Tapping the Tube

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The Old Ways

Before percussion and mediate auscultation were discovered, methods of physical examination—in particular chest examination—were limited. Only observation was used with any regularity. From the time of Hippocrates, palpation and direct auscultation had been used sporadically to detect heartbeats but had not proved to be of practical value because clinicopathological correlation had not yet been established. At last, when a new method called percussion was conceived by Auenbrugger in 1761, it was ignored for almost forty years. Not until the French School evolved did percussion become established, largely through Corvisart, Napoleon's private physician. Coincident with the revival of percussion, Laennec, another physician of the French School, invented the stethoscope and mediate auscultation. How remarkable that these two methods of chest examination came into use at the same time and in a period of history when chest disease—especially tuberculosis—was rampant!

Until the mid-seventeenth century systematic instruction in clinical examination was nonexistent; no patient contact was required for medical training or degrees, and it was necessary to pass only an oral test. Two great clinicians, Sydenham and Boerhaave, who practiced in the seventeenth century, helped to change this pattern and emphasized the importance of observation as a method of clinical examination.

Thomas Sydenham (1624–1689), an Englishman, had barely begun his college career when it was interrupted by the Civil War. Four years later when the war between the King and Parliament was over, Sydenham felt too old to start a college education again. "At a loss for a career," he decided to study medicine at Oxford.[1] Because of his war experiences and his brief formal medical education, Sydenham's approach to medicine was practical and relatively unspoiled by the old theorizing which was popular until his time. Sydenham realized the need for practical clinical study as he expressed in his words: ". . . the human mind is far too limited in its ability and knowledge to settle the great problems of what disease is, and why there should be disease. While we debate such questions there are sick men who need help. . . . The place to study disease is at the bedside of the sick man: by observation and experience we can learn the nature of disease."[2] He recorded thorough observations on many diseases including scarlet fever, measles, chorea, smallpox, malaria, and dysentery, but his masterpiece was a meticulous description of gout, a disease from which he himself suffered. Because his style of clinical observation and description resembles that of Hippocrates, Sydenham has earned the title the "English Hippocrates."[3]

Hermann Boerhaave (1668-1738) also stressed clinical observation and popularized bedside medicine. He was born in Holland, the son of a clergyman, began his studies in theology at Leyden, and, becoming interested in the sciences and medicine, he resolved to become a doctor. Respected and loved by his pupils as a physician, he was able to promote new ideas on the nature of disease. "A disease," he said, "is a physical thing and its cause is also a physical thing . . . which induces a change in the solids and fluids of the body."[4] Boerhaave was a pioneer in associating clinical features of disease with post-mortem appearances, although

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clinicopathological correlation did not reach its full potential until later through the work of Morgagni.

During Boerhaave's time, and still later in the eighteenth century, examination of a patient's unclothed body remained a rarity even in the case of infants. Boerhaave, however, after a history had produced no clues, would resort to physical examination. An account is given of an infant taken to Boerhaave with a fever of unknown origin. After an unrevealing history, he demanded that the infant be undressed, whereby he discovered a needle in its body as the source of infection.[5] Besides observation, Boerhaave instituted other tools in his practice at Leyden; he used the Fahrenheit thermometer, looked at blood and urine under the microscope, and routinely performed autopsies.[6] These methods and ideas were propagated and spread throughout Europe, and his fame extended even to China. His students came from several foreign countries, and his influence on other universities was considerable. Two of his pupils, Van Swieten and de Haen, were responsible for the development of the old Vienna School, and all the founders of the Medical School at Edinburgh trained under Boerhaave. Bedside observation and post-mortem examination became important traditions in these schools, and it was in Vienna that Auenbrugger studied and made his remarkable discovery.[7]

Percussion

Leopold Auenbrugger (1722-1809), born at Gratz in the Austrian province of Styria, was the son of an innkeeper and often helped his father in the inn. He completed his medical studies under Van Swieten at the Vienna School and became an attending physician at the Spanish Military Hospital of the Holy Trinity (1751). This large hospital, the finest in Vienna, provided abundant opportunities for clinical observations, and over a seven-year period, Auenbrugger tested his famous discovery.[8] The idea of percussion came about as Auenbrugger was tapping on wine barrels in his father's inn to locate the fluid level without having to open the barrels. In this manner he could determine when the supply was dwindling, the hollow sound indicating emptiness. He ingeniously applied the new principle of percussion to his patients and found that he could detect consolidation, pleural effusion, and even cardiac dilatation. Not only did he confirm his diagnostic impressions at autopsy, but he also tested his method by injecting fluid into the pleural space in cadavers and then percussing them to find the fluid level.[9]

Auenbrugger published his findings in 1761 in "Inventum Novem," a modest 95-page volume which has become a medical classic. The full translated title of the book is *A New Discovery that Enables the Physician, From the Percussion of the Human Thorax, to Detect the Diseases Hidden Within the Chest.*[10] Auenbrugger's observations are found in Camac's *Epoch-making Contributions to Medicine*[11] and are now summarized. First, a description of the normal chest sound and its characteristics in different areas is presented. In the healthy state this sound is like a "stifled drum covered with a thick woolen cloth." Variation according to body habitus is explained, the sound being more prominent in the lean and almost lost in the obese. The technique for percussion is suggested: the chest is "struck slowly and gently, with the points of the fingers brought close together and at the same time extended." Methods are given for percussing the clothed and unclothed chest, positioning the patient, and instructing him how to breathe. Next, the dull sound called the "preternatural" or "morbid" sound is described. In this part an analogy is drawn between a cask of fluid and a chest with effusion. Other observations relate those diseases producing the dull sound; for example, inflammation of the pleura or lungs, serous, purulent, and bloody effusions, pericardial effusion, cardiac enlargement; and those diseases not causing a dull sound; for example, asthma, consumption, small lesions.

Interestingly, Auenbrugger, with much insight and wisdom, had stated in the preface of his book, "I realize . . . that envy and blame and even hatred and calumny have never failed to come to men who have illuminated art or science by discoveries."[12] Indeed, his masterpiece did not immediately achieve the attention and success it deserved. Van Swieten, to whom Auenbrugger almost dedicated his book, failed to comprehend the value of percussion. De Haen, who lamented the "obscurity and difficulty of diagnosis of thoracic disease," likewise never acknowledged percussion and its possibilities.[13] Others either ignored or grossly misinterpreted the "Inventum Novem" as did

Rudolph Vogel, an authority in medicine in Göttingen, who mistakenly wrote that Auenbrugger's percussion was only a variation of Hippocrates' succussion, and was annoyed that Auenbrugger did not give credit to Hippocrates.[14] The succussion splash known to Hippocrates was a sign pathognomonic of seropneumothorax and heard less often with pyopneumothorax; it really depended on the presence of both air and fluid in the pleural cavity. Hippocrates elicited this sign by shaking the patient's shoulders and either listening from arm's length or with the ear to the chest when he would hear a "splash" or metallic tone.

Despite the lack of enthusiasm for his discovery, Auenbrugger lived a happy life. He was well accepted among his peers for his congeniality and loved by his students for his generosity and compassion. He enjoyed a golden anniversary with his wife, a peaceful retirement in the suburbs, and died at the age of eighty-seven. His method was only temporarily put to rest and was later revived by the French physician, Corvisart. Still later, after percussion had gained popularity, another French physician named Piorry promoted a modified form of Auenbrugger's method, mediate percussion, which is still used by modern physicians.

The French School and the New Medicine

In the last few years of the eighteenth century, France was experiencing a Revolution in medicine as well as in politics. The philosophical mood which favored observation, experience, and skeptical empiricism instead of the classical beliefs, carried over into the field of medicine and the famous French School in Paris.

All remnants of the old regime were swept aside by the Revolution, and the universities and medical colleges closed. A few years later when France was at war, the shortage of doctors became serious, and the only places available for training were the hospitals. The hospitals became "the workshops of new medicine," and according to the historian Ackerknecht, ". . . it was only in the hospital that the three pillars of the new medicine—physical examination, autopsy, and statistics could be developed."[15]

The hospital clinical training as formulated during this period sounds surprisingly similar to today's attending round. "The professor would pause at the bedside of each patient long enough to question him and examine him properly; he would draw the students' attention to the diagnostic signs and the important symptoms of the disease . . . ."[16] The students would "read little, see much, and do much," learning as they practiced at the bedside.[17] Thus the French School gave birth to medicine as it is practiced today, produced many great physicians, and became the leading school in Europe.

The Revival of Percussion

Jean Nicolas Corvisart (1755–1821) was an eminent figure in the French School, and as a proponent of percussion and teacher of Laennec, he became "the connecting link between the men who did the most for the practical science of medicine"—Auenbrugger and Laennec.[18] Corvisart began his career in surgery and anatomy but then turned to internal medicine. In 1782 he was rejected for a position at the Necker Hospital despite excellent qualifications because he refused to wear a powdered wig! However, he successfully held positions in subsequent years at the Charité, École de Santé, and Collège de France.

It was in 1799 that Corvisart came upon Auenbrugger's work through a book by Eyerel, a student of the Vienna School who praised the method of percussion. Giving full credit to Auenbrugger, Corvisart found and translated the original "Inventum Novum" from Latin into French, added to it his own commentaries, and published the entire work in 1808. Two years previously, Corvisart had published a book on heart disease, *Maladies du Coeur,* in which he brilliantly discussed pericarditis, cardiac dilatation and hypertrophy, cardiomyopathy, and valvular and aortic disease. However, by far his greatest gift to modern medicine was the revival and propagation of percussion, so that by 1825 it was in use practically everywhere.[19]

In 1804, Corvisart was selected to be Napoleon's physician, in part because of the Emperor's appreciation of percussion. Corvisart was called into consultation for a persistent cold bothering Napoleon, who was impressed when this great physician used percussion in his examination.[20] In 1815, following the downfall of Napoleon, Corvisart retired from medicine altogether and in 1821 died of a stroke. One of his most outstanding qualities was his ability to in-

spire and encourage his pupils and their ideas. He closely assisted his students, particularly in bedside observation. In this way, Laennec came to know and esteem Corvisart and to become his favorite pupil.

Mediate Auscultation

Rene Theophile Hyacinthe Laennec (1781–1826) was born at Quimper in Bretagne, a province in northern France. His mother, having exposed Laennec to tuberculosis, died of the disease when he was six years of age. Consumption shortened Laennec's life as well but did not hamper his productivity. His father, who was an eloquent lawyer but irresponsible and always in debt, sent his sons to live with their rector grand-uncle at Elliant. At age 11 Laennec went to Nantes to live with his uncle Guillaum Laennec, a physician and faculty member at the University of Nantes who was instrumental in Laennec's decision to study medicine.

Laennec's early education was interrupted by the French Revolution, but at age 19, after much deliberation, he went to the renowned Paris School to study medicine. In the year that followed, he won two prizes given in medicine and surgery at the University of Paris. At age 23 he successfully completed a medical thesis on Hippocrates. Following his formal medical training, he spent four years as physician at Beaujon Hospital in Paris and then obtained a position at the Necker Hospital where he made his famous discovery of mediate auscultation.

The examination of the chest just before Laennec's discovery consisted of inspection, palpation, the newly added method of percussion, and immediate or direct auscultation. Auscultation in this form was known to Hippocrates but was neither popular nor frequently used. It had a number of disadvantages. Some patients, if not most, were unwashed or vermin-infested, making direct contact undesirable. Other patients had a voluminous amount of fat which rendered the method somewhat less useful; furthermore, direct auscultation proved to be an embarrassment to the female patient.

As immediate auscultation "shocked his decency and modesty," Laennec himself used it only in cases of suspected heart disease when the heart beats could not be felt by palpation.[21] In his own words, "(It was) as uncomfortable for the doctor as it was for the patient, disgust in itself making it impracticable in hospitals. It was hardly suitable where most women were concerned and, with some the very size of their breasts was a physical obstacle to the employment of this method . . . ."[22]

The Tube

In 1816, Laennec was consulted at the Necker Hospital by a young female patient thought to have heart disease. On his way to visit this patient, he saw several children playing on some lumber in the gardens of the Louvre, and he was reminded of an acoustic principle. As one child tapped on the beam at one end, the signal reached the other child with his ear on the opposite end. Excitedly, Laennec hurried to the bedside of his patient with a cylinder of tightly rolled paper tied with string and found that by placing this instrument between his ear and the patient, he could hear heart sounds more clearly than ever before. It immediately occurred to him how useful this method might be in studying all movements produced in the thorax—breath sounds, voice, wheezing, pleural and pericardial effusions.[23]

Laennec called the new method "mediate auscultation," "auscultation" for the method in its direct form begun by Hippocrates, and "mediate" for the interposed instrument. The term "auscultate" originated from the Latin "ausis," to hear, and "culto," to cultivate, and meant to give attention through hearing.[24] Laennec named his tool the "stethoscope" combining "stethos" meaning chest and "scope" from the Greek word meaning to examine. Other names initially applied to the invention included "a pectoriloquy," "medical trumpet," "the cylinder," or "the tube."[25]

Laennec and everyone else at the Necker Hospital began experimenting enthusiastically with the tube. He varied the length, width, and central hollow, and decided upon a one-foot cylinder with a quarter inch central space which he accidentally found to be necessary for listening to the voice. A solid cylinder, he discovered, would suffice for heart sounds, breath sounds, and rhonchi; however, breath sounds and rhonchi were augmented with the central hollow plus a cupped shape carved at the end. Many materials were tried—"ebony, cedar, malacca cane, lime wood, glass, various metals, . . . gold-beater's skin . . . ."[26] He even used his

cousin's oboe but finally decided a light beechwood was his preference.[27]

Early in 1818 Laennec, having collected his preliminary observations, demonstrated his new method and instrument to the Société d'École. Though he thought it was premature to publish his findings, he felt he should speak for his work as others were mentioning his invention in various publications. At this time he had recorded an outline for his book and was experienced in separating normal from abnormal chest sounds. In the same year he presented his findings to the Académie Médecine, which appointed a commission for study of the method. Laennec continued to accumulate data and propose new applications for the stethoscope. A key case was that of Madame de Châteaubriand who had recurrent hemoptysis and had been diagnosed by a previous consulting physician as a consumptive in the terminal stage. Laennec, finding no signs of cavitation by stethoscope, confidently diagnosed bronchiectasis; Châteaubriand lived to age 75.[28] This differential diagnosis was encountered now and then and was important to the patient as it made the difference between a life or death prognosis.

In attempting to expand his method's application, Laennec reportedly suggested a means of helping deaf-mutes.[29] He also, on occasion, extended his professional career to include auscultating animals. During his countryside vacations which he took only to convalesce from exacerbations of tuberculosis, he was seen auscultating his dogs, "Kiss" and "Moustache."

In April 1819, he delivered to the publisher the final product of his labors, *De l'auscultation médiate, ou Traité de Diagnostic des maladies des poumon et du coeur fondé principalement sur ce nouveau moyen d'exploration;* also known by the shorter title, *Traité de l'Auscultation Médiate.*[30] To provide the editor with an ample supply of stethoscopes to sell with his book, Laennec spent countless hours at his lathe meticulously making the wooden instruments. The book was ready for sale in August 1819 for 13 francs; and the stethoscopes sold for three francs each.[31] A further edition of his book followed in 1826.

Laennec's stethoscope flourished in many countries: England, where consumption was raging, Germany, Italy, Spain, Holland, Sweden, Russia, Poland and even across the Atlantic in America. About 35 years after its discovery, a binaural model was designed by George Philip Camman of New York. Other varieties refining the original were developed from time to time including the modern diaphragm type.

Laennec's New Signs

Laennec described most of the stethoscopic signs used in modern medicine; not only did he describe them, but as an experienced pathologist he was able to correlate them with autopsy findings, distinguishing numerous conditions including tuberculosis or pulmonary phthisis as it was called then, bronchitis, bronchiectasis, emphysema, asthma, pneumonia, and pleurisy. Here are some of the signs Laennec left to medicine:

Aegophony. Greek aix or aegis = goat + phone = sound, sound similar to the bleating of a goat; heard at the upper border of an effusion.

Amphoric resonance. Latin amphora = a jar, also has Greek derivation, sound resembling that heard when blowing into an open bottle; indicates cavity.

Bronchial respiration. Greek bronchos = windpipe, Latin similar, sound heard over larynx, trachea, large bronchi; increased in pneumonia and dilatation of bronchi.

Cavernous respiration. Latin caverna = a cavern, similar to amphoric breathing, hollow sound; indicates cavity.

Crepitant râles. Latin crepitus = little noises, crackling; pulmonary edema.

Metallic tinkling. Sound as made by sand falling into metal cup; indicates cavity.

Pectoriloquy. Latin pectus = breast + loqui = to speak, voice sounding very close to ear through stethoscope; sign of cavity.

Pleural friction. sound resembling rough surfaces rubbing together; heard in tuberculous pleuritis.

Puerile breathing. Latin puer = boy, respiration heard in child, sonorous with marked inspiration.

Râles. French râler = to rattle, crackling sounds; Laennec described them as moist or crepitant, mucous or gurgling, dry or sonorous (snoring), dry sibilant (whistling); heard in multiple situations depending on character.

Rhonchus. Greek word—snoring, Latin rhonchus = snoring, sound heard in many conditions—pneumonia, tuberculosis, bronchitis . . . .

Vesicular respiration. Latin vesicula = little bladder, breath sounds heard over normal lung fields except over trachea and mainstem bronchi.[32]

The Test of Time

Most of the signs Laennec discovered with his stethoscope have remained important to the modern physician. Some are more frequently used than others; for instance, vesicular and bronchial breath sounds, râles, rhonchi, pleural friction rub, and aegophony. Those signs associated with cavitary disease, however, are less often encountered because of the decline in advanced pulmonary tuberculosis, specifically amphoric or cavernous breathing and pectoriloquy. Two terms have wider clinical application than realized by Laennec: aegophony, heard above pleural effusions, is sometimes found in consolidation; pectoriloquy can be used to detect early pneumonia, atelectasis, and infarction.

Yet another method of chest diagnosis has come to be used since Laennec—the X-ray. With the X-ray the physician has been able to look into the chest and actually see pathologic changes. It enables him to confirm with his eyes what he has heard with his ears and also to detect lesions not producing stethoscopic findings. Even so, the stethoscope remains the most convenient and the quickest method of forming diagnostic impressions, determining the need for further diagnostic work-up, and clinically following disease processes in the chest.

Laennec's auscultation has survived the test of time, and along with Auenbrugger's percussion has become a permanent part of systematic chest examination. The chest and its diseases which for so long were mysteries to the clinician began to be solved with these methods. After Laennec, vast numbers of books on chest disease appeared. Though Laennec did more to elucidate pulmonary than cardiac disease, his invention cleared the way for Corrigan and Stokes of the Irish School to make further advances in the realm of cardiac and pulmonary diseases. Thus, the coincident establishment of percussion and auscultation by the French School has certainly been among the greatest milestones in physical diagnosis, adding two new methods to chest examination and offering new frontiers for the clinicians who followed.

As a final note, new uses may be found for auscultation. A recent author described a new variation combined with carotid phonoangiography. It consists of auscultating bruits with a special microphone connected to an oscilloscope.[33] These bruits are recorded graphically and evaluated in terms of percentage stenosis. This is one non-invasive means of determining which patients with transient ischemic attacks would benefit from caroted arteriography. Thus, auscultation, used in its traditional form with the binaural stethoscope, has developed new applications which may expand further in the future.

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