

2Manuscript received August 5, 2024; revised September 23, 2024; accepted December 21, 2024; date of publication December 22, 2024
Digital Object Identifier (DOI): xxxx

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Innovative

Comparative Analysis of The Accuracy of Several Types of Syringe Brands With Flowrate And Volume Parameters on Syringe Pump

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ABSTRACT

In the field, especially in hospitals, syringe stock that is limited units makes the hospital use different brands of syringes. This case is a major concern in the development of the use of syringe pumps, especially in terms of the use of syringes. Therefore, for the use of the syringe to be by the setting value, a test is required. The purpose of this study is to determine the accuracy level of flow rate and volume of different brands of syringes so that the flow rate of drug doses entering the patient's body is accurate and according to the setting. The type of research used is quantitative, by measuring and comparing the accuracy level of 3 types of syringe brands where the original syringe from the unit, namely Terumo, with the syringe brand that is not by the unit, namely Nipro and B-Braun with the same size, namely 50 mL which is measured based on flowrate and volume parameters. This test uses the Naully 1CSiB-2101 calibration simulator as a support and a 100 mL measuring cup as a volume measurement and comparison of the output values in the simulator with the values in the measuring cups. The results in the measurement of the flowrate parameter of the Terumo brand syringe have an accuracy of 94.00% and an error of 6.00%, the Nipro syringe of 99.98% and an error of 0.02%, and the B-Braun syringe of 99.99% and an error of 0.01%. In the measurement of the volume parameter of the Terumo syringe, it obtained an accuracy of 99.90% and an error of 0.09%, then the Nipro syringe was 94.00% and the error was 6.00%, the B Braun syringe was 100.00% and the error was 0%. So it can be concluded that the Terumo, Nipro and B Braun brand syringes can be used normally and are still within the tolerance limit of $\pm 10\%$ ECRI (Emergency Care Research Institute) Standard.

KEYWORD: Syringe pump, Spuit, Accuracy, Flowrate, Volume

I. INTRODUCTION

A syringe pump is one of the medical devices included in the category of Life Support Equipment which functions to help inject medicinal liquids and food into the patient's body according to the dose that has been set within a certain period (mL/hour). Syringe pumps are commonly used for drug delivery in hospitals and

clinical environments. These instruments are of great importance in neonatology and oncology, where there are variations in flow rate and the quantity of the drug dosage can lead to severe incidents and even patient death. It is therefore very important to determine the accuracy and precision of this unit using the calibration that corresponds to the method. Knowing the inner

diameter of the syringe is also needed by performing high precision, mileage, and a long enough time where it is possible to calculate the flow rate of the liquid in the syringe and its uncertainty [1].

In some cases of patients such as hypertension before surgery, heart disease, and neurological diseases, the administration of medicinal fluids must be carried out intensively, namely the volume of medicinal fluids must be appropriate with a flow rate constant. In patients with critical conditions, intensive care is needed so that there is no imbalance of fluids in the body[2].

Lack of knowledge of doctors and nurses about syringes and Syringe pumps is a major concern in the development of medical equipment that is not only seen from the main unit, namely the Syringe pump However, attention is also paid to another element, namely the syringe which plays an important role in flowing doses of drugs and food into the patient's body so that it is necessary to pay attention to its accuracy.

In the field, especially in hospitals, syringe stock is limited units so the hospital uses syringes of different brands. This case is a major concern in the development of the use of syringe pumps, especially in terms of the use of syringes. Therefore, for the use of the syringe to be by the setting value, a test is required. In conducting tests to get accuracy values by the specifications of the tool, it can be obtained with the correct adjustment activities, namely by testing the accuracy of the flow rate and volume.

II. LITERATURE REVIEW

A. RESULT OF PREVIOUS RESEARCH

Research [3], testing the tool is carried out by checking the tool, testing the function of the tool by turning on the tool and trying the working principle of the tool, checking the power cable, power supply, and battery, checking the sound buzzer and the alarm light (make sure it's red) then the sensor replacement size by preparing syringes with sizes of 10 mL, 20 mL, 30 mL, and 50 mL inserted into the syringe size from each side of the syringe with the next problem, namely power

supply completely shut down, the sensor is empty and the battery is soaked. The results showed that the reading of 10 mL worked well, then the 20 mL size of the second experiment was successful. For the third experiment, the size of 30 mL was successful. For the last experiment, the size of 50 mL was also successful. For the last experiment, the size of 50 mL was also successful.

In contrast to the research [4] measurements were made for 4 types of variables syringe The ones used are 10 mL, 20 mL, 30 mL, and 50 mL with 2 measurement parameters, namely resistance, and voltage at the measurement points of the detector circuit syringe size on the tool Syringe Pump Brand Terumo Type TE-331. Each measurement point was measured 6 (6) times with the result of Measurement Point 1 (TP1), which serves to determine the value of resistance to rheostat when installing syringes of 10 mL, 20 mL, 30 mL, and 50 mL. Measurement Point 2 (TP2), serves to determine the output voltage at the rheostat during installation syringe sizes of 10 ml, 20 ml, 30 ml, and 50 ml and the results of these measurements are then compiled in the form of a measurement table.

In contrast to research [5], the method used is by adjusting the volume and flowrate, data collection, data analysis, data presentation and then conclusion the tools and materials used are ESA (Electrical Safety Analyzer), Syringe Pump, Infusion Device Analyzer (IDA), and Disposable Syringe (syringe) by measuring and comparing the results of the comparative conformity measurement flowrate and volume Liquids in 5 types of syringes of different brands were then taken. Results of data obtained from performance Syringe Pump Some are not by the desired output results, the use of different brands of syringes can affect the accuracy because some samples are below the ECRI standard threshold ($\pm 10\%$).

Almost similar [6], to the experimental setting method, which uses two syringe sizes, namely 20 mL and 50 mL, the volume used starts from 5 mL to 50 mL with increments every 5 mL and 4 different types of flowrates at different speeds with data collection carried out 5 times. With the way it works, the calculation of the average error with a 20 mL syringe is = 0.09%, and

with a 50 mL syringe value = 0.085%. The results of the study concluded that after volume measurement using a 20 mL syringe, the smallest error occurred at the 30 mL volume point of 0.007% and the largest error occurred at the 5 mL volume point of 0.4%. For volume measurement using a 50 ml syringe, the smallest error occurred at the 30 ml volume point of 0% and the largest error occurred at the 5 ml volume point of 0.280%. The software to run the minimum range of the microcontroller system runs well so that it can run the tool as per the settings. The tool works well because the maximum error value is 0.4% while the maximum allowable error is 5%.

B. THEORETICAL BASIS

Syringe pump It is a medical device used to regulate the amount of fluid that enters the blood circulation through a vein. Specifically, this tool focuses on the amount of fluid that is put into the patient's body, in milliliters per hour. [7]. There are two common types of syringe pumps, namely; medical infusion pump and research syringe pump. The medical infusion pump is a device used to drain a predetermined amount of fluids controlling nutrition, medicines, chemotherapy, and blood to patients. These types of units are used for diagnosis in-vivo treatment. While research syringe pump is a tool used in research laboratories for applications that can distribute a very small fraction of liquid or liquid medicine [8].

The parameters on the Syringe pump that is flowrate and volume. Flowrate The aim is to determine the accuracy of the syringe pump in injecting medicinal liquids. Character flow rate can verify the precision and comparison of flow rate ranges and volumes for different types of syringes. [9]. At low flow rates, it also has a considerable start-up delay. [10]. The volume aims to determine the accuracy of injecting the volume of the drug liquid.

Occlusion/Pressure aims to determine the output voltage of the occlusion detection circuit against the pressure conditioned at certain values.

III. RESEARCH METHOD

A. RESEARCH DESIGN

The following is a flowchart of the comparative analysis of the accuracy of several types of syringe brands with flow rate and volume parameters on syringe pumps.

The type of research used to analyze the comparison of syringe brands with flowrate and volume parameters on syringe pumps uses a quantitative research type. Quantitative research is a type of research that produces discoveries that can be achieved (obtained) using statistical procedures or other means of quantification (measurement) [13].

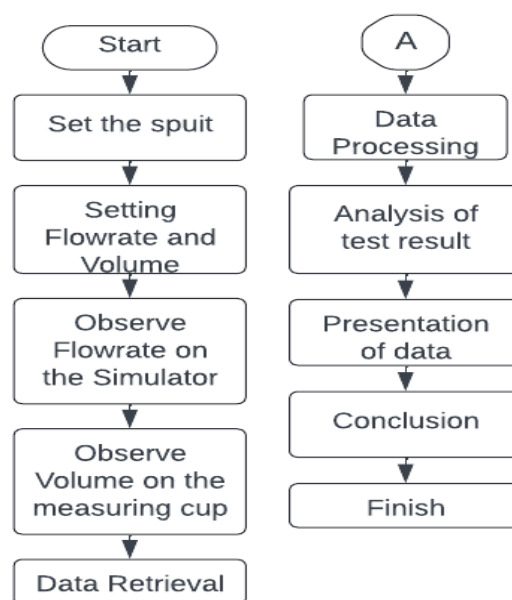


FIGURE 1. Flowchart Research Comparative Analysis of the Accuracy of Several Types of Syringe Brands With Flowrate and Volume Parameters on Syringe Pump

This test measures and compares the accuracy level of the original syringe brand of the unit, namely Terumo, with the syringe brand that is not by the unit, namely Nipro and B Braun with the same size, namely 50 mL. Where the measurement is based on parameters *flowrate* and the volume in the test is expected to be the original syringe brand of the unit, namely Terumo, the accuracy level is higher than that of other syringe brands, so that the flow rate of drug doses that enter the patient's body is accurate and according to the setting. This test uses the Naully calibration

simulator 1CSiB-2101 as a support and the measuring cup as a volume measurement and comparison of the output value in the simulator with the value in the measuring cup with an error tolerance allowed is $\pm 10\%$ (ECRI Standard (*Emergency Care Research Institute*)).

B. DATA COLLECTION TECHNIQUE AND RESEARCH INSTRUMENT

1. Data Collection Technique

A) FLOWRATE TESTING

Flowrate was tested using a syringe pump calibration tool, namely the Naully 1CSiB-2101 simulator, and a measuring cup. Naully 1CSiB-2101 is used to determine the output value of the flow rate of the syringe pump which will later be compared with the output value of the Naully 1CSiB-2101 simulator calibration device while the measuring cup is used to measure the liquid that comes out for 1 hour. This test serves to find out whether the flow rate is by the settings or not. This test was carried out 6 times with 3 different brands of syringes.

B) VOLUME TESTING

This test is carried out by measuring the volume of liquid coming out of the syringe pump using a measuring cup. This test is carried out to find out if the volume coming out of the tool has been met. This test was carried out 6 times with 1 measuring cup and 3 different brands of syringes.

The author uses data collection techniques with literature studies and documentation.

2. Research Instrument

To analyze the syringe brand with *flowrate* and volume parameters on the *syringe pump* tool, several tools and materials are needed, including the following:

1. Syringe Pump, merk Terumo, type TE-SS730, SN: 2202010101
2. Simulator Kalibrasi, merk Naully, type 1CSiB-2101, SN: K07-210111004
3. Syringe, Terumo brand 50 mL, price Rp.24.000
4. Syringe, brand Nipro 50 mL, price Rp.7.500

5. Syringe, brand B Braun 50 mL, price Rp.60.000

C. DATA ANALYSIS TECHNIQUE AND CALCULATION ACCURACY

1. Data Analysis Technique

The author uses a quantitative method, namely by analyzing the results of the accuracy comparison of 3 different syringe brands by conducting 6 data collection experiments. Testing and analysis will be carried out based on the Minister of Health Regulation on syringe quality test samples which will later determine conclusions based on the electromedical aspect. In conducting data analysis, the author does data classification, data verification, accurate calculations, and data processing.

2. Calculation Accuracy

- a. Average Score

$$\bar{x} = \frac{\sum_{i=1}^n xi}{n}$$

- b. Standard Deviation

$$s^2 = \frac{\sum_{i=1}^n (xi - \bar{x})^2}{n - 1}$$

- c. Value Error

$$\text{Error} = \text{Setting} - \text{UUT}(\text{Unit Under Test})$$

- d. Percentage of Error Values

$$\% \text{ Error} = \frac{\text{Koreksi}}{\text{Setting}} \times 100\%$$

- e. Measurement Accuracy Percentage

$$\% \text{ accuracy} = 100\% - \% \text{Error}$$

- f. Uncertainty Type A

$$U_a = \frac{\text{Standar Deviasi}}{\sqrt{n}}$$

- g. Uncertainty Type B

$$U_{b1} = \frac{\text{Usertifikat}}{k}$$

- h. Resolution Uncertainty (Ub2)

$$U_{b2} = \frac{a}{\sqrt{3}}$$

- i. Combined Uncertainty (Uc)

$$U_c = \sqrt{U_a^2 + U_{b1}^2 + U_{b2}^2}$$

j. Uncertainty of the Stretch (U_{exp})

$$U_{exp} = k \times U_{exp}$$

IV. RESULT AND EXPLANATION

Table 1 is showed measurement results of a comparative analysis of the accuracy of several types of syringe brands with flow rate and volume parameters measured 6 times the measurement.

Table 2, shows that if the average value with the *flowrate parameter* of the Terumo brand syringe is 53.00 mL/h with an accuracy of 94.00% and an error of 6.00%, the Nipro syringe is obtained with an average of 49.14 mL/h with an accuracy of 99.98% and an error of 0.02% and the B Braun syringe with an average value of 50.49 mL/h with an accuracy of 99.99% and an error of 0.01%. Furthermore, from the measurement with *the flowrate* parameter compared with the volume parameter on the measuring cup to ensure the accuracy of the *flowrate setting* value with the results of the Terumo syringe, an average of 49.83 mL with an accuracy of 99.90% and an error of 0.09%, then a Nipro syringe with an average of 47.00 mL/h, an accuracy of 94.00% and an error of 6.00%, a B Braun syringe with an average of 50.00 mL/h, an accuracy of 100.00% and an error of 0%.

TABLE 1

COMPARISON OF THE RESULTS OF THE MEASUREMENT OF THE FLOWRATE PARAMETERS OF TERUMO, NIPRO, AND B BRAUN SYRINGES

Setting mL/h	Brand		
	Terumo	Nipro	B Braun
50 mL/h	52,19	50,49	49,53
	53,47	47,87	48,55
	49,22	48,55	51,88
	55,26	49,18	49,91
	55,66	48,87	50,86
	52,20	49,88	49,37
Average	53,00	49,14	50,59
Correction Value	3,00	-0,86	0,49

Error	6,00%	0,02%	0,01%
Std.Dev	2,36	0,94	2,09
Ua	0,96	0,38	0,30
Ub1	0,30	0,30	0,30
Ub2	0,29	0,29	0,29
Uc	1,03	0,56	0,59
K	2,00	2,00	2,00
Uexp	2,06	1,12	1,18
%Accuracy	94,00%	99,98%	99,99%
Tolerance	±10%	±10%	±10%

TABLE 2

COMPARISON OF THE RESULTS OF MEASURING THE VOLUME PARAMETERS OF TERUMO, NIPRO, AND B BRAUN SYRINGES

Setting Alat mL/h	Brand		
	Terumo	Nipro	B Braun
50 mL/h	50,00	45,00	50,00
	49,00	45,00	50,00
	48,00	46,00	50,00
	50,00	49,00	50,00
	51,00	48,00	50,00
	51,00	49,00	50,00
Average	49,83	47,00	50,00
Correction Value	-0,47	-3,00	0
Error	0,09%	6,00%	0%
Std.Dev	1,16	2,09	0
Ua	0,47	0,85	0
Ub1	0,30	0,30	0,30
Ub2	0,29	0,29	0,29
Uc	0,63	0,94	0,59
K	2,00	2,00	2,00
Uexp	1,26	1,18	1,88
%Accuracy	99,90%	94,00%	100,00%
Tolerance	±10%	±10%	±10%

With the meaning of the Terumo syringe that is by the Syringe Pump unit, the accuracy is lower than Nipro and B Braun in the *flowrate parameter*, but in the measurement of the Nipro syringe has a high level of accuracy even though the price is cheap, while B Braun has the highest level of accuracy because the price is more expensive and the quality is guaranteed.

In measurements using the volume parameter in the Terumo syringe measuring cup, the accuracy is higher than that of Nipro, which

means that the amount of liquid that enters according to the setting and no water drips out, Nipro has low accuracy in the volume parameter because some drops of water do not enter the measuring cup, and B Braun has high accuracy because no water drips out of the measuring cup and the quality of the syringe does have the advantage of higher accuracy, but the three syringes can be used normally because they are still within the tolerance limit of $\pm 10\%$.

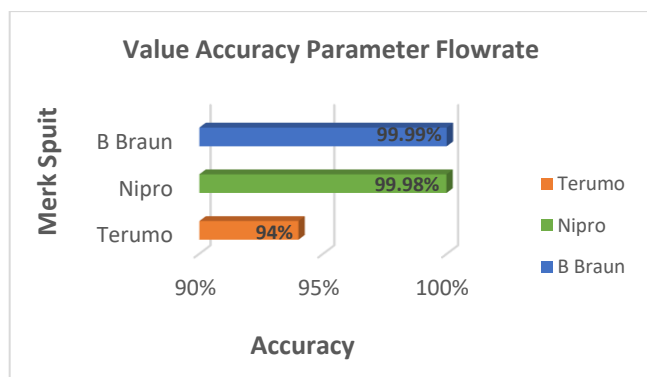


FIGURE 2. Value accuracy parameter flowrate

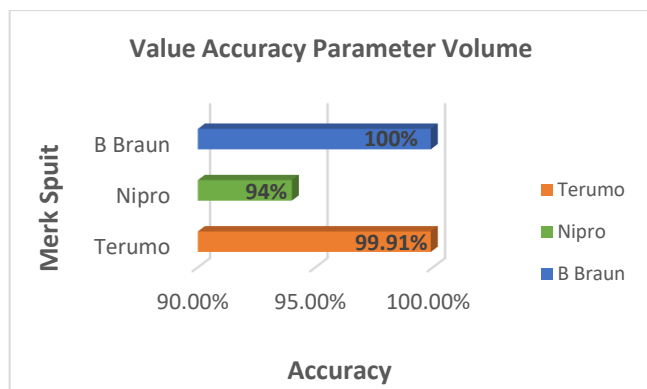


FIGURE 3. Value accuracy parameter volume

V. CONCLUSION

Based on the results of the measurements that have been taken, the level of flowrate accuracy on Terumo brand syringes is 94.00%, Nipro brand syringes are 99.98%, and B Braun brand syringes are 99.99%. Meanwhile, the volume accuracy level on the Terumo is 99.91%, the Nipro brand syringe is 94.00%, and the B Braun brand syringe is 100.00% and can be used normally and is still

within the tolerance limit of $\pm 10\%$ (ECRI Standard).

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