THEORY OF OPERATION - CARDIOVISION MS-2000

The CardioVision® Model MS-2000 measures blood pressure, records pulse, pulse pressure (systolic minus diastolic blood pressure), and provides additional cardiovascular information (Arterial Stiffness Index - ASI) to the physician or other health care provider. Blood pressure provides important clinical information on the blood circulation system since the actual blood pressure level is a function of cardiovascular dynamics that are determined by the strength of the heart beat and the overall condition of the arterial system. This information can be evaluated while measuring blood pressure.

The MS-2000 utilizes a Computerized Oscillometric method of blood pressure measurement as opposed to the traditional method of Auscultation (using a stethoscope). This method is a common, but comparatively recent method of indirectly measuring blood pressure using the relationship between the cuff pressure and the amplitude of the pulse waves caused when the brachial artery in the upper arm (which the pressurized cuff is wrapped around) expands each time the heart pumps.

In the Computerized Oscillometric method, the cuff pressure is first increased to a level above the systolic pressure (the pressure reached at heartbeat) and then gradually reduced. At it's maximum, the cuff pressure constricts the brachial artery and prevents pulsation. When the cuff pressure descends to a level near the systolic pressure the pulsation of the brachial arterial vessel appears again. This pulsation is transmitted to the cuff as a minute change in the volume of the arm that which then changes the volume of the cuff. Since the cuff is filled with air, the cuff volume change can be measured as a change in inner pressure. When the inner pressure of the cuff falls below the systolic pressure, minute pressure changes appear. As air within the cuff is released, and the pressure falls, the amplitude of the pressure variations increases. The artery itself does not completely open until the cuff pressure falls to the diastolic level.

As the blood pressure rises only in the systole, when the cuff pressure is between the systolic and diastolic pressure, the artery will open only if the blood pressure is higher. When cuff pressure becomes equal to the mean blood pressure, the amplitude of the pulse pressure reaches its highest level. Because of the arterial pressure/volume properties, when the cuff pressure equals the mean blood pressure, the elastic modulus of the brachial artery is at a minimum (i.e.: the expandability of the artery is at its greatest). Therefore, when the cuff pressure decreases to the mean blood pressure, the artery increases in elasticity and the arterial volume change caused by the pulse pressure of the blood vessel increases. As a result, the pulsatile volume change in the cuff is also increased. When the cuff pressure falls below the mean blood pressure, the expansive pressure of the blood within the artery caused the arterial elasticity to diminish. This, in turn, causes the amplitude of the pulse wave to again decrease. Thus, the Computerized Oscillometric method determines blood pressure according to the arterial volume change patterns that which are caused by the steadily decreasing cuff pressure.

Before the invention of the MS-2000, Oscillometric blood pressure measuring devices typically provided only the patient's systolic, mean, and diastolic pressure levels, and the number of heartbeats per minute. Through extensive research in Japan, it was observed that a high level of correlation existed between certain cardiovascular conditions and the type of patterning obtained from the Computerized Oscillometric pulse measurement over the course of the entire cuff pressure drop from systolic to diastolic. The MS-2000 software employs this data to provide five identified, distinct, graphical patterns (and combinations thereof)

which show close correlation to known cardiovascular conditions. The pressure/volume relationship of an artery is not linear. When blood is infused into a relaxed artery, a great deal can enter initially with no increase in pressure. This is true until the artery becomes full enough to create a measurable pressure change. As the internal pressure increases, the rigidity of the artery also increases. Therefore, the ratio of liquid volume to pressure becomes higher. This property of the artery is related to the dynamic character of the elastic fibers and collagen fibers that comprise the arterial wall. The elastic fiber is a soft, muscular fiber that maintains the expandability of the artery and the tension of the arterial wall when the inner pressure of the artery is low. The collagen fiber makes up the outer part of the artery and has low elasticity. As the artery stretches its further expansion is restricted.

An occluded artery will have high stiffness producing a flat-topped graphical pattern with the MS-2000 (pattern C). This phenomenon is quantitated by an Arterial Stiffness Index of greater than 210. An artery free of impedance or occlusion will produce a sharp-peaked mountain graphically represented by the MS-2000 as pattern A (ASI less than 80). When a patient has arrhythmia the accuracy of usual methods for measuring blood pressure is adversely affected because the Computerized Oscillometric method is not accurate when blood pressure varies during measurement. In the case of arrhythmia, the blood volume per each heartbeat is not constant. This is caused by variations in blood flow into the heart during diastole, since each systolic period is not the same. As a result, the blood pressure per heartbeat can vary greatly. A large pulse pressure is obtained after a long diastolic period due to large stroke volume, whereas the pulse pressure after a short diastolic period is small. In this situation, the amplitude of the pulse waves, which appear while cuff pressure is being reduced, is irregular and the interval between appearances is not equal. Due to this instability in the changes in arterial volume, the MS-2000 records and displays a very choppy graphical pattern (pattern D).

This is a peripheral device which, when linked to a desktop or notebook computer, can both function as a highly accurate and easy to use oscillometric blood pressure monitor, and also provide information on the overall condition of the cardiovascular system which can be of use to the physician or other health care provider in screening for possible health problems, or monitoring patient progress. Unique to CardioVision® is its ability to produce an Arterial Stiffness Index (ASI) marking the position of stiffness in Patterns A, AC, and C.

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