 727
38. Fick A: Ein neuer Blutwelienzeichner. Reicherts u du Bois-Reymond's. Arch Anat Physiol S583:543-548, 1864
39. Fick A: Ein verbesserung des Blutwellenzeichners. Arch Physiol 30 S592:608-612, 1883
40. Flint HL: The Heart: Old and New Views. New York, Paul B. Hoeber, 1921
41. Forke A: Mo Ti des Sozialethikers und seiner Schuler philosophische Werke. Mitteilungen d Seminar f Orientalische Sprachen, vol 23-25. Berlin, Bei Bande, 1922
42. Forssmann W: Die Sondierung des Rechten Herzens. Klin Wochenschr 8:2085, 1929
43. Frank O: Kritik der elastischen Manometer. Z Biol 44:445-613, 1903
44. Frank O: Die Theorie der Segmentkolbenkapsel. Zschr Biol 59:526-530, 1912-1913
45. Frank O: Ein neues optisches Federmanometer. Zschr Biol 82:49-65, 1924
46. Fulton JF: Selected Readings in the History of Physiology. Springfield, IL, Charles C Thomas, 1930
47. Fulton JF: Harvey Cushing-A Biography. Springfield, IL, Charles C Thomas, 1946
48. Galvani LA: De viribus electricitatis in motu musculari commentarius. Comment Bonon Scient et Art Inst Bologna 7:363, 1791
49. Garten S: Beitrage zur Lehre vom Kreislauf. Zschr Biol 66:23-82, 1916
50. Geddes LA: The Direct and Indirect Measurement of Blood Pressure. Chicago, Year Book Medical, 1970, pp 9-36
51. Ghalioungui P: Magic and Medical Science in Ancient Egypt. London, Hodder and Stoughton, 1963
52. Golz F, Gaule J: Uber die Druckverhaltnisse im Innern des Herzens. Arch Physiol Menschen Thiere Bonn 18:100-135, 1878
53. Grunbaum OF: On a new method of recording alterations of pressure. J Physiol 22:xlix-li, 1897-1898
34. Haddad SI, Khairallah AA: A forgotten chapter in the history of the circulation of the blood. Ann Surg 104:1-8, 1936
55. Hales S: Statical Essays: Containing Haemastaticks; or, an Account of Some Hydrostatical Experiments Made on the Blood and Blood-Vessels of Animals, vol. 11. London, W. Innys & R. Manby, 1733
56. Harvey AM: Harvey Williams Cushing: The Baltimore Period, 1896-1912. Johns Hopkins Med J 138:196, 1976
57. Harvey W: First Lumleian Lectures by William Harvey (manuscript notes). British Museum, April 16-18, 1616
58. Heard JD, Straus AE: A report on the electrocardiographic study of two cases of nodal rhythm exhibiting R-P intervals. Am J Med Sci 155:238-252, 1918

Continued on Page 15

A Review of Anesthetic Accidents

In somno securitas is the motto of the Association of Anaesthetists of Great Britain and Ireland, and the following paper indicates that most of the time the motto bears fruit. However, the author of this paper indicates that, through the years, the old adage, "to err is human" is applicable to anesthetists occasionally. We are indebted to Mr. Peter Sykes and the Proceedings of the History of Anaesthesia Society for permission to reprint this paper which appeared in the Proceedings of the H.A.S. 15:49-54, 1994.

IN SOMNO *SEMI*-SECURITAS
A Chapter of Anaesthetic Accidents

by Mr Peter Sykes
Retired General Dental Practitioner, Ampthill
President, Society for the Advancement of Anaesthesia in Dentistry.

Considering the cheerful ignorance with which anaesthesia was first used, and the primitive nature of the equipment available, the early years were remarkably accident-free. There is, of course, no way of gauging morbidity, but the worst possible outcome of any anaesthetic is the death of the patient, and it is a result which can be recorded without equivocation. I could find no record of any anaesthetist deliberately murdering a patient on the operating table, so that any who have done so presumably got away with it. Deaths under anaesthesia can be assumed usually to have resulted from accident, and if we examine the deaths directly associated with anaesthesia, we can gauge to some extent the accidents which have occurred, and the reasons for them.

The first recorded death in England occurred under chloroform in 1848 - two years after the first successful general anaesthetic had been demonstrated professionally. The victim was a young girl of 15, Hannah Greener, who was to have an ingrowing toe-nail removed. In the parish register, alongside the entry in the left margin, the Registrar has noted: 'Died from the effects of chloriform'.

John Snow investigated deaths under chloroform during the first ten years of its use,[1] before the numbers began to increase dramatically. In 1848 he wrote:[2]

> After seeing how rapidly the vapour of chloroform kills animals when it pervades to a certain extent the air they breathe, and when we recollect that it came all at once to be generally administered without any previous teaching on the subject in the schools, it ought not to surprise us..... that a few cases have occurred in different parts of the world in which the exhibition of chloroform has been attended with fatal results.
> I am of the opinion that ether is incapable of causing this kind of accident, for the blood may imbibe with safety so considerable a volume of its vapour that the quantity which the lungs can contain at once adds but little to that effect. And I consider that a patient could only lose his life by ether from its careless continuance for several inspirations after well-marked symptoms of danger had set in.

Snow found in the first 10 years, 25 deaths from chloroform in England and Wales, 6 from Scotland and 19 from the rest of the world. These figures cannot be accurate. It is hardly likely that the whole of the rest of the world should produce a lesser number of deaths than England and Wales alone. What they demonstrate is that Snow, although well read, would not have had access to, or even perhaps, been able to read in the original, much of the foreign medical press, and deaths from overseas were much less likely to be reported in the English journals. Nevertheless, there had by this time been a number of deaths under chloroform around the world. By 1882, Henry Lyman, of the USA,[3] had collected case reports of 410 deaths associated with chloroform, 27 associated with ether and 8 with nitrous oxide. Of the last 8, one was due to the patient inhaling a bottle cork which had been used as a dental prop! Whether it was the dentist, the anaesthetist or the patient who had emptied the bottle is not recorded. These figures made N_2O seem incomparably safe, but it must be remembered that its use was largely confined to dental operations which were invariably short, and performed upon basically healthy patients. Most general surgery was carried out under ether or chloroform, not infrequently upon moribund patients because surgery was often the last resort.

By 1876 it was beginning to be realised that there were certain common features to some of the accidents, and that factors other than the toxicity of the drugs themselves or the susceptibility of the patients might be of importance. In England, Dr Lauder Brunton[4] had come to the conclusion that irritation of the fifth cranial nerve under light anaesthesia might stop the heart through the vagus. He drew this conclusion to explain dental fatalities, but it was known that many other minor operations were liable to stop the heart under chloroform — removal of the toe-nail having a particularly bad reputation. Lauder Brunton's contemporaries pointed out that by no stretch of the imagination could either the trigeminal or the vagus be connected anatomically with the toe-nail. With our present knowledge of widely different surgical stimuli causing cardiac arrhythmias, it is surprisingly uncommon for anaesthetists routinely to use local blocks in association with general anaesthesia.

More recently, it was reported[5] that sinus arrest had been induced by a trivial nasal stimulation. A nineteen old girl was anaesthetised with alfentanil, followed by thiopentone and suxamethonium and with nitrous oxide/oxygen in a circle system for maintenance. A temperature probe inserted into the left nostril caused a sudden and profound decrease in heartrate. The probe was withdrawn and the heart rate immediately recovered. Reinsertion of the probe led to sinus arrest of almost three seconds' duration, which resolved when the probe was withdrawn. Since the maxillary branch of the trigeminal innervates the nasal mucosa, the case provides a modern justification for Lauder Brunton's theory propounded 114 years earlier.

Chloroform was more dangerous, for staff as well as patients, when used after dark. The operating rooms of those days were lighted by gas, and above the operating table would be a multiple gas burner. In 1899[6] it was reported that, after giving chloroform to a midwifery case in a small room with three gas jets burning, such a violent coughing and gasping for breath was induced in the attendants that the forceps could not be applied, and the operation had to be concluded under ether. Following a 4-hour operation in Westphalia, Germany, the previous year, a nurse collapsed, and two days later died. Five years before, a letter to the *Lancet* had explained that when chloroform came into contact with a naked flame, highly toxic phosgene gas was produced.[7]

In 1906, twelve years after that letter, John Bouchier-Hayes gave the remedy[8] — it was to dip cloths in ammonia and hang them up near the lights. Ammonium chloride was formed, and phosgene gas eliminated. Phosgene was one of the poisonous gases used extensively in the First World War, and before gas masks were developed the remedy was the same as Bouchier-Hayes' — to soak a cloth in one's own readily available source of ammonia and breathe through it! Not the most immediately attractive of methods, but no doubt the more frightened you were, the more readily available was the source of ammonia.

Not all accidents were due to ignorance; stupidity has always played a part in human affairs, and anaesthesia is no exception. Ferdinand Sauerbruch, the German surgeon, says in his autobiography:

> The operation was proceeding normally when, through a cause we were never able to ascertain, the glowing cautery set light to the ether vapour used as the anaesthetic. The violent explosion that followed was repeated almost immediately as an oxygen cylinder blew up. The patient was killed on the spot, the sister and the assistant were injured, and I lost an eardrum.

This is exactly like saying: 'I dropped a lighted match into the fuel tank when, through a cause we were never able to ascertain, the vehicle caught fire'.

In the early days, all anaesthetic agents were freshly prepared before use. Iron cylinders containing compressed gases were introduced in about 1870, and with them the possibility of confusion. All cylinders initially were painted black, with the chemical formula for the gas, or its name, stencilled on in white, much as it is today. In the early simple apparatus this was of no concern because the only gas used was nitrous oxide, diluted as necessary with air. When the oxygen, too, was presented for use in anaesthesia, some method of distinguishing it from the N_2O had to be devised and the accepted way of doing this in the UK was to paint a white band around the top of the oxygen cylinder. It was not until many deaths had occurred from connecting the cylinders up wrongly, or from giving the wrong gas, that an attempt was made to prevent this by painting the cylinders in different colours; however, deaths due to the wrong gas continued. Lundy's 1942 textbook described a mechanical method of making wrong connections theoretically impossible by altering the standard cylinders and yokes. Unfortunately, it did not, in fact, make wrong connection *impossible*. You have to be very clever indeed to make things idiot-proof. Even the introduction by Heidbrink in 1954 of the pin-index system has not fully resolved the problem. Wrong gases continue to be administered. A meticulous checking of the gas cylinders does not guarantee that the gas in the cylinder will be the one which it should be. As recently as 1991 a report from Hong Kong[9] described how a series of patients was given oxygen and nitrous oxide from properly coloured and pin-indexed cylinders, but became hypoxic. The anaesthetic machine, flowmeters and vaporisers were all expertly checked without finding anything amiss. Only when the contents of the cylinders were checked was it discovered that the oxygen cylinder in fact contained pure nitrogen. No explanation was ever forthcoming.

As soon as complicated pieces of equipment were invented to improve the delivery of anaesthetic drugs, the problems which still beset us today began to appear. The famous Clover bag slung over the shoulder caused at least one death. In Clover's technique, a measured dose of chloroform was put into the bag, which had a fixed capacity, and which was then filled with air by means of a bellows. The patient breathed only from the bag, no additional air being given. In theory, the chloroform vapour could not exceed 2.8%, which practice had shown to be safe, but in 1873 a patient in Broadmoor Asylum died. It was found by Clover that the bag had not been fully inflated and therefore the chloroform vapour had been too concentrated.[10]

In 1857, the German anaesthetist, F E Junker, invented a chloroform vaporiser which consisted of a draw-over bottle into which air was pumped by a hand-operated bulb, the outlet being connected to the patient by way of a face mask. If the tubes were connected in the wrong way, the patient received liquid chloroform when the bulb was pumped. Although many attempts were made to correct the fault, the wrong connection was not made impossible until 1892. Along the way, several delightfully imaginative pieces of apparatus were designed for the better delivery of chloroform, such as Hewitt's modified Junker's inhaler and Tyrell's inhaler, which went one better by incorporating one bottle for ether and another for chloroform, both conveniently accommodated in the anaesthetist's waistcoat pockets. Even these intimately supervised pieces of apparatus could go wrong. As late as 1931 there was a death from explosion when a similar tandem system was being used.[11] The ether bottle had been turned off and oxygen was being passed through the chloroform. It was an oral operation and a pencil light was introduced into the mouth. There was an explosion in the mouth, the anaesthetic apparatus blew up, and the patient died. Later experimentation showed that the oxygen took up some ether vapour on its way to the chloroform. A 4-volt electric spark would not ignite ether and air, but would ignite ether and oxygen; the torch was driven by a 4-volt battery.

Although we have virtually ceased to use flammable anaesthetic agents, we are still aware of the dangers of explosion if such agents are used with anaesthetic machinery which is not adequately earthed and protected from static electricity sparks. Less well-known, perhaps, is the danger present when an oxygen bottle is opened. In the 1960s, a colleague of mine burned down part of his dental surgery building when the oxygen cylinder valve was opened suddenly with the reducing valve closed. The sudden liberation of high pressure oxygen had compressed the air in the space between the two valves and the heat caused an explosion. It is, of course, the principle which is used in a diesel engine. I later discovered that a similar accident had been reported as far back as 1931.[12]

In 1925 a 16-year-old boy was having a broken jaw reduced and splinted under ether and oxygen anaesthesia. After about 25 minutes the teeth were being dried by the time honoured method of heating the nozzle of an air syringe and blowing the warmed air on to them. The spirit lamp for warming the

Continued on Page 14

In Somno. . . From Page 13

syringe was about six feet away, there were no other naked lights near, and the nozzle of the syringe was not red-hot. On the third application, there was an explosion at the back of the boy's mouth: he died in ten minutes and autopsy revealed rupture of the bronchi and collapse of the lungs. The case was reported in the *British Medical Journal,*[13] and in subsequent issues, several correspondents made suggestions about the cause, varying from catalytic action to bits of burning wick on the nozzle, but no definite conclusion was ever reached.

Giving the wrong strength of solution is a comparatively common mistake. I was taught to write prescriptions in drachms and ounces, and the symbols used for those quantities were so alike as to make confusion almost inevitable. The pharmacist needed a good knowledge of common dosage in order to be able to interpret some people's writing. Nowadays, we make things safer by using the metric system. Unfortunately, it is only too easy to multiply by ten by omitting or misplacing the decimal point and so we still read of deaths caused by overdosage.

It is also surprisingly easy to misread a label. Very frequently we see what we expect to see. In 1988 a British dentist killed a patient under most unfortunate circumstances. He commonly used intravenous diazepam, preceded by atropine in order to protect against bradycardia, which was then the standard technique. In his practice, drugs of this nature were kept in a special cabinet and only drawn by his nurse when needed. It was the practice routine for the unopened ampoule of the drug to be placed on a tray for the dentist to check before being drawn up into a syringe and labelled by the nurse. After it had been drawn up and labelled, he again checked that it was the correct drug before he injected it. On this occasion he performed all his normal checks, so far as he could recollect afterwards. He then injected the atropine, his patient went into ventricular fibrillation and died, despite prompt and efficient CPR. Devastated, the dentist retrieved the glass ampoule for pharmaceutical analysis and, as he looked at it again, he realised that it was labelled adrenaline, not atropine. The practice never used adrenaline and did not keep it in stock except as part of the emergency kit: both the nurse and the dentist had seen what they expected to see and read 'adrenaline' as 'atropine'.

In a paper from the USA, Tinker et al.[14] in 1989 reviewed 1,175 anaesthetic-related claims on insurance companies for medical malpractice, and concluded that of 1,097 cases where sufficient information was available to make a judgement on its probable value, some 31.5% of cases would have been improved by the application of additional monitors which means, of course, that 68.5% would not. They considered that the monitors most useful in mishap prevention were the pulse oximeter and the capnograph. In 1986 an editorial in *Anaesthesia* stated that: 'There is firm evidence that a considerable reduction in the incidence of avoidable mortality and severe morbidity could be achieved by the simple expedient of increased vigilance by individual anaesthetists'.

Anaesthesia is as near to death as most people will come until they die. Any procedure which interferes so drastically with human physiology must constitute a hazard, with an inescapable mortality. Even when death is not actually caused by the anaesthetic, it will still be reported by the press as if it were. The aim must be to reduce the danger of anaesthesia to the very minimum possible, and it is very evident that the single most important factor in doing this is good patient management. All too often, it is a failure here which is responsible for a fatal outcome: inadequacy of the anaesthetist, not of the anaesthetic. It is a truism much quoted that there is no safe anaesthetic, only a safe anaesthetist. It is equally true to say that it is not possible to solve the problem of anaesthetic mortality by throwing more technology at it.

Once apparatus began to assume greater importance and became more complicated, accidents which previously had been confined to human error were compounded. If it is true that to err is human, but to foul things up completely requires a computer, then it is equally true that the greater the complexity of the machine, the more opportunities there are for the operator to get it wrong.

Anaesthesia nowadays is certainly more safe than it used to be, even 30 years ago. The use of sophisticated machinery has enabled advances in techniques to be made which have revolutionised surgery, and greatly improved human life expectancy, but there is still no substitute for the keen pair of eyes and the educated pair of hands. Throughout the ages, deaths have occurred in the advancement of medical knowledge. It is always dangerous to be part of a developing frontier, but if one death takes place because of an unavoidable error, then it is a death too many. If one were to sum up the lessons to be learned from the literature, then a modification of one well-known sentence would suffice — the price of *safety* is eternal vigilance.

News About Dr. Carl Koller

A recent letter from Mrs. Hortense Becker, an Honorary Member of the Anesthesia History Association, informs us that the papers (some 1500 items) of her father, Dr. Carl Koller, who introduced local anesthesia in surgery in 1884, are now housed and available in the U.S. Library of Congress.

These items are listed under *Carl Koller—1857-1944—Papers 1879-1963*, and comprise a variety of subjects, including:

a) detailed notes of lectures of several prominent professors at the University of Vienna in the 1860s.

b) correspondence with Sigmund Freud while at graduate school.

c) scientific papers, as well as medical journals.

d) anti-Semitism at the University of Vienna which triggered a duel with a young medical officer, including newspaper accounts of the discussions.

We are most grateful to Mrs. Becker for making this information known, which will be a treasure trove to those interested in the history of that era from a medical viewpoint.

References

1. Sykes WS. *Essays on the First Hundred Years of Anaesthesia.* Vol 2, Churchill Livingstone, London, 1960, p 26.

2. Snow J. On narcotism by the inhalation of vapours. *Med. Gazette* 1848; 1: 243.

3. Lyman HM. *Artificial Anesthesia and Anaesthetics.* Sampson Low, London, 1882.

4. Brunton TL. Remarks on one of the causes of death during the extraction of teeth under chloroform. *British Medical Journal* 1875; 2: 695-697.

5. Bailey PL. Sinus arrest induced by nasal stimulation during alfentanil-nitrous oxide anaesthesia. *British Journal of Anaesthesia* 1990; 65: 718-720.

6. Annotation. *Lancet* 1899; 1: 1727.

7. Sykes WS. *Essays on the First Hundred Years of Anaesthesia.* Vol. 2, Churchill Livingstone, London, 1960, pp 2-3.

8. Answers. *British Medical Journal* 1906; 2: 1343.

9. Menon MRB, Lett Z. Correspondence. *Anaesthesia* 1991; 46: 155-156.

10. Correspondence. *Lancet* 1873; 1: 846.

11. Ether-oxygen anaesthetic fatality. *British Medical Journal* 1931; 1: 915.

12. Section of Anaesthetics. *Proceedings of the Royal Society of Medicine* 1931; 25: 128.

13. An unusual anaesthetic fatality. *British Medical Journal* 1925; 2: 713.

14. Tinker JH. Role of monitoring devices in prevention of anesthetic mishaps: a closed claims analysis. *Anesthesiology* 1989; 71: 541-546.

Cardiovascular. . . *From Page 11*

59. Hirsch NP, Smith GB: Harvey Cushing: His contribution to anesthesia. Anesth Analg 65:288-293, 1986

60. Jolly WA, Ritchie WT: Auricular flutter and fibrillation. Heart 2:177, 1911

61. Korotkoff NS: On the subject of methods of measuring blood pressure. Bull Imp Military Med Acad St. Petersburg 11:365-367, 1905

62. Krumbhaar EB: Electrocardiographic observations in toxic goiter. Am J Med Sci 155:175-203, 1918

63. Laennec RTH: A Treatise on the Diseases of the Chest, in Which They Are Described According to Their Anatomical Characters, and Their Diagnosis Established on a New Principle by Means of Acoustick Instruments. (Translated by John Forbes) First American ed. Philadelphia, J. Webster, 1823, p 319

64. Lancisi GM: De Subtancis Mortibus. Rome, 1707

65. Lancisi GM: De Motu Cordis et Aneurysmatibus. Naples, 1728

66. Leared A: NY Med Times IV:140,1855

67. Lockhart ML: Electrostethograph, U.S. Patent No. 2,099,938. In Official Gazette of U.S. Patent Office 484:845, 1937

68. Luciani L: Human Physiology, translated by FA Welby, vol. 1. London, Macmillan & Co., Ltd., 1911, p 592

69. Ludwig C: Beitrage zur Kenntniss des Einflusses der Respirations bewegungen auf den Blutlauf im Aortensysterne. Muller's Arch Anat Physiol Wissensch Med, 1847, pp 240-302

70. Lyons AS, Petrucelli Rj: Medicine: An Illustrated History. New York, Harry N. Abrams, 1987

71. Mackenzie J: The ink polygraph. Br Med J i:1411, 1908

72. MacWilliam JA: Fibrillar contraction of the heart. J Physiol 8:296, 1887

73. Major RH: A History of Medicine, vol. 2. Springfield, IL, Charles C Thomas, 1954

74. Marey EJ: Pression et vitesse du sang. In Physiologie Experimentale. Travaux du Laboratoire de M. Marey. Paris, Masson & Cie, 1876, pp 236-371

75. Marsh NB: Improvementin stethoscopes, U.S. Patent No. 8,591. In Report of the Commissioner of the United States Patent Office, U.S. House of Reps. Doc. No. 102, Washington, 1851

76. Meyerhof M: Ibn an-Nafis (XIIIth cent.) and his theory of the lesser circulation. Isis 23:100-120, 1935

77. Morgan JD, Lamb DS: Laennec and the Stethoscope. Washington, DC, Heresford Press, 1910

78. Oersted JC: Experimenta circa effectum conflictus electrici in acum magneticam. J Chem Phys 29:275, 1820

79. Peters JL: Historical review. In A Manual of Central Venous Catheterization and Parenteral Nutrition. Littleton, MA, John Wright PSG Inc., 1983, pp 3-11

80. Piorry PA: De la percussion mediate. Paris, 1828

81. Poiseuille JLM: Recherches sur la force du coeur. Arch Gen Med, 1828, p 18

82. Potain PCE: La Pression Arterielle chez t'Homme a I'Etat Normal et Pathologique. Paris, Masson & Cie, 1902, p 191

83. Resnick R, Halliday D: Physics: Parts I and 11 Combined, Wiley International edition. New York, John Wiley & Sons, 1966, p 648

84. Riva-Rocci S: Un nuovo sfigmomanometro. Gaz Med Torino 47:981-1001, 1896

85. Rollason WN: Electrocardiography for the Anaesthetist. Oxford, Blackwell Scientific Publications, 1964

86. Said HM: Greco-Arab Concepts on Cardiovascular Diseases. Karachi, Pakistan, Hamdard Foundation Press, 1983

87. Samojloff A: Reminiscences of the late Professor Willem Einthoven. Am Heart J 5:545-548, 1930

88. Schinz RE: Das Schinz'sche Dampfmanometer fur Locomotiven. Dingler's Polytech J 113:85-90, 1849

89. Servetus M: De Restitutio Christianismi. Vienna, 1553, p 170

90. Shephard DAE: Harvey Cushing and anaesthesia. Can Anaes Soc J 12:832-842, 1965

91. Tomlinson H; On the increase in resistance to the passage of an electric current produced on stretching. Proe R Soc 25:451-453, 1876-7

92. Veith I: Huang Ti Nei Ching Su Wen: The Yellow Emperor's Classic of Internal Medicine. Berkeley, University of California Press, 1972

93. Vierordt K: Die Lehre vom Arterienpulses. Braunschweig, 1855, S. 21

94. Volta A: An account of some discoveries made by M. Calvani, with experiments and observations on them. Phil Trans R Soc, London, 1793

95. von Basch S: Ueber die Messung des Blutdrucks am Menschen. Z Klin Med 2:79, 1880

96. Waller AD: A demonstration on man of electromotive changes accompanying the heart's beat. J Physiol 8:229, 1887

97. Walsh J: Phil Trans Lond, 1773, pp 461-477

98. Walsh J: Correspondence to Benjamin Franklin, 1774

99. Wiggers CJ: Some factors controlling the shape of the pressure curve in the right ventricle. Am J Physiol 33:382-396, 1914

100. Wiggers CJ, Baker WR: A new universal optical manometer. J Lab Clin Med 10:54-56, 1924

101. Williams CJB: Diseases of the Chest, ed 3. London, Churchill, 1835

102. Williams CT: Laennec and the evolution of the stethoscope. Br Med J ii:6-8, 190

103. Willius FA, Dry TJ: A History of the Heart and the Circulation. Philadelphia, W.B. Saunders Co., 1948

104. Wong KC: The pulse lore of Cathay. China Med J 42:884-897, 1928

ABA Founding. . . *From Page 5*

7. Scrapbook of John S. Lundy. *The Collected Papers of John Silas Lundy, M.D.* The Wood library-Museum Collection, Park Ridge, Illinois

8. Gillespie NA: *Ralph Milton Waters: A brief biography*. Unpublished, The Wood Library-Museum Collection, Park Ridge, Illinois

9. Morris LE: The continuing influence of Ralph Waters and the aqua-alumni. Unpublished, The Wood Library-Museum Collection, Park Ridge, Illinois

10. Sim P: From Indiana to New York: Dr. Paul Meyer Wood's Hoosier roots. *American Society of Anesthesiologists Newsletter*, 58:8-13, 1994

11. Betcher AM: *Paul Meyer Wood (1894-1963)*. Unpublished. The Wood Library-Museum Collection, Park Ridge, Illinois

12. A glance through the *Quarterly Cumulative Index to the Medical Literature* for the years 1920-1940 clearly demonstrates the tremendous growth anesthesiology was undergoing technologically.

13. Haines FH: Economic problems in anesthesia. *Anesth Anal* 6:26, 1927.

14. Betcher AM, Ciliberti BJ, Wood PM, Wright LH: The jubilee year of organized anesthesia. *Anesthesiology* 17:226-264, 1956

15. Bacon DR, Lema MJ: To define a specialty: A brief history of the American Board of Anesthesiology's first written examination. *Clin Anesthesiology* 4:498-497, 1992

16. Letter from Ralph M. Waters to Francis H. McMechan, December 14, 1932. *The Collected Papers of Ralph M. Waters, M.D.* Steenbock Library, University of Wisconsin, Madison

17. Letter from Francis H. McMechan to Ralph M. Waters, April 17, 1933. *The Collected Papers of Ralph Waters, M. D.* Steenbock Library Collection, University of Wisconsin, Madison

18. Letter from Paul M. Wood to Wallace W. Dill, May 27, 1937. *The Collected Papers of Paul M. Wood, M.D.* The Wood Library-Museum of Anesthesiology, Park Ridge, Illinois

19. Letter from Paul M. Wood to Ralph M. Waters, M.D., January 31, 1933. *The Collected Papers of Ralph M. Waters, M.D.*, Steenbock Library Collection, University of Wisconsin, Madison

20. Letter from Ralph M. Waters to Paul Wood, November 5, 1934. *The Collected Papers of Ralph Waters, M.D.*, Steenbock Library Collection, University of Wisconsin, Madison

21. Application for Fellowship in the American Society of Anesthetists, *The Collected Papers and Minutes of the Long Island, New York and American Society of Anesthetists.* The Wood Library-Museum Collection, Park Ridge, Illinois

22. Letter from Paul M. Wood to Ralph M. Waters, September 25, 1935. *The Collected Papers of Ralph M. Waters, M.D.* Steenbock Library Collection, University of Wisconsin, Madison

23. Letter from Ralph Waters to Paul Wood, September 24, 1935. *The Collected Papers of Ralph M. Waters, M.D.* Steenbock Library Collection, University of Wisconsin, Madison

24. Letter from Paul M. Wood to Ralph M. Waters, January 27, 1936. *The Collected Papers of Ralph M. Waters, M.D.* Steenbock Library Collection, University of Wisconsin, Madison

25. Minutes of Meeting, February 13, 1936. *The Collected Papers and Minutes of the Long Island, New York and American Society of Anesthetists.* The Wood Library-Museum Collection, Park Ridge, Illinois.

26. Minutes of meeting of the American Society of Anesthetists, March 9, 1936. *The Collected Papers and Minutes of the Long Island, New York and American Society of Anesthetists,* Wood Library-Museum Collection, Park Ridge, Illinois

27. Letter from Ralph Waters to Everts Graham, December 16, 1936. *The Collected Papers of Ralph M. Waters, M.D.* Steenbock Library Collection, University of Wisconsin, Madison

28. Minutes of meeting of the Representatives of the Committee on Fellowship, January 10, 1937. *The David M. Little Collection*, Wood Library-Museum of Anesthesiology, Park Ridge, Illinois

29. Betcher AM: Historical development of the American Society of Anesthesiologists, Inc. *The Genesis of Contemporary American Anesthesiology*. Edited by Volpitto, PP and Vandam, LD. Springfield, Charles C Thomas, 1982, pp 185-208

30. Letter from Paul M. Wood to Ralph M. Waters, April 20, 1937. *The Collected Papers of Ralph M. Waters, M.D.*, Steenbock Library Collection, University of Wisconsin, Madison

31. Letter from John S. Lundy to J. Pallin (Chairman, AMA Council on Scientific Assembly), *The Collected Papers of John Lundy, M.D.* The Wood Library-Museum Collection, Park Ridge, Illinois

Dr. Calverley. . . *From Page 3*

by Dr. Clyde Jones of San Diego. Dr. Jones is a retired Navy anesthesiologist and was Chief of Anesthesia at both the San Diego Naval Hospital and the San Diego Kaiser Foundation Hospital. He was also a founding member of the Anesthesia History Association. Dr. Jones was led into medical mission work by Rod's example. Rod traveled on medical missions to Afghanistan and Malaysia, among other countries, and had just returned from Sarajevo a week before his death. He also emphasized Rod's zeal and enthusiasm and sense of humor, especially when telling stories of Afghani yaks.

A remembrance of Rod with his family was delivered by Mr. Buck Serrano, who served as a Boy Scout leader for Rod's son Grant. Father Carroll gave the final blessing. A bagpiper in full Scottish dress appeared at the rear of the church, piping *Amazing Grace*, and the casket was moved to the cathedral's courtyard. A brief military ceremony occurred, and the casket's flag was presented to the family.

Attendees gathered in the cathedral's Great Hall afterwards for refreshments. Family and professional pictures were on display, as were items from Rod's anesthesia equipment collection and anesthesia book collection. Among those attending from the world of anesthesia were Dr. N. Ty Smith and his wife, Dr. Penelope Cave Smith, and Dr. and Mrs. Clyde Jones (previously mentioned); Dr. and Mrs. Leslie Rendell-Baker of Loma Linda, CA (he is an expert on anesthesia equipment history, author with William W. Mushin of *Origins of Thoracic Anesthesia*—reissued by the WLM in 1991—and had recently worked with Rod on equipment at the Wood Library-Museum), Dr. and Mrs. Gil Kinyon of San Diego (Dr. Kinyon was previously president of the California Society of Anesthesiologists and received its Distinguished Service Award in 1986, developed modern anesthesia in San Diego and was interviewed by Rod on videotape for the WLM's Living History series), Dr. John Haddox of San Diego (the 1980 ASA president and recipient of the ASA Distinguished Service Award in 1992), Dr. and Mrs. Larry Saidman (he is Editor of *Anesthesiology* and a UCSD colleague of Rod's), Dr. Jonathan Benumof (another UCSD colleague and author of numerous anesthesia publications related to airway management and anesthesia for thoracic surgery), Dr. Tom Joas (a previous CSA president) and Dr. Harvey Shapiro, Rod's previous chairman at UCSD. Some of Rod's current and former residents attended. I represented the ASA's Wood Library-Museum (Rod was a member of its Board of Trustees) and the Anesthesia History Association (which Rod and I founded).

Others attending were the San Diego VA's Hospital Director, Leonard Rogers, and the VA's Chief of Staff, Dr. Jackie Partmore. Reflecting Rod's interest in all kinds of people, many nurses from the UCSD affiliated hospitals and even housekeeping staff from the VA attended. The ORs were closed at both the University Hospital and the San Diego VA, to allow staff to attend the funeral.

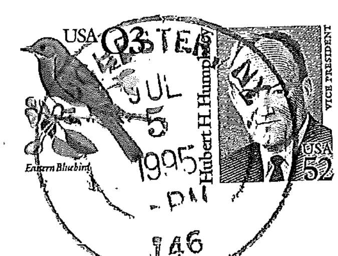
I ducked back into the cathedral before leaving for the long drive back to Los Angeles. Diagonal stripes of red, yellow, blue and green light from the stained glass windows played on the now-empty pews and plain grey walls. I reflected for some time on the ceremony and the man. The ceremony was as Rod would have wanted it: military, quiet and with style. The man was a unique human being who we all loved. The sense of loss was profound.

Dr. Ty Smith had stated that Rod's legacy to us should be for us to take on Rod's love of humanity and his enthusiasm for helping others. "I hope those who knew Rod will try to remember this legacy: 'When you do some kind act to someone else, however large or small, especially one that you might not otherwise have done, please think of me.' " There could be no greater gift back to Rod, who gave us all so much of himself.

The body was cremated. Burial is at Fort Rosecrans Military Cemetery in San Diego.

(N. Ty Smith MD made helpful comments on this article.)

Bulletin of Anesthesia History
C. Ronald Stephen, M.D., C.M., Newsletter Editor
15801 Harris Ridge Court
Chesterfield, MO 63017 U.S.A.



Patrick Sim
Librarian
Wood Library-Museum
520 N. Northwest Highway
Park Ridge IL 60068-2573