The Journal of
OBSTETRICS AND GYNECOLOGY of India

J Obstet Gynecol India Vol. 59, No. 6 :November/December 2009 pg 535-536

Milestones

Christian Doppler and the study of waveforms and blood flow patterns

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The cardiovascular system and the circulation of blood in the human body has been a subject of study since time immemorial. The earliest medical writings are found in the Ebers papyrus, an ancient Egyptian document dating back to the 16th century BC. Shushruta described the presence of blood channels in the human body. Greek and Roman scholars were confounded by the nature of blood flow and the circulation and the middle ages were mired with confusion. In 1628, William Harvey established the relationship between arteries and veins and he argued that a beat of the heart produced continuous circulation of blood through capillaries [1]. It should be noted that all the studies until then were conducted on cadavers, animals and humans under anesthesia during surgeries. There was no method of studying the intact circulation by non-invasive means. The fetal circulation could not be studied by X-rays for the fear of radiation. It was only after ultrasound was introduced in medical practice by Professor Ian Donald, that the study of the maternal and fetal circulation was conceptualized. The principle on which the study of blood flow rests is the Doppler effect.

Figure 1. Professor Christian Doppler.

Christian Doppler came from a family of master stonemasons who had a successful business in Salzburg since 1674. He was born on 29 November 1803 in the family house in the Hannibal Platz 1 (now Makart Platz 1). The neighbourhood is also well known for being the birthplace of the musical genius, Amadeus Mozart. There is some controversy about Doppler's complete name. His baptismal certificate is in the name of Christian Andreas Doppler, while his gravesite says Christian Johann Doppler. What is not controversial is that Christian Doppler showed mathematical acumen from his early days in primary school. He studied in Vienna and was a mathematics and physics graduate at the young age of 21 years. He pursued further studies in mathematics, mechanics and astronomy at the Vienna University of Technology. He worked at the University under Professor Adam von Burg and wrote the first of his 51 scientific papers in 1831. Inspite of his work, he was not able to get an academic position. He even supported himself by working as a bookkeeper in a cotton factory. At this time he was close on giving up and had started preparation to migrate to the USA. In 1835 he had sold his possessions and had reached Munich when he eventually was offered a position as professor of elementary mathematics and practical geometry at the State Secondary School in Prague. The following years were very strenuous. Besides research his position also included a heavy burden of teaching, and Doppler had to spend countless hours in cramped, unhealthy and crowded lecturing rooms. His contemporaries believe that it was during this strenuous time he contracted the tuberculosis which was to take his life [2].

Things took a turn for the better in 1841. He was working on a number of subjects including waveforms. He was known to be an intuitive thinker. His thought process and methods were not always easy to follow but the work that he produced was simple and lucid. In 1842, at a meeting of the Royal Bohemian Society in Prague, he presented the work that was to make him world famous: "On the coloured light of double stars and certain other stars of the heaven"[3]. He elucidated the principle which relates the frequency of a source to its velocity relative to an observer. This was applicable to sound and light waves. Although it was not possible to study light waves at that time, the situation with sound was rather different. As early as 1845 experiments were conducted with musicians on railway trains playing instruments and other trained musicians writing down the apparent note as the train approached them and receded from them. In 1846 Doppler published a better version of his principle where he considered both the motion of the source and the motion of the observer.

In 1847 he left Prague for the professorship of mathematics in Schemnitz (Banská Štiavnica). Unfortunately, the revolution broke out in 1848 and he had to flee to Vienna. Recognizing his abilities, Emperor Franz Joseph appointed him to a specially created professorship of experimental physics at the Royal Imperial University of Vienna. (Figure 1). His students included Mendel, who studied physics and later became the father of modern genetics. In November 1852, he was forced to take leave and went to Venice to regain strength. His condition worsened and on the morning of March 17 1853, Christian Doppler died in the arms of his wife, Mathilda.

The Doppler principle found a number of applications in modern science. The one of interest to medicine and obstetrics in particular was the marriage of this principle to ultrasound. Shigeo Satomura and his Japanese team were the first to demonstrate its application in retrieving heart signals in 1955. Further refinements by Japanese and later American scientists allowed the Doppler effect to be developed further. Today, we are in a privileged position today to study the blood flow and circulation in the smallest and remotest of fetal and placental vessels with these techniques.

References

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