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Sources of Error in Blood Pressure Measurement Using Digital and Aneroid Tensimeters

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Abstract: A tensimeter is an instrument works with concept of physics used to measure blood pressure. The measured blood pressure is the relative pressure between the pressure inside the blood vessels compared to the pressure of the atmosphere. Blood pressure measurements using a digital tensimeter are much more acurate than measurements using an aneroid tensimeter. Measurements with an aneroid sphygmomanometer at a hospital in the city of Mataram showed a measurement error up to 20 mmHg compared to a digital sphygmomanometer. Source of error consist of two main factors ie. Instrument error and human error. From this research it was found that measurements using a digital sphygmo-manometer are more accurate, so the use of this type of sphygmomanometer is highly recommended for clinical measurements in hospitals and health hospitals.

Keywords: Aneroid Sphygmomanometer; Blood Pressure Measurement; Digital Sphygmomanometer,

Introduction

A tensimeter is a physical instrument used to measure blood pressure. Measured blood pressure is the relative pressure between the pressure inside the blood vessels compared to the pressure of the outside air or atmosphere (Anisya et al., 2018; Dirta & Suyatno, 2013). The unit used in measuring blood pressure is mm Hg. Accuracy of measuring blood pressure is very important because blood pressure parameters really determine the accuracy of diagnosis of a disease. Many diseases can be detected or indicated by increased blood pressure or decreased blood pressure in patients.

The most common diseases whose symptoms are increased pressure in the blood vessels are hypertension and/or high blood pressure and hypotension or low blood pressure. Hypertension is a disease of increased pressure in the blood vessels caused by narrowing of the blood vessels and high blood pressure from the heart to the arteries, while hypotension is the opposite disease (Puspaningtyas & Putriningtyas, 2017).

There are 2 physical parameters in measuring blood pressure, namely diastole and systole. Systole is the blood pressure in the vessels when the heart pumps blood into the arteries, while diastole is the blood pressure when the heart draws blood from the arteries or veins to the heart.

Blood measurements can be carried out using a sphygmomanometer with several different physical principles, namely a digital sphygmomanometer and an aneroid sphygmomanometer. Using a digital blood pressure monitor is very easy to do and no special training is required. Measurements with this type of sphygmomanometer can be done even by lay people (Kartika et al., 2019; Yuningrum, 2019).

Measuring a sphygmomanometer using an aneroid sphygmomanometer is much more difficult than with a digital an-nur. This is because these two types of tensimeters rely on accuracy in seeing pressure drops through a number indicator that is synchronized with the use of a stethoscope on the ear, so this tool requires experience, special skills and high concentration in its use. The use of this measuring instrument is also prone

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to errors caused by the lack of synchronization between the sight of a decrease in blood pressure and the sound of the heartbeat heard through a stethoscope.

Method

Research Subjects and Places

This research was carried out in a hospital in the city of Mataram with 18 patients to measure blood pressure.

Working principle of Measuring Instruments

Measured blood pressure is the relative pressure between vessel pressure and external air pressure. This relative pressure is often called relative pressure or in physics terms it is known as pressure gauge (Ma'rif & Apriyanto, 2018).

In principle, blood pressure in human blood vessels is always greater than atmospheric pressure or outside air. This is shown by the fact that if a person experiences a scratch or cut that is large enough, blood will come out of the body, this shows that the pressure in the blood is greater than atmospheric pressure. In accordance with the physical principle that fluid flows from high pressure to low pressure, blood will come out of the vessels where the pressure is greater to outside the body where the pressure is lower (Rokhman et al., 2019). If the external pressure is greater than the pressure inside the blood vessels then air will enter the blood vessels and this never happens.

(a)

(b)

Figure 1. (a) Digital tensimeter and (b) Aneroid tensimeter

Fluid can enter the blood vessels if the fluid pressure outside is greater than blood pressure. This can happen to injured divers. During diastole, blood will come out, while during systole water can enter the blood vessels (Yazid & Harmoko, 2011). This can happen if the diver is at a considerable depth. Figure 2 shows the pressure of fluid moving in a pipe. According to Bernoulli's equation, point 1 has a greater pressure than the pressure at point 2. This is because the position of point 1 is lower than the position of the second point and also the speed there. 1 is smaller than the pressure at point 2.

If at point 1 there is a leak at the edge of the pipe, what will happen is that the fluid from inside the pipe will gush out because the pressure in the pipe is greater than the outside air pressure. If at point 2 there is a hole in the pipe, what will happen is that air will enter the pipe as a result of the fluid pressure in the pipe being less than the outside air pressure.

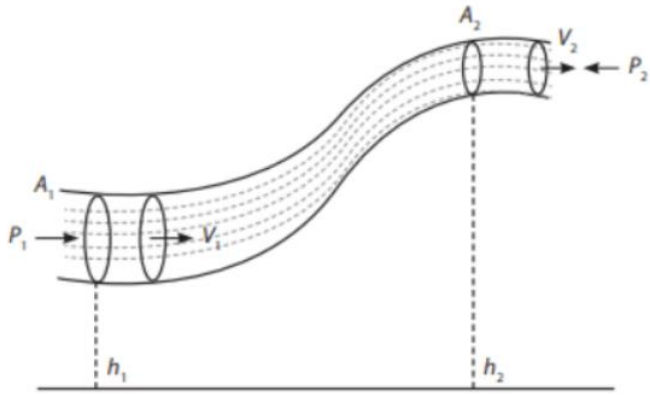

Figure 2. Fluid pressure moving in a pipe

The difference in pressure inside the pipe with the difference in pressure outside the pipe is called relative pressure or pressure gauge. This relative pressure is measured on a sphygmomanometer in mm Hg.

It should be remembered that the air pressure above the earth's surface near sea level is approximately 76 cm Hg or 760 mm HG, while the relative pressure in the blood vessels compared to the outside air pressure in healthy people is 120 mm Hg in diastole and 90 mm Hg in systole.

According to the author's observations, quite a lot of nurses in hospitals, health centers or health hospitals do not measure blood pressure accurately and thoroughly. This is due to instrument limitations and lack of experience and adequate training when using aneroid tensimeters.

Result and Discussion

This research was conducted in one of the hospitals located in the city of Mataram. Measurements were carried out on 18 patients who were measured by health workers using an aneroid tensimeter. After the

examination process was complete, the patients then had their blood pressure measured using a digital tensimeter.

Measurement errors made with a digital sphygmomanometer occur due to differences in reading time which depend on the number of pulse beats per minute and also depend on the rate of drop in blood pressure on the measuring instrument. In principle, the slower the decrease in blood pressure readings on the instrument, the more accurate the measurements that can be made with that tool, however, the lower rate of this decrease will result in a longer measurement time (Satoto et al., 2019; Siswati & Adriyani, 2017).

The magnitude of this error can be formulated as the product of the heartbeat period multiplied by the rate of pressure drop in the instrument.

Table 2. N-Gain of all students. Numbers divided based on the criterion of High, Fair and Low

	Digital		Aneroid	
Patient	SBP	DBP	SBP	DBP
1	137	80	140	80
2	135	87	140	80
3	110	70	120	80
4	121	83	130	90
5	127	78	130	90
6	153	69	150	70
7	137	87	140	90
8	130	80	140	90
9	136	73	140	80
10	101	71	110	80
11	102	57	110	60
12	140	80	150	80
13	126	90	130	80

Reading errors on manual sphygmomanometers are caused by several factors, namely parallax reading errors, inaccuracy when looking at the dial on the instrument, inaccuracy when listening to the heartbeat and other errors in the form of reaction time between hearing time and reading time.

From the measurement results, data is obtained as shown in table 1. From this table, assuming that measurements using a digital sphygmomanometer are more accurate than those with a sphygmomanometer, a difference in measurement results can be obtained which can be concluded as an error or uncertainty in the reading with a manual (aneroid) sphygmomano-meter.

In the Table 1, it can be concluded that the average error or uncertainty in a manual sphygmomanometer has a standard deviation of 22.2 mmHg in cystole and 15.3 mmHg in diastole. The standard deviation of cystole and diastole measurements together is 19.6 mmHg. This shows us that manual (aneroid) tensimeters have less reliable measuring capabilities compared to digital tensimeters.

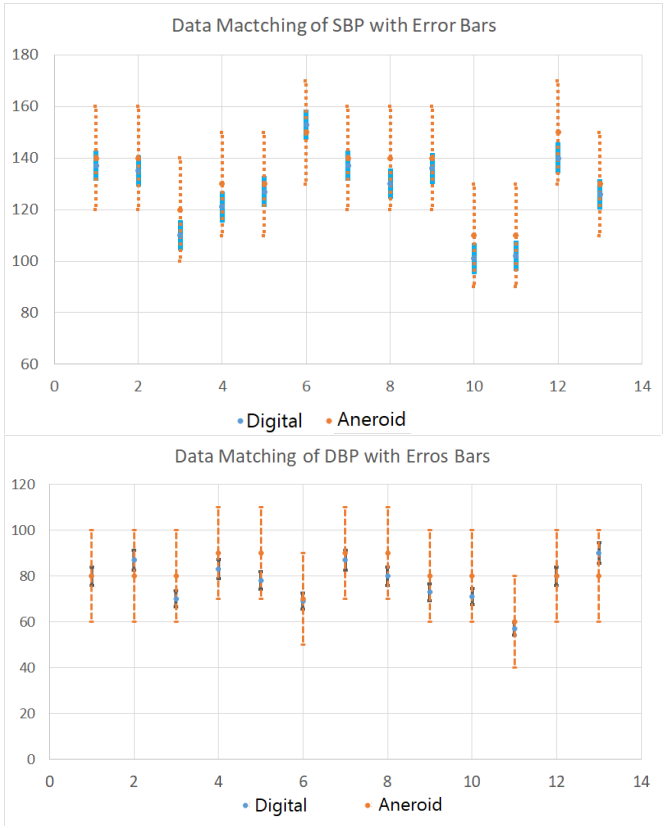

Figure 3. Data Macthing of SBP with Error Bars

Conclusion

Measurements using a digital sphygmomano-meter have much better results and are much more accurate than measurements using a aneroid sphygmomano-meter. Measurements using a digital sphygmomano-meter do not require special training and are very easy to use. Measuring using a aneroid tensimeter requires special skills and adequate training so it is quite difficult to do.

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