

HISTORICAL VIGNETTES

A Chapter from History

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INTRODUCTION

Measuring blood pressure is standard clinical procedure performed on every adult patient. But, one hardly remembers the person who first conceptualized blood circulation theory or the one who measured blood pressure quantitatively. It is rightly quoted by Johannes Muller that "the discovery of the blood pressure was more important than the discovery of the blood." Through his profound experiments, William Harvey was the first person to correctly describe blood's circulation in the body. He showed that arteries and veins form a complete circuit. The circuit starts at the heart and leads back to the heart. The heart's regular contractions drive the flow of blood around the whole body. Harvey made his discoveries by ignoring medical textbooks and preferring his own observations and the deductions he made during dissections of animals. Harvey published his masterpiece in 1628 – referred to as *De Moto Cordis* – the Motion of the Heart. This revolutionary concept of blood circulation encouraged physicians and physiologists for developing techniques of blood pressure measurement. It took almost 100 years to discover blood pressure measurement technique by Reverend Stephen Hales in 1733.

Stephen Hales, an English clergyman, had creative and inquisitive mind that led to crucial findings in science. His interest in scientific experiments first came to public notice when he read a paper to the Royal Society concerning the effects of the sun's rays on the rising sap in trees. He measured "the force of the sap" or root pressure. This was a new technique of measurement in plant physiology and this research was published in "Vegetable Statics." Further, he worked on animal physiology and

became the first person who measured blood pressure quantitatively. The classic experiment (Fig. 1) by which blood pressure was first measured was published in his manuscript *Haemastatics*.¹

In his publication, he wrote: "In December, I caused a mare to be tied down alive on her back. A fistula was placed on her withers ... having laid open the left crural (femoral) 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 of the artery, the blood rose in the tube 8 feet 3 inches perpendicular above the level of the left ventricle of the heart; ... when it was at its full height, it would rise and fall at and after each pulse 2, 3 or 4 inches; ... then I took away the glass tube, and let the blood from the artery mount up in open air, when the greatest height of its jet was not above 2 feet. I measured the blood as it ran out of the artery, and after each quart was run out, I refixed the glass tube to the artery to see how much force the blood was abated; this I repeated to the 8th quart, and then its force being much abated, I applied the glass tube after each pint had flowed out."^{1,2}

Three horses were used in this manner, all of them killed as considered unfit for service. Certainly, it is difficult to believe that he would obtain ethical approval for such experiments today. From one of the horses, he measured the blood lost by bleeding and after adding the



Fig. 1: Artist's impression of Stephen Hales's experiment in which blood pressure was first measured in a horse (Reproduced from *Medical Times* 1944 by kind permission)

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probable amount in the large veins, he estimated the total as five wine gallons. He recognized it as low, remarking that: "There is doubtless considerably more, but it is not easy to determine how much." The jugular pressure in one of the horses he found to be 12 inches when quiet, but this rose to 52 inches when the animal struggled.

Hales went on to measure blood pressure in a number of animals and estimated that the blood pressure in humans would be approximately 7.5 feet, which if converted into millimeters of mercury corresponds to a systolic pressure of 176 mm Hg.

Hale's another distinguished finding in animal physiology was calculation of cardiac output. For calculation of cardiac output, he filled the left ventricle of a dead horse heart with warm beeswax, which was then cooled and solidified. Heart muscle was then cut away and volume of ventricle was measured (160 mL). Cardiac output was found to be 61 per minute as the heart rate was 36 beats per minute. He also introduced the concept of peripheral resistance, vascular diameter estimation, and resistance across the vascular tree. Owing to his remarkable contribution in modern cardiovascular physiology, he was considered as the "Father of Hemodynamics."

Extensive research was done later, to measure blood pressure accurately. Until 1855, arterial puncture was a prerequisite for measurement of blood pressure with the available apparatus. Samuel Siegfried Karl Ritter von Basch and Potain made substantial contribution for the development of instruments for noninvasive measurement of blood pressure. Though the introduction of sphygmomanometer in clinical practice was encouraged by several physicians, the British Medical Journal

held the view that by using the sphygmomanometer "we pauperize our senses and weaken clinical acuity." It was Scipione Riva-Rocci, an Italian physician, who designed the modern sphygmomanometer for noninvasive measurement of blood pressure.³ He proposed use of brachial artery (rather than radial artery) to measure blood pressure as it offers larger arterial size and a more direct continuity with aortic blood pressure. Moreover, he devised pneumatic cuff which allowed exertion of an even circumferential pressure around the artery and thereby avoided overestimation of blood pressure due to the eccentric compression of the more peripheral arteries. Apart from these distinguished features, the instrument was simple to use and so small that it was possible to measure blood pressure at the bedside. The contribution made by Riva-Rocci did not go unnoticed as the American neurosurgeon Harvey Cushing used the instrument in his surgical intervention and made it successful worldwide. The sphygmomanometer which was designed by him required few marginal modifications. His discovery of white-coat effect and blood pressure variability is valid till today despite the implication of more sophisticated methods of measuring blood pressure.

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