Who was the first to monitor blood pressure during anaesthesia?

The measurement of blood pressure is the single most common clinical examination; its importance in the treatment and prevention of hypertensive cardiovascular disease, and as a predictor of mortality and morbidity cannot be disputed. In acute medicine, such as intensive care and anaesthesia, mandatory blood pressure monitoring has played an important role in improving the outcome. It is fair to say that the progressive advancement in the quality of anaesthesia from its birth 150 years ago to modern times owes a great deal to the vigilant monitoring which includes repeated measurements of blood pressure.

The years 1996 and 1997 have a special importance to anaesthetists: these two consecutive years mark the anniversaries of the introduction of ether and chloroform, and therefore, the birth of the specialty. The inauguration of ether was duly celebrated in 1996 at the 11th World Congress of Anesthesiologists in Sydney, Australia, while 1997 has been marked by the chloroform sesquicentenary [1]. In this atmosphere of celebrations, it seems appropriate to record that 1997 is also the centenary year of the first report on monitoring blood pressure during anaesthesia.

Ether and chloroform became widely used all over the world shortly after their introduction, and remained the only major anaesthetic agents for over 100 years. The mortality associated with chloroform was a matter of great concern, even during the first decade of its introduction. Later, growing concern led to the appointment of a committee by the Royal Medical and Chirurgical Society, who published their report in 1864. This voluminous report mentioned that a haemodynamometer had been used to assess the effect of chloroform on animal hearts during the experiments carried out for the report [2]. This confirms the recognition that close monitoring of the heart during chloroform anaesthesia was a useful observation.

The earliest device capable of recording the pulse was invented during the same decade in which anaesthesia was discovered. A Frenchman had introduced Marey’s Sphygmograph in 1860, and this instrument was improved by many modifications, which soon found a place in clinical practice [3,4]. These novel devices, forerunners of present-day non-invasive blood pressure measuring apparatuses were successfully used by physicians in their clinical practice. Some of the investigations using these devices which were published were well-executed studies in which the actions of various chemicals and therapeutic agents on the heart were investigated and a number of workers obtained the earliest tracings of the pulse.

In 1866, the sphygmograph was used by comparing the difference in the sphygmographic tracings of radial arteries from both sides to monitor and confirm the diagnosis of an aneurysm of the right axillary artery [5]. In 1867, the sphygmograph was again used as a prognostic tool during acute pulmonary consolidation [6]. In another study, the pulse tracings were made during the administration of alcohol, a popular therapeutic agent [7].

Towards the last quarter of the nineteenth century, still better and more reliable devices were introduced so that the pulse recordings could be made both in physiological laboratories and at the bedside. One such apparatus, a real object de art of Victorian engineering, was the Dudgeon Sphygmograph and its improved modification by Richardson, which was capable of marking the time intervals while the pulse trace was recorded on smoked paper [8,9]. Other devices which were classed as sphygmometers are worth mentioning: von Boch’s sphygmometer and Potain’s sphygmometer, both of which were introduced towards the latter half of the nineteenth century [10,11]. These instruments were used not only in France, but also in the UK and America. The sphygmometers were portable, easy to use and reasonably accurate instruments which were widely available and popular among physicians who could conveniently use them.
A SIMPLE AND ACCURATE FORM OF SPIRAEOMETER OR ARTERIAL PRESSURE GAUGE CONTRIVED FOR CLINICAL USE.

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This instrument consists of: (1) A brass armlet, which is strapped round the upper arm. The armlet is fixed at a right angle to a flattened sack of thin indiarubber. The rubber bag is connected by a Y-branch with (2) a small compressing air pump fitted with a valve and (3) a pressure gauge.

The pressure gauge is of special construction. Roughly, it consists of a metal lamour, the expansion of which is exhibited in a highly magnified form by means of an index or pointer which travels round a dial. This dial is graduated in millimetres of mercury. The armlet, pump, and pressure gauge are all fixed at an angle of 90° in the two forementioned limbs of the lamour. The instrument is used thus: (1) The armlet is strapped round the upper arm so that the Y-branch is placed as close to the skin as possible. (2) By means of the pump the pressure is raised within the rubber bag until the pressure indicated by the index of the pressure gauge becomes of maximum excursion. (3) At this point the index is fixed and the bag is sucked up at the two forementioned limbs of the lamour. The pressure indicated by this bag is the mean arterial pressure. The armlet can be applied to the arm of any individual with an arm of suitable size. On the armlet is tied a small handkerchief to keep the armlet in position. (4) The pressure is raised within the bag until the index is returned to the position at which it was first placed. By raising the pressure within the bag the venous outlets are blocked. Then, if continued for long, profound extreme congestion of the arm and discomfiture. For this reason the readings must be taken rapidly. The pressure is never to be maintained on the arm for more than a minute or so. The following is a convenient plan of work: (1) Force up the pressure rapidly till pulsation appears. (2) Continue to force up the pressure till pulsation disappears or becomes indistinct. (3) Slightly open the valve and allow slow drainage. As the pressure falls, note where the index is when the bag is empty of venous blood. An empty arm of venous blood either by elevation of the limb or injection. (4) Keep the operation still and take another reading. (5) By following the above plan no pain or discomfort will arise. 

In studying the effect of exercise, posture, drugs, etc., successive readings must be taken in the above manner, first during the normal, and then during the experimental condition.

Owing to the effect of position on the circulation, the readings must be taken uniformly, with the arm placed by the side and on the same level as the heart. The musculature of the arm must be relaxed during the observations. The arterial tension is constantly varying slightly, owing to changes in the form of the heart and its respiratory oscillation of pressure. Thus the maximal oscillation may be found now at one place and now at another, a few millimeters higher or lower. The mean of the different readings must be taken just as it is done when the mercurial manometer is used in physiological experiments on animals. In conditioned circumstances, it is usual to find the pressure in the femoral artery as indicated by the mercurial manometer, and the pressure in the carotid arteries as indicated by the spirometrometer. The maximal pulsation of the index of the spirometrometer was found to occur always at a pressure which exactly corresponded with the mean pressure in the femoral artery.

It is known that the carotid and femoral manometers are practically the same in the dog when the animal is in the recumbent position. But the instrument was found to be suitable for use during ether or chloroform anaesthesia, but somehow, they did not find their place. The practice of anaesthesia during the first 50 years remained totally dependent on the observation of the pressure in the femoral artery as indicated by the mercurial manometer, and the pressure in the carotid arteries as indicated by the spirometrometer. The maximal pulsation of the index of the spirometrometer was found to occur always at a pressure which exactly corresponded with the mean pressure in the femoral artery.

At the bedside. No doubt, these instruments were also suitable for use during ether or chloroform anaesthesia, but somehow, they did not find their place in monitoring the pulse. Surprisingly, there are no reports in which any such instruments were employed to study and monitor the patient during surgical anaesthesia. Perhaps maintenance of the airway and level of anaesthesia with primitive inhalers fully occupied the thoughts of the single-handed anaesthetist.

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MEMORANDA: 

MEDICAL, SURGICAL, OBSTETRICAL, THERAPEUTICAL, PATHOLOGICAL, ETC.

THYROID GLAND SUBSTANCE IN OBESITY.

I have been trying this treatment on several Anglosaxonized (who were depriving themselves of one or two, and improving their figure) for some time back, but have only done so systematically and regularly since the beginning of this year. I met several fat subjects of the whole gland substance...
during anaesthesia was not recognized as a good practice: ‘you never see any one here with his fingers on the pulse while chloroform is given’ [12]. In contrast with this, the picture in the anaesthesia history books of Dr J. T. Clover feeling the pulse while administering ether to a patient is a unique example. No wonder he was credited with exceptional success in his profession!

In 1896, Scipione Riva-Rocci (1863–1936), while he was professor at Turin, described his vertical mercury manometer with a rubber arm cuff to occlude the brachial artery. His extensively researched 30-page paper was published in December 1896 [13]. This classic historical publication has never been translated into English, but there is no mention that Riva-Rocci's revolutionary apparatus was considered for the measurement of blood pressure during anaesthesia in the summary translations which are available. This apparatus was introduced in America by Harvey Cushing in 1901, who was also responsible for introducing the practice of blood pressure recording on the anaesthetic charts [14].

The first report of blood pressure monitoring during anaesthesia was recorded in a joint publication to the British Medical Journal on 2 October 1897 (Fig. 1). It was a short, one-page article by Leonard Hill and Harold Barnard, describing a new blood pressure measuring device. At the start of the paper, the instrument was described briefly. It consisted of a narrow armllet to occlude the brachial artery, a small bicycle-type metal pump and a metal manometer graduated in mmHg. The construction of the pressure gauge was described as consisting of a metal tambour connected to a needle or a pointer. The pressure changes caused the pointer to move over a round, graduated scale to 200 mmHg. The authors also described a portable, pocket sphygmometer, although the date of its introduction cannot be ascertained accurately. Both of these instruments are in the exhibition at the Wellcome Museum in London.

The following quote from the Hill and Bernard paper offers ample evidence that the authors had carefully monitored the blood pressure of anaesthetized patients:

‘The facility with which the instrument can be used for clinical purposes is illustrated by a series of observations which we have made upon patients placed under the influence of anaesthetics. Before and during administration a series of readings were taken at intervals of time, and from the figures thus obtained curves were plotted out. In 8 cases of anaesthesia with gas and oxygen (sitting posture) the arterial pressure either rose a few millimeters of mercury or remained constant. In 4 cases of anaesthesia with ether the arterial pressure remained or fell a few millimeters of mercury. In 6 cases of anaesthesia with chloroform the sphygmometer indicated an extensive and rapid fall of arterial pressure. This fall equalled 20 to 40 mm. of mercury. The normal arterial pressure in most healthy young men appears to be 110 to 130 mmHg in sitting position.’ [15]

The above quotation offers the first evidence of measurement of blood pressure during surgical anaesthesia. Unfortunately, my efforts to trace details and data on relevant material mentioned in the quote have not been fruitful.

Harold Leslie Barnard (1868–1908) was born in London (Fig. 2). He was the grandnephew of Michael Faraday. Barnard qualified with many distinctions...
After 100 years, it is only justice that the pioneering contributions made by the two doctors who were the first to monitor blood pressure during surgical anaesthesia should be recognized.

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