

# The history of diagnostic technology for diseases of the lungs

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We can see the precise state of things within. John Forbes<sup>1</sup>

I admitted a frightened 59-year-old woman in the same week I was asked to write this article. She had dyspnea and severe right chest pain. Percussion revealed dullness, and auscultation revealed poor breath sounds on the right side. A spirometer measured a marked loss of vital capacity. Her chest radiograph showed opacification of the right hemithorax, but how much of this was consolidation, pleural effusion and collapse was unclear. Bronchoscopy did not help. Thirty-five years ago we would have proceeded to an exploratory thoracotomy at which I, as the intern, would have held the retractor. The result would have been what patients with cancer dread — open and close surgery. With the ease of today's modern technology an ultrasound-guided pleural tap identified cancer cells, and a computerized axial tomography revealed the underlying carcinoma. Palliative care was promptly arranged.

The investigation of this case was made possible by 200 years of technological advance in the diagnosis of thoracic disease. This historical survey of the development of 3 of those technological advances — the stethoscope at the beginning of the 19th century in France, the spirometer at mid-century in England and x-ray imaging at the close of the century in Germany — will also reflect on how readily new technologies are accepted into medical practice and how, once they are accepted, they may influence the nature of the doctor-patient relationship.

From antiquity to the end of the 18th century the diagnosis of internal disease, apart from a few notable exceptions such as Hippocrates' succussion splash, was dependent upon an analysis of what the patient described to the physician. Edinburgh's William Cullen, a leading clinician of the era, even provided consultations and diagnoses based on self-reported symptoms described in letters.<sup>2</sup> His skill lay in his interpretation of the symptoms reported; he carefully considered patients' accounts and reassured them with tact and compassion.

All was to change in Cullen's lifetime, as modern medicine emerged from the intellectual ferment of the French revolution. The doctrine of diseased organs, through the revelations of the pathologists Morgagni and Bichat, replaced the classical concepts of illness enshrined in the corpus of Hippocrates. Physicians strove to identify the abnormalities of the body using all of their senses. Looking, listening and palpating were supplemented with such things as sniffing for putrefaction and tasting, for example, urine for sugar. The physical examination, at least of men, became the hallmark of a good consultation.<sup>3</sup>

Listening advanced medicine the most. In 1761 Auenbrügger described the use of percussion to detect pleural effusions.<sup>4</sup> He recommended that for percussion to succeed the physician wear a glove of unpolished leather "for the naked hand and chest alters and obscures the natural character of the sound." Auenbrügger's monograph was vague and lacked corroborating pathology. Percussion was ignored until Corvisart proclaimed its value in 1806.<sup>5</sup> Percussion and listening directly to the chest, direct auscultation, quickly led to advances in the diagnosis of heart and lung disease.

A decade later Laënnec cemented the value of this technology when he exploited the physical properties of sound transmission. When faced with the need to listen to the heart of a plump young lady he recalled that the sound waves generated by a fallen pin are carried better by a solid beam than they are by air. He placed tightly rolled paper between his ear and the chest wall, and thus was born the stethoscope.<sup>1</sup>

Both percussion and auscultation were subjects of considerable experimentation. To reduce the variability of percussion Piorry invented a pleximeter which was to be struck with a small hammer.<sup>6</sup> He tried using lead, leather, horn and wood but finally decided to use a small ivory disc. Laënnec also experimented with various materials to improve the acoustic properties of his cylinder. Eventually, after determining that metal and glass were too heavy and cold, he settled on a medium wood, favouring rattan. Having tried



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[Table of Contents](#)



the stethoscope cylinder with and without a central canal, he concluded that a canal enhanced respiratory sounds, but for cardiac sounds the canal should be occluded.<sup>7</sup> In due course, however, it became clear that the stethoscope functioned better with air in its lumen. Soon this instrument became as symbolic of a physician as the Aesculapian staff.

This new technology was received slowly into general medical practice. Although the stethoscope was for sale in London within a year of the release of Laënnec's book, it was as late as 1834 before it was regularly used in medical practice in England, even in such a prestigious teaching hospital as Guy's Hospital.<sup>8</sup> In 1885 Cammam introduced the modern binaural flexible model, which was designed for comfort, not improved acoustics. This new model required less pressure on the patient's skin, and using it was easier on the physician's posture.<sup>9</sup>

Today these simple acts associated with the physical examination are part of the "art" of medicine; it is overlooked that they represented the science and technology of the day. Reflecting on computer technology and the fact that writing is a technology that is now taken for granted Weiser suggests that "the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life."<sup>10</sup> The main disadvantage of the stethoscope was that its value depended much on the skill and experience of the physician.

In the mid-19th century in England, the crucible of the Industrial Revolution, another invention that showed promise for diagnosis appeared. Physician Thomas Beddoes, engineer James Watt and scientist Humphrey Davey were pioneers in the study of the lungs' volume at the Pneumatic Institute, but they did not apply their research to diagnosis.<sup>11</sup> In 1844 Hutchison used a spirometer to measure the vital capacity of the lungs, and he used these measurements for the diagnosis of lung disease. He calculated predictive values based on the lung capacities of 1200 men and showed that a fall in vital capacity could indicate pulmonary disease before audible signs could be detected with a stethoscope. This technology permitted "doctors, whether able or inept, to make accurate judgements. No exquisite sensory training was required to obtain or understand its data."<sup>12</sup> In 1866 Salter added the kymograph to the spirometer to record time as well as the volume obtained; he stressed the objectivity of this new technology and implied that for physicians, seeing is believing. He wrote of his tracings, "They will have the same kind of value as a photograph. ... The lines will not be 'doctored' whatever the patient may be. There will be no disputing them; it will be impossible to say that they are the result of imagination or error."<sup>13</sup> However, this easy-to-perform, accurate and sensitive technology never really caught on. Spirometry was not used in regular clinical practice until the 1950s, following Gaensler's influential paper on the topic.<sup>14</sup>

By the end of the 19th century, because of state investment in education and research, Germany had become one of the leading countries in the study of medicine. In 1895 the physicist Roentgen reported his discovery of x-ray imaging, and on New Year's Day 1896 he exposed the bones of his

wife's hand. His discovery was widely and rapidly publicized. An x-ray image soon appeared in the *BMJ*.<sup>15</sup> The physician could now truly see inside the body; even the least skilled would have to believe what was revealed on the x-ray film. The value of this new technology in fracture detection was soon established; it replaced the old technology of listening to the crepitus of the broken bones with a stethoscope.<sup>16</sup> Crepitus was painful for the patient, and this new technology was pain free. (The hidden risks of radiation were not yet recognized.) Demonstrations of radiographs became common at meetings, but it was quite some time before the x-ray imaging became standard practice. Although chest radiographs of pleural effusions were reported as early as 1896,<sup>17</sup> 23 years later Sir William Osler was operated on for empyema by physicians who were confident in their skills of percussion and auscultation, and there were no radiographs taken before his surgery.<sup>18</sup> As late as 1920 only 83% of the patients with fractures at the New York Hospital had x-rays images taken,<sup>19</sup> and it was 1945 before the Royal Society of Medicine in England at last concluded that the radiograph was superior to the stethoscope for diagnosis.<sup>20</sup> They then debated whether every physician should be taught to read the films or whether they should rely on the opinion of an expert radiologist.<sup>20</sup>

Thus, 19th-century medical technology was founded on the principles of physics and applied after considerable experimentation. The technology advanced the ease, accuracy and acuteness of diagnosis. New techniques were publicized promptly and were soon widely available, but it took many years for them to become routine medical practice.<sup>8,14,17,19,20</sup> History suggests that older physicians adapt more slowly to new technologies, possibly because they feel competent in their diagnostic skills and experience has made them confident in their craft. For example, Cullen expressed his doubts about the usefulness of percussion in 1784 when he wrote, "How far the method proposed by Auenbrügger will apply to ascertain the presence and quantity of water in the chest I have not had opportunity to observe."<sup>21</sup> An inherent mistrust of new technology, as described by George Eliot in *Middlemarch*,<sup>21</sup> is seen when the young hero Lydgate, who used the stethoscope, was suspected of "a certain showiness to foreign ideas" by conservative physicians in his community.

Younger physicians with less experience may not be as adroit in diagnosis and are thus attracted to new and simpler methods. Although a picture or graph seems more accurate and believable, an astute clinician may still have rejected them. When I was an intern an influential cardiac surgeon backed clinical acumen over an angiogram with the justification that an x-ray image was simply a shadow photographed in the dark!

It is evident that technology has improved the sensitivity and specificity of diagnosis. However, it has also affected the nature of the doctor-patient relationship.<sup>19,22</sup> It was once thought that technology might lead to a breach of the Hippocratic tradition of confidentiality. It necessitated that the physician would collaborate with an ever-increasing range of professionals, and the reports that they produced



would circulate through the system. With the advent of these new technologies people also worried that on-lookers might have access to their innermost secrets. An excerpt from *The Lancet* in 1829 expressed concern that the stethoscope could lead to eavesdropping.

Auscultation Extraordinary.  
Quoth Rodrick I'll a place contrive  
So dark and safe, no man alive  
Shall to our private meetings grope  
Egad, cries Johnny, that won't do,  
If there's no crack to listen through  
They'll make reports by stethoscope.<sup>23</sup>

More threatening, however, was x-ray technology with fears that voyeurs would use it to inspect the naughty bits of the modestly dressed. The following appeared in *Punch* within a month of the debut of x-ray imaging:

We only crave to contemplate  
Each other's usual full-dress photo,  
Your worse than "altogether" state  
Of portraiture we bar *in toto*!<sup>24</sup>

People were disturbed by the thought that the x-ray image revealed one's inner self. A patient's reaction to it is unveiled by Thomas Mann.<sup>25</sup> When Hans Castorp saw his own skeleton on an x-ray film, "he gazed at this familiar part of his own body, and for the first time in his life he understood that he would die."<sup>25</sup>

There was the risk that new technologies would distance the doctor from the patient — that technical terminology would hamper conversation and become a barrier. As Furst states, "the spoken language is the most important tool in medicine."<sup>26</sup> At the bedside physicians in Laënnec's generation used Latin to discuss the patient's condition in an attempt to protect the patient from unpleasantness. Today, although we believe in fostering communication with patients, the nomenclature of modern medicine (often acronyms) is easily incomprehensible to the layperson. The swiftness with which new technology provides an accurate diagnosis ought to have freed the physician to spend more time attending to the patient's concerns and fears. Yet some feel that it has encouraged physicians to dwell on the mechanical aspects of the disease and neglect the patient; the primary physician too often becomes a mere conduit for reports of experts who have never had contact with the patient. Thirty-five years ago Godber, chief medical officer in Britain, warned, "But though mechanical aids and measuring devices extend the capacity of the doctor to serve the patient, they do not replace him. They are the adjuncts to the human relationship between doctor or nurse and patient; they cannot replace the art."<sup>27</sup> To some extent physicians have lost confidence in the old way of doing things at the bedside; they may feel unscientific if they simply talk to patients. Nevertheless, most patients are not fully satisfied unless they have had a chance to communicate with their physician and understand the information that has been given. It is fitting that the epigram of

the biography of the skilled diagnostician Dr. Johnathan Hullah is this quote from Robert Burton, "The body's mischiefs, as Plato proves, proceed from the soul; and if the mind be not first satisfied, the body can never be cured."<sup>28</sup>

Technology has enabled us to see, promptly and painlessly, the precise state of things within, and it has led to accurate diagnoses and more appropriate treatments. At the same time, however, history demonstrates that it takes time for new technologies to be adopted into common practice, and there is always the risk that it will subvert the personal touch that is pivotal to the miracle of medicine.

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