Review Article

Review of BP Measurement in Clinical and Research

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Historical perspective of BP measurement

Blood pressure (BP) measurement was first recorded in 1700's by Hales who concluded that it was due to a pressure in the blood [1, 2]. This is his well renowned discovery besides his other experiments on the capacity of ventricles and many other feature of circulatory system. The development of BP measurement was then rather quiet until about a century later. The accurate study of BP started with the introduction of mercury manometer by Poiseuille in 1800's who demonstrated that the arterial pressure was maintained in smaller arteries and that the blood flow through mesenteric bed did not depend on development of the venous change but varied directly with arterial pressure [3]. In the year of 1928, Poiseuille work was recognised when he won the gold medal of Royal Academy of Medicine for his doctoral dissertation on the measurement of BP using mercury manometer that was directly inserted with cannula filled with potassium bicarbonate as anticoagulant into an artery [3]. Later, his invention has enabled Carl Ludwig to develop kymograph, a method to record clinical physiological data including the BP measurements [3].

Before 1855, arterial pressure was determined by invasive means and therefore not clinically approachable [1]. Vierordt postulated that an indirect, non-invasive technique might be used by measuring the counter pressure which would be necessary to cause the pulsation in an artery to cease [3]. The counter pressure is able to be produced by applying adequate pressure from outside the body that compressed the affected artery thus ceased the arterial pulsation. The theory was proved possible by the invention of sphygmomanometer by Samuel Siegfried Karl Ritter von Basch in 1881 [3]. It consisted of a water-filled bag connected to a manometer. The manometer reading was compared to a direct BP measurement via direct catheterization. It was confirmed that von Basch's design is reliable. Later, Scipione Riva-Rocci developed the mercury sphygmomanometer which became the prototype of the modern mercury sphygmomanometer [4].

In 1905, Nikolai Korotkoff made a history when he reported that by placing the bell of a stethoscope over the brachial artery at the cubital fossa, distal to the Riva-Rocci cuff, tapping sounds can be heard as the cuff were deflated which caused by blood flowing back into the artery [3]. The tapping sounds were then named after him, the Korotkoff sound. In an experimental setup, Freis demonstrated that the the first Korotkoff's sound was simultaneous with a very large and abrupt pressure drop from the proximal to the distal half of the arterial segment under the cuff, thus probably caused turbulence and resulting sound [5]. The pressure gradient slowly diminished following further decompression of the cuff and disappears once the flow is laminar.

The first Korotkoff's sound heard was corresponded with the maximum BP which is the

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systolic blood pressure (SBP) and as the cuff was further deflated, the sound disappeared which reflected the diastolic blood pressure (DBP) [4]. This auscultation technique is very reliable and become the standard in the clinical setting until today [1].

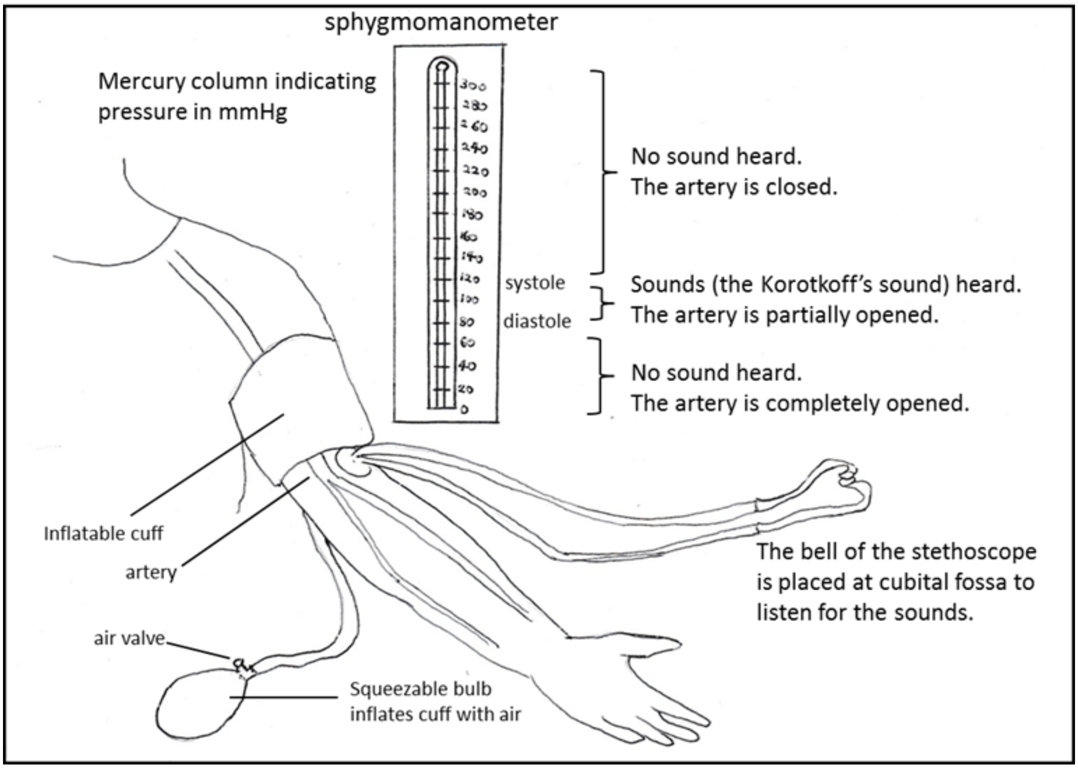


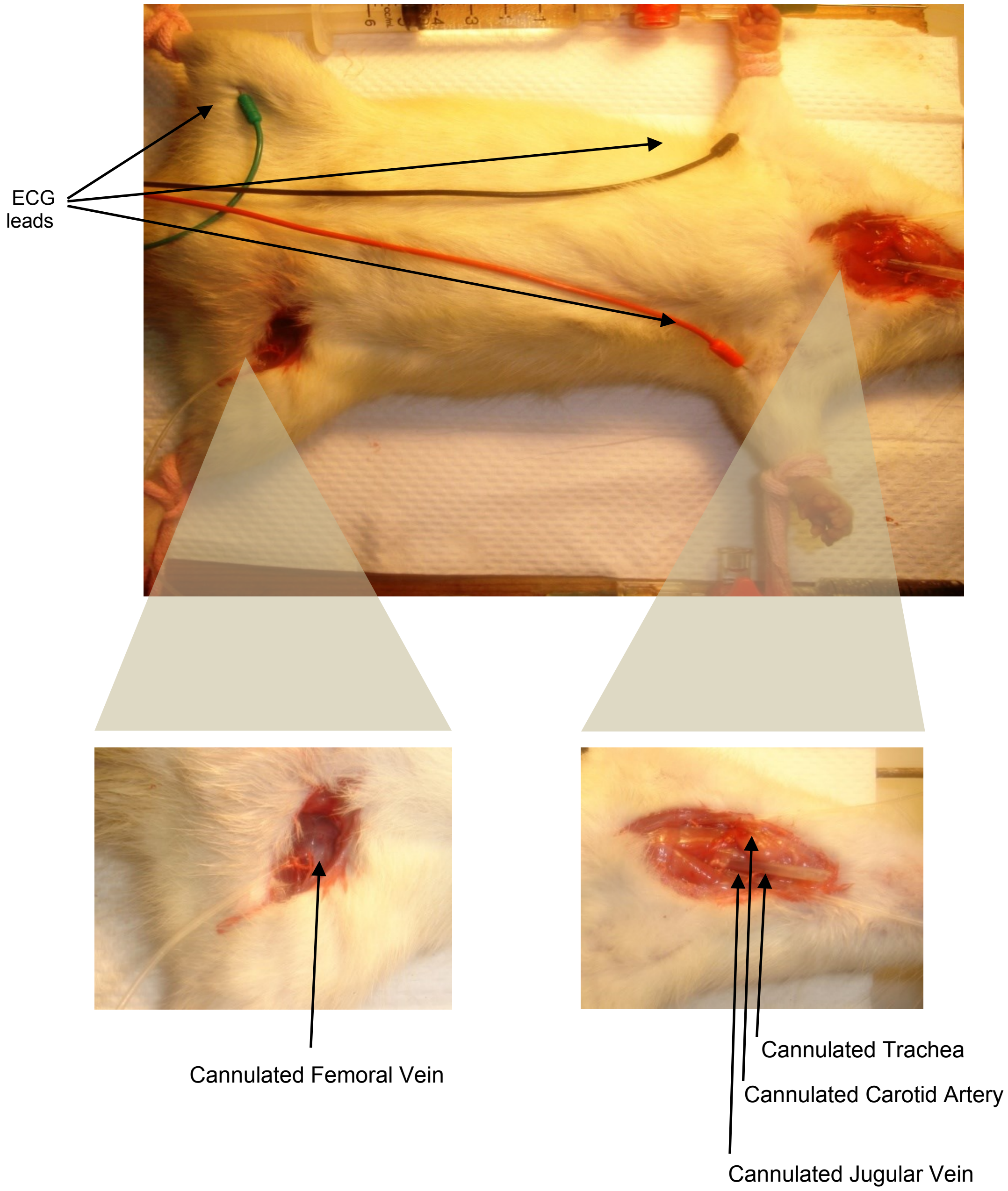
Figure 1: Illustration of theory behind the standard BP measurement

Techniques in measurement of BP

Generally, there are two BP measurement techniques used in the laboratory, the direct and indirect methods. In the laboratory, direct methods are always preferred over the indirect methods due to the ability of direct methods to comprehensively monitor the highly dynamic nature of BP that rapidly changes according to the physiological condition of a subject from time to time [6]. The most commonly used direct method of measurement for research and experimental purposes is the cannulation of the carotid artery of experimental animals while the indirect method is the tail-cuff technique [6].

The direct BP measurement by cannulation, in which the carotid artery is inserted with a heparinized fluid-filled catheter and connected to measuring device, is the oldest and most widely used method of measuring BP [6]. This technique is very versatile and can be used effectively for acute studies in anesthetised animals or for long-term, continuous monitoring of arterial pressure in conscious animals [6]. For chronic studies, the exteriorised portion of the catheter will be housed in a protective sleeve and accessed whenever measurements of BP is needed and for long-term continuous recording, the catheter can be connected to a pressure transducer via a swivel device and tether system that allows relatively free movement of the animal [7].

In the tail-cuff technique, although the animal (rats) were trained and allowed to acclimatise prior to the procedure, this method impose substantial amounts of thermal and restraint stress that are known to affect the BP, HR and stress hormones which will influence the BP reading [8]. Therefore, it is recommended that studies using the tail-cuff technique should be verified by direct BP measurements [9].



Hypertension study

Hypertension is a serious health issue. Although many lines of evidence support the association of aging with hypertension [10, 11], other reports have also shown that hypertension can occur in adolescents [12]. Therefore age is not the main factor for the development of the condition, even though the prevalence of hypertension is much higher in the elderly [13].

In the study of hypertension and investigation of novel hypotensive compounds, experimental setups always involve some invasive procedures that are not suitable for humans and they include intracerebral injections, denervation, nephrotomy [9, 14] and carotid cannulation [15]. Therefore, it is necessary to use experimental animals for studies on hypertension.

The animal models of hypertension share many features which are common to human hypertension. Many of these models have been developed by utilising the etiological factors that are presumed to be responsible for human hypertension such as excessive salt intake, hyperactivity of the renin-angiotensin system (RAS) and genetic factors [15]. Although rats are generally used as models for hypertension [6, 16], other animals such as rabbits, monkeys, pigs and mice have also been employed to produce experimental hypertension [15].

There are several techniques developed to produce animal models for hypertension. One of the most common approaches is through the phenotype-driven technique [17], that was employed in producing the spontaneously hypertensive rat (SHR), which was originally bred from the Wistar rats [18]. The SHR was produced from selective breeding of hypertensive rats [17] and they appeared to have similar pathophysiological features to hypertension in humans [19]. Therefore, SHR is a suitable animal model for hypertension.

As a control to the SHR, the most commonly used normotensive rat, is the Wistar-Kyoto (WKY) rat which was bred from the descendants of the original normotensive strain of the WKY that also produced the SHR [20].

Today, with the advances of technology, the world has witnessed the introduction of automated BP measurement devices that are easy to carry around the invention do not contain medical mercury anymore. It incorporates the engineering technology and the understanding of the Korotkoff's sound in which the machine detects the movement due to change in pressure within the arm area and displayed electronically [21]. Yet, medical practitioners always prefer the mercury sphygmomanometer with stethoscope over the automated one as the readings were more reliable [22, 23]. The use of the modern manometer is therefore limited to home use as monitoring device as it is more users friendly.

In conclusion, the discovery of Korotkoff's sound was a significant breakthrough in the history of BP measurement. Together with the invention of the BP measurement device that were improvised from time to time. The Riva-Rocci creation of the mercury sphygmomanometer was the point that allows us to further understand the BP as it become clinically approachable to detect hypertensive condition and thus start the research quest for its treatment and preventions. Until today, the use of auscultation technique with the use of mercury sphygmomanometer and stethoscope remain the BP measurement technique of choice in clinical settings. It is the gold standard for clinical practice as the BP reading obtained was in agreeable with the direct cannulation technique [24]. As for the experimental purposes, the experimental animals are hard to control. The animals used are affected by the handling and straining technique applied [6], the direct cannulation is the choice rather than indirect methods as it provide more accurate readings as the animals are anaesthetised and therefore, physical stress is not a factor and will not affect the readings.

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