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Concepts in cardiology - a historical perspective

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Abstract

Our current knowledge of the anatomy and physiology of the circulatory system has been reached by deduction and reasoning over several centuries. In this article, we briefly outline the history of these theories.

MeSH: History of Medicine, Heart defects, congenital, Cardiology/history, Portraits

Disease is as old as life itself. Primitive man associated natural disasters, including ill-health, with superstitious concepts, and considered the birth of obvious congenital malformations as major supernatural events. Congenital malformations have been described since early times. Primitive man's interest in these phenomena has found expression in drawings, carvings and sculptures throughout the world, including Australia, the South Pacific Islands, and the Americas. Less obvious malformations, such as congenital heart disease (CHD), were less likely to be noted.

Primitive man as early as circa 30,000 years ago was almost certainly aware of the life-driving force of the heart. In 1908 Abbe' Breuil, the father of the study of prehistoric art, sketched in red chalk the mammoth drawn by Aurignacian man in the cave of Pindal in Northern Spain. This 16.75 × 17.5 inch drawing was noted by Breuil to have "A broad, almost heart-shaped spot, placed in the middle of the body". He first believed this to indicate the flap of the ear, but later objectively described the infill as "A broad red spot covers the place where the heart should be situated".[1] Generally assumed to be a depiction of the heart which the hunter had to aim for, the Aurignacian drawing indicates primitive man's knowledge of the vital role of this organ in sustaining life.

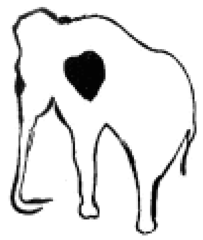

Figure 1: Abbe' Breuil's reproduction of a mammoth from a cave drawing

The earliest written records of congenital malformations, in the form of clay tablets, have been passed down from Babylon from the Royal Library of Nineveh, which was assembled by the Assyrian King Asshurbanipal (c.700 BC). These tablets, which date back to 4000 BC, include a list of sixty-two human malformations with their associated prophetic implications.[2] Ectopia cordis was included in this list, and it was believed that "when a woman gives birth to an infant ... that has the heart open and that has no skin over it, the country will suffer from calamities".

The Greek philosophical movement of the Classical Period brought a new outlook to medical thought, shifting the emphasis from magico-religious concepts to a more empirico-rational view. This movement was pioneered by the Greek physician Hippocrates (460-375 BC). Hippocratic medicine explained disease as 'isonomia', an excess of one of the four humors or fluids that comprised the body - the humoral theory (see table below). This theory eventually led to treatment regimens such as blood letting aimed at restoring the humoural balance.[3]

Humor	Associated season	Associated element	Excess causes	Asso qu
Yellow bile	Summer	Fire	Choleric	Hot
Black bile	Autumn	Earth	Melancholic	Cold
Phlegm	Winter	Water	Phlegmatic	Cc m
Blood	Sping	Air	Sanguine	H m

Figure 2 Hippocrates

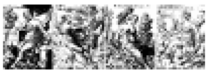

Figure 3 Temperaments associated with humors

Figure 4 Aristotle contemplating a bust of Homer (Rembrandt)

For the ancients, the functions of the heart and blood vessels were a great mystery. Alcmaeon of Croton, a Greek (circa 500 BC), suggested that sleep was caused by blood draining from the brain via the veins, and that death was the result of the brain becoming completely drained. Two hundred years later, Aristotle (384-322 BC) ascribed the power of thought to the heart, which he contended also contained the soul. He also is credited with the earliest observations of normal cardiovascular function by describing the fetal pulsations in a chick embryo. After the death of Hippocrates, medical thought and practice centred on Alexandria where the first great medical school of antiquity was set up. The study of the human body reached its full development with human dissection being permitted. The original writings of the chief thinkers of the Alexandrian School have not been preserved, but scrappy and imperfect knowledge has been afforded by later Roman writers including Pliny, Celsius and Galen. The two most distinguished names of the Alexandrian School included Herophilus and Erasistratus.

Herophilus of Chalcedon (circa 280 BC) was considered by Pliny to have the honour of being the first physician “who searched into the causes of disease”. A pupil of Praxogaras he was the first to restrict the pulse to a distinct group of vessels and held that it could be used as an indicator of disease, Herophilus’ most important contribution to clinical medicine was his development of the theory of the diagnostic value of the pulse. Herophilus counted the pulse, using the water-clock for the purpose, and made many subtle analyses of its rate and rhythm. He was influenced by the musical theories of the period (mainly those of Aristoxenus of Tarentum), and from these, he built up a rhythmical pulse lore which continued in medicine until recent times. He realised that the pulse is not an innate faculty of the arteries, but was derived from the heart. He distinguished the pulse not merely on quantitatively grounds, but also qualitatively from palpitations, tremors and spasms, which are muscular in origin. Unfortunately, since the pulse doctrine of Herophilus was based on musical tenants, it was so complicated that only a skilled musician could possibly understand it, and this the theory failed to gain ground[4].

Figure 5 Herophilus of Chalcedon

Erasistratos of Iulis (250 BC) elaborated the view of the pneuma, one form of which he believed came from the inspired air, and passed to the left side of the heart and to the arteries of the body. It was the cause of the heart-beat. Erasistratus argued, that intaken breath entered the arteries, which thus carried nothing but air.[4] This erroneous view was maintained for almost four centuries.

It was disproved by Claudius Galenus (AD 129-201) who showed by experiment that arteries carried blood and not air. He studied the actions of the heart, the heart valves, and the pulsations of arteries. Galen also noted the structural differences between arteries and veins but did not realise that blood circulated. He believed that blood was produced by the liver which sent it to the periphery of the body in order to form flesh. He was also the first to attempt to explain the function of the arterial duct and the foramen ovale[5]. Galen subscribed to the humoral theory of bodily fluids, but he also believed that sickness could arise from an insufficiency of one of the four humours, and not only from an excess, a guiding principle of Galenic medicine. Galen also believed that life was sustained by food, which was converted into blood by the liver and sent to the rest of the body for nourishment. Galen also believed that blood was used in the removal of wastes. Galen was thus the first to suggest a relationship between food, blood and air. Medical and church authorities considered Galen's work to be based upon divine inspiration and therefore infallible, dubbing him Divinus Galenus.[4,5]

Figure 6 Claudius Galenus

Galen's views were to hold sway for several centuries until the birth of modern science during the Italian Renaissance in the 15th and 16th centuries. During this important period, medical knowledge was promulgated through the translations of many ancient works, such as those of Hippocrates and Galen. The move towards the study of human anatomy by secret dissection which had been previously shackled by the infallibility ascribed to Galen's doctrines based on animal studies, also helped open new horizons in pathological anatomy. In 1513 the artist and scientist Leonardo da Vinci (1452-1519) drew and described a case of atrial septal defect. Leonardo also subscribed to the Galenic theory of flux and reflux through the veins.[5]

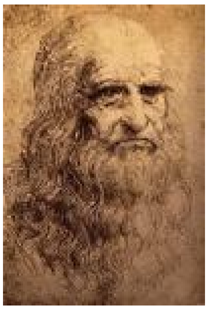

Figure 7 Leonardo da Vinci (self portrait)

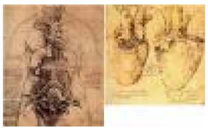

Figure 8 Anatomical drawings of the circulatory system and the heart by Leonardo

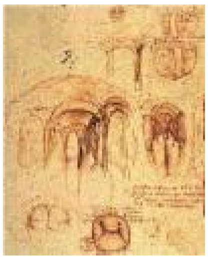

Figure 9 Drawing of the mitral valve

The study of human anatomy freed itself completely from the shackles of Galenic theory by the publication in 1543 of the first complete textbook of human anatomy by Andreas Vesalius (1514-1564). Vesalius proposed that the heart was the centre of the vascular network, and believed that the pulmonary veins carried air from the lungs to the left atrium[6]. Vesalius' monumental work opened the doors to further advances.

Figure 10 Andreas Vesalius

Michael Servetus (1511-53) was a Spanish physician who held certain religious beliefs views, particularly with regard to the Holy Trinity, that brought widespread condemnation from theologians both of the Reformation and of the Roman Catholic Church. He changed his name to Michel de Villeneuve, and spent some time in Paris studying medicine, where he became famous for his dissecting and medical abilities. He also discovered that some of the blood circulates through the lungs. Servetus was burned to death, in part for publishing his views against the doctrine of the Trinity. The execution was approved by Martin Luther, John Calvin, and Sir Thomas More.

Realdus Colombus (1516-1559) also showed that the pulmonary veins carry blood, not air[5] and Hieronymus Fabricius ab Acquapendente (1533-1619) described valves in veins, recognising them as general structures in the venous system and calling them little doors “ostiola”.[4,7]

Figure 11 Hieronymus Fabricius ab Acquapendente

The English physician William Harvey (1578-1657) finally elucidated the system of blood circulation. Harvey showed experimentally the function of valves in maintaining centripetal flow in veins, thus establishing the true concept of a circulation propelled by the heart, and refuting the hallowed theories of Galen, laying the foundation for modern physiology.[8] Harvey also proposed the existence of capillaries, which would link arterial and venous systems, but was unable to demonstrate the capillary network due to the lack of a microscope.

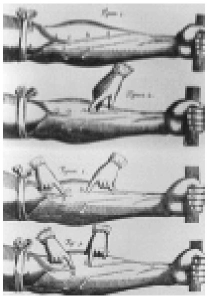

Figure 12 Illustration from: Exercitatio anatomica de motu cordis et sanguinis in animalibu

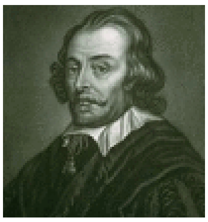

Figure 13 William Harvey

René Descartes received Harvey's doctrine regarding the circulation of blood positively but with reservations in 1637. A mechanist by profession, Descartes viewed man as a machine, and Harvey's ideas about the circulation of the blood fitted his mechanical concepts. Descartes however did not believe that the heart contracted, but rather that it expanded. He believed that the heart acted as a furnace; heating up the blood until it was gaseous, which re-condensed into a fluid in the cool lungs[4].

Figure 14 René Descartes

The final link to Harvey's concept was made by the discovery of capillaries in frog experiments by Marcello Malpighi (1628-94). Malpighi also demonstrated the existence of red blood cells and showed that they gave blood its colour.

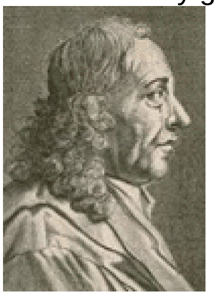

Figure 15 Marcello Malpighi

Malphigi's findings were confirmed and developed by Antoni van Leeuwenhoek (1632-1723), who demonstrated how red blood cells circulated through the capillaries of a rabbit's ear and the web of a frog's foot. In 1674, Leeuwenhoek gave the first accurate description of red blood corpuscles.

Figure 16 Antoni van Leeuwenhoek

The 17th century also saw a revival of interest in CHD. Several congenital cardiac malformations were described, including Fallot's tetralogy described by Steno (1638-1686) well before the condition's clinical aspects were emphasized.[9,10] Giovanni Battista Morgagni (1688-1771) whose De sedibus et causis morborum per anatomen indagatis (1761) is one of the great books in medical literature, described ventricular septal defect and single ventricle heart.[11] From the 19th century, various detailed descriptions of CHD began to be published, and the first book dealing with the full spectrum of CHD was published in 1858[12] leading to today's understanding of the pathophysiology of the numerous lesions which comprise CHD.[13]

Figure 17 Giovanni Battista Morgagni

The era of premortem diagnosis of congenital malformations began with the discovery of auscultation by Rene' Theophile Laennec.[14] Before Laennac, the examination of a patient had been largely by sense of sight, supplemented by that of touch, as in estimating the degree of fever or character of the pulse. Auenbrugger's Inventum novum of percussion in internal disease discovered in 1761 re-introduced by Corvisart had extended the field. With the use of the stethoscope, the era of physical diagnosis began.[4]

The early decades of the twentieth century saw the increasing acceptance of technological methods of diagnosis particularly related to radiology. The early 1930s saw the introduction of effective cardiological investigations with the use of cardiac catheterization.[15] This method enabled an accurate diagnosis to be made which, combined with advances in surgery and anaesthesia, was to initiate operative interventions on the heart and cardiovascular system in the 1940s, primarily with extracardiac procedures such as ligation of a patent duct.[16] Intracardiac operations, initially without and later with cardiopulmonary bypass, began to be undertaken in the early 1950s. Initially however, apart from the correction of simple lesions with relief of stenotic valves or closure of septal defects, only palliation was possible for complex lesions, with operations aiming to augment or reduce blood flow to the lungs in cyanotic lesions and lesions causing heart failure respectively.[17,18] More complex operations were eventually conceived with intracardiac re-routing of blood and the replacement of missing structures by bridging with homograft tubes. This meant that operations began to be less palliative and more curative.

The mid-1960s ushered the next major step with the first interventional catheterizations,[19] allowing the postponement of surgery, and eventually even replacing surgery for certain conditions in the early 1970s. The last decades have introduced computing facilities which have increasingly more massive calculating and storage capacities. These have allowed the introduction of echocardiography, a very computer-intensive imaging technique. This technique has proved to be a diagnostic milestone, eventually striving to replace catheterisation for the diagnosis and follow-up of the vast majority of congenital cardiac malformations.[20]

Advances in diagnostics and physical intervention were paralleled by pharmaceutical progress which have followed a better understanding of the inherent physiology of cardiac function. Diuretics and inotropes were initially used palliatively, later being used as support until intervention could be carried out. A fine example is that of the introduction of prostaglandins in the late 1970s,[21] which are used to maintain patency of the arterial duct in duct-dependent CHD, allowing transportation and surgery to be carried out prior to death from cardiovascular collapse.

Figure 18 Foxglove (Digitalis purpurea)

The diagnostic and treatment armamentarium available today has given practitioners the means of effectively dealing with the problems arising from cardiac malformations. The new millenium which will no doubt see further innovative developments. It is only fitting that the basic groundwork done by our predecessors in the previous millenia should be acknowledged. In the words of the leading 14th century surgeon Guy de Chauliac: "We are like children standing on the shoulders of a giant, for we can see all that the giant can see, and a little more".

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