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Comparison of Flowrate and Occlusion in a Vertical Infusion Pump and Horizontal Infusion Pump

Nur Hasanah Ahniar, Hendra Marwazi, Rismarini Yufita
Department of Electromedical Engineering Poltekkes Kemenkes, Jakarta II
Jl. Hang Jebat III/F3, Kebayoran Baru, South Jakarta, 12120, Indonesia
#ana.ahniar@gmail.com, hendramarwazi@yahoo.com, rismariniyufita17@gmail.com

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***Abstract*— An infusion pump is a device used to enter fluid into the patient's body through a continuous. During its development, there are currently two types of infusion pumps namely vertical infusion pumps and horizontal infusion pumps used by users. The two infusion pumps have different technologies. Doctors and nurses as users sometimes feel confused in their use, caused by different technologies. This research was conducted to compare the results of the performance of the two infusion pumps. Is it true that there are differences in results so that users can use the type of infusion pump appropriately? At the time of data collection, the infusion pump is given intravenous fluids then the number of drops is examined, and occlusion. Before data collection, Infusion Pump is calibrated first by using an Infusion Device Analyzer to check the condition of the device. Data collection was carried out 5 times with 3 minutes for each parameter. The results of the data collection will be tested using the normality test and the different tests. Based on the T-Test results a significant value on the data collected is greater than 0.05, which means that the null hypothesis is accepted while the alternative hypothesis is rejected. Based on the results of the T-Test it can be concluded that there is no difference between the vertical and horizontal Infusion Pump outputs. The results of this study can be used as a useful reference in their use of patients. Infusion pump users no longer need to be confused using a vertical or horizontal infusion pump because there is no difference in the function of the two.**

Keywords—Infusion Pump; Vertical; Horizontal; Advanced Technology

I. INTRODUCTION

The need for medical devices in health services continues to increase along with increasingly rapid technological developments. One of the technological developments is smart infusion technology which plays a role in the final check to ensure that the infusion parameters are appropriate and by following the guidelines and do not exceed the prescribed limits. This is because, in America, it is estimated that there are 750,000 pumps used to administer drugs with more than one million doses per day during intravenous therapy, which is associated with 61% of the most serious life threats due to drug administration [1].

The development of an Infusion Pump equipped with an Optocoupler sensor circuit as a detector for the number of infusion droplets that have entered the patient's body. This designed module works when there is an error ie empty bottles or dripping drip chamber and accuracy calculates the number of droplets per minute of 96.2% [2] . This makes the manufacturers of medical devices, especially in Indonesia, continue to compete to innovate in improving the technology of medical devices, both in terms of work principles, components used up to the form or design of tools that are modified to simplify use, use and display more results accurate.

Infusion Pump is one of the electromedical equipment that experiences different shapes or designs. At present, there are 2 different design models of Infusion Pump, namely vertical models (old models) and horizontal models (new models), with the use of different technologies where the vertical form of Infuse Pump uses a standard technology, while the Infuse Pump forms horizontally using advanced technology. Infusion Pump with a manual model utilizing the force of gravity always changes the number of drops. Infusion pump droplets that are inserted into the patient's body are not always the same, this is influenced by several things that result in the amount of fluid entering the patient's body being different [3]. The infusion pump design can cause user errors, so application performance is needed [4]. There is no significant difference to the infusion pump of 3 brands, all of which can be used according to their function [5]. The application of intelligent pumps has proven to be effective in preventing infusion-related programming from patient support [6].

Errors in drug administration using an IV pump can resolve the patient's death. Medication errors associated with infusion pumps are common, but the extent of this error is largely unknown [7]. The number of drops the infusion pump needs to be monitored because it affects the amount of drug fluid (infusion) the patient receives. Infusion pump droplets can be controlled and monitored using infrared sensors [8], optocoupler sensor with fuzzy logic [9], load cell sensors can also be used as a gauge for the weight of intravenous fluids, while the photodiode sensor can be used to measure the rate of droplets of intravenous fluids entering a patient's body [10]. No research

addresses the problem of differences in the number of droplets in a vertical and horizontal infusion pump. While both of these infusion pumps have circulated widely in the market and have been used by users. Both of these infusion pumps also need to be monitored on the amount of liquid droplets.

Based on the differences in design that are related to the differences in technology used, the authors examine whether there are differences in the results of the two forms of Infuse Pump devices on the technology possessed in both forms of Infuse Pump, so that the use of Infuse Pump with vertical or horizontal forms can be maximized by the user. We examined this based on the assessment of the user of the tool, the measurement of the flow rate and the pressure of occlusion found on both forms of the Infuse Pump. The accuracy of the amount of drip liquid droplets and the length of the alarm time in receiving a response from the sensor.

II. MATERIALS AND METHODS

A. Experimental Setup

This study was conducted at one of the government hospitals in Jakarta, using the same brand of Infusion Pump. Infusion Pump is given 3 different liquid infusions, use 3 parameters flowrate setting and the data collection repeated 5 times, with 3 minutes for each parameter. The results of the data collection will be tested using the normality test and difference test.

1) Materials and Tool

This study uses Infusion Pump with vertical models (BBraun, Infusomat P, Germany) and horizontal (BBraun, Infusomat Space P, Germany). Infusion Device Analyzer (Fluke, IDA 4, USA) used to test the Infusion Pump. The second Infusion Pump is the procurement of tools in 2014, they have the same service life. Stopwatch (Casio, HS70W, Japan) used to observe the time needed for Infusion Pump in each drop. An infusion set (BBraun, BBraun Medical Indonesia, Indonesia) used to drain intravenous fluids. Digital count used to calculate the number of droplets in the infusion fluid that comes out of the infusion pump manually.

2) Experiment

In this study, the Infusion Pump was calibrated first by using the Infusion Device Analyzer to check the condition of the tool. If the tool is in good condition, it can be used in data retrieval. There are 3 flowrate parameters used (50 ml/h; 100 ml/h and 200 ml/h). Each setting is compared to the Infusion Device Analyzer.

B. The Diagram Block

This study uses two different types of infusion pump, vertical infusion pump, and horizontal infusion pump. Each infusion pump is given 3 different intravenous fluids. An infusion set is needed as a connector for infusion fluid with an infusion pump. The Infusion Device Analyzer used in IDA 4 type, can be used directly by 2 infusion pumps at once. IDA 4 is used as a measuring device for the accuracy of the number of droplets produced by each infusion pump. Data retrieval has done if the instant and average graph on IDA 4 has coincided. The digital counter used as a comparison of the number of droplets manually with IDA 4. The stopwatch used to timer each observation, each observation takes 3 minutes.

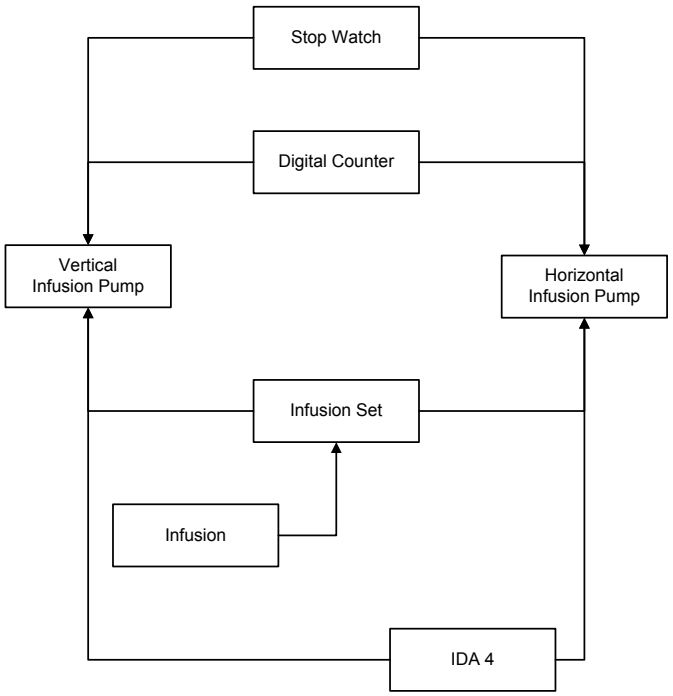

Fig 1 The Diagram Block of this study

C. The comparison of standard and advanced infusion pump technology

Standart infusion pump technology (vertical) and advanced infusion pump technology (horizontal) have different specifications and technology in several ways. Comparison of technology can be seen from the table I

TABLE I THE COMPARISON OF STANDART TECHNOLOGY AND ADVANCE TECHNOLOGY OF INFUSION PUMP *[11] [12]*

NO		Standart Technology (Vertical)	Advance Technology (Horizontal)
1	Speed Setting	0.1 – 999.9 ml/h	0.1 – 1200 ml/h
2	Bolus Speed	1 – 999.9 ml/h	1 – 1200 ml/h
3	Weight	3.1 kg	1.4 kg
4	Medicine	Cannot input medicine name and dosage	can input the name of the drug and the dose is up to 1200 types

5	Pressure Setting	High and Low	Has a pressure detection setting
6	Dimension	140 x 240 200 mm	214 x 68 x 124 mm
7		can only be used 1 unit	Can be stacked up to 3 units at a time
8		Cannot be used on MRI examinations	MRI Compatible with the MRI Space Station can used up to 4 pump units in the MRI Room

D. The Normality Test

The normality test is a test to measure whether the data held is normally distributed so that it can be used in parametric statistics, if the data is not normally distributed, non-parametric statistics can be used [13]. Based on the empirical experience of some statisticians, data with more than 30 digits (n> 30), assumed to be normally distributed. Said as a large sample.

We use the T-Test which is a parametric test/difference test, namely a statistical test group that asks for certain requirements to give good results, in this case, related to the assumption of data distribution. Parametric tests require the distribution data requested to be normally distributed.

1) One Sampel T-Test

Used to compare a group of data from 1 sample/group with 1 reference value. The data sample is compared with 1 number (one sample). There is 1 variable type interval/ratio because the other data is a reference number.

2) Paired Sample T-Test

Used to compare the averages of two existing data sets where the two data sets are from the same group of objects/respondents. This is possible because, for example, measurements are taken at different times but the object/respondent remains the same so that it has 2 groups of data or different measurements are made because of the treatment of the object/respondent.

3) Independent Sample T-Test

Used to compare the averages of two data sets, the two data sets are from the same group of objects/respondents. This is possible because, for example, measurements are taken at different times but the object/respondent remains the same so that it has 2 groups of data or different measurements are made because of the treatment of the object/respondent. The criteria of the three types of T-Test test methods are:

1. If significant > 0.05 the data is normally distributed
2. If significant < 0.05 the data is not normally distributed

E. Flowrate Measurement

The measurement of the flowrate uses three settings, 50 ml/h, 100 ml/h, and 200 ml/h taken from the values of the measurement ranges of the low, medium and high categories. The result flowrate measurement, shown in TABLE II and TABLE III

TABLE II VERTICAL INFUSION PUMP FLOW RATE MEASUREMENT

NO	Setting (ml/h)	Measurement Result (ml/h)				
		1	2	3	4	5
1	50	52.55	52.42	52.34	52.3	52.55
2	100	101.9	101.8	101.8	101.7	101.7
3	200	198.2	198.1	198.2	198.1	198.0

TABLE III HORIZONTAL INFUSION PUMP FLOW RATE MEASUREMENT

NO	Setting (ml/h)	Measurement Result (ml/h)				
		1	2	3	4	5
1	50	52.34	52.5	52.55	52.5	52.34
2	100	101.8	101.7	101.8	101.8	101.8
3	200	198	198.2	198.2	198.2	198

F. Occlusion Measurement

The measurement of the occlusion uses three settings, 50 ml/h, 100 ml/h, and 200 ml/h taken from the values of the measurement ranges of the low, medium and high categories. The result flowrate measurement, shown in TABLE IV and TABLE V

TABLE IV MEASUREMENT OF OCCLUSION IN THE VERTICAL INFUSION PUMP

NO	Setting (ml/h)	Measurement Result (Psi)				
		1	2	3	4	5
1	50	12.5	12.5	12.88	12.8	12.88
2	100	14.53	14.53	14.5	14.53	14.55
3	200	14.58	14.58	14.58	14.65	14.6

TABLE V MEASUREMENT OF OCCLUSION IN THE HORIZONTAL INFUSION PUMP

NO	Setting (ml/h)	Measurement Result (Psi)				
		1	2	3	4	5
1	50	12.25	12.5	12.88	12.8	12.8
2	100	14.53	14.53	14.5	14.5	14.55
3	200	14.6	14.65	14.58	14.58	14.58

III. RESULTS

A. Normality Test and Paired Sample T-Test Flowrate

1) Setting Flowrate 50 ml/h

Based on TABLE XII it can be concluded that the data are normally distributed because the significance value is more than 0.05, then based on TABLE XIII, it can be concluded from the data generated that is accepted. Where significant > 0.05, there

is no difference in the results of the use of different technologies for the vertical form of infusion and horizontal form infusion.

Based on TABLE XIII, it can be concluded from the data generated that is accepted. Where significant > 0.05, there is no difference in the results of the use of different technologies for the vertical form of infusion and horizontal form infusion.

TABLE VI NORMALITY TEST FLOWRATE 50 ML/H ONE-SAMPLE KOLMOGOROV-SMIRNOV TEST

		Vertikal	Horizontal
N		5	5
Normal Parameter[a,b]	Mean	52.4320	52.4460
	Std. Deviation	.11606	.09889
Most Extreme Differences	Absolute	.245	.307
	Positive	.186	.258
	Negative	-.245	-.307
Test Static		.245	.307
Asymp. Sig. (2-tailed)		.200[c,d]	.138[c]

a. Test distribution is Normal
b. Calculated from data
c. Lilliefors Significance Correction
d. This is a lower bound of the true significance

TABLE VII T-TEST FLOWRATE 50 ML/H PAIRED SAMPLES TEST

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Internal of the Difference				
					Lower	Upper			
Pair 1	Vertikal - Horizontal	-.01400	.21078	.09427	-.27572	.24772	-.149	4	.889

2) Setting Flowrate 100 ml/h

TABLE VIII NORMALITY TEST FLOWRATE 100 ML/H ONE-SAMPLE KOLMOGOROV-SMIRNOV TEST

		Vertikal	Horizontal
N		5	5
Normal Parameter[a,b]	Mean	101.8300	101.8240
	Std. Deviation	.10050	.7925
Most Extreme Differences	Absolute	.291	.181
	Positive	.187	.169
	Negative	-.291	-.181
Test Static		.291	.181
Asymp. Sig. (2-tailed)		.194[c]	.200[c,d]

a. Test distribution is Normal
b. Calculated from data
c. Lilliefors Significance Correction
d. This is a lower bound of the true significance

TABLE IX T-TEST FLOWRATE 100 ML/H PAIRED SAMPLES TEST

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Internal of the Difference				
					Lower	Upper			
Pair 1	Vertikal - Horizontal	.00600	.11653	.05212	-.13870	.15070	.115	4	.914

Based on TABLE XIV, it can be concluded that the data is normally distributed because the significance value is greater than 0.05. And based on TABLE XV, it can be concluded from the data generated that is accepted. Where significant > 0.05, there is no difference in the results of the use of different technologies for the vertical form of infusion and horizontal form infusion.

3) Setting Flowrate 200 ml/h

Based on TABLE XVI it can be concluded that the data is normally distributed because the significance value is greater than 0.05. Based on TABLE XVII, it can be concluded that from the data generated, Ho is received. Where Ho is there is no difference in the results of the use of different technologies for the vertical form of infusion pump and horizontal form infusion pump.

TABLE X NORMALITY TEST FLOWRATE 200 ML/H ONE-SAMPLE KOLMOGOROV-SMIRNOV TEST

		Vertikal	Horizontal
N		5	5
Normal Parameter[a,b]	Mean	198.1640	198.1900
	Std. Deviation	.10597	.12942
Most Extreme Differences	Absolute	.261	.279
	Positive	.261	.260
	Negative	-.191	-.279
Test Static		.261	.279
Asymp. Sig. (2-tailed)		.194[c,d]	.200[c,d]

a. Test distribution is Normal
b. Calculated from data
c. Lilliefors Significance Correction
d. This is a lower bound of the true significance

TABLE XI T-TEST FLOWRATE 200 ML/H PAIRED SAMPLES TEST

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Internal of the Difference				
					Lower	Upper			
Pair 1	Vertikal - Horizontal	-.02600	.15291	.06838	-.21586	.16386	-.380	4	.723

B. Normality Test and Paired Sample T-Test Occlusion

1) Setting Flowrate 50 ml/h

TABLE XII OCCLUSION NORMALITY TEST 50 ML / H ONE-SAMPLE KOLMOGOROV-SMIRNOV TEST

		Vertikal	Horizontal
N		5	5
Normal Parameter[a,b]	Mean	12.7120	12.6460
	Std. Deviation	.19627	.26473
Most Extreme Differences	Absolute	.273	.320
	Positive	.260	.188
	Negative	-.273	-.320
Test Static		.273	.320
Asymp. Sig. (2-tailed)		.200[c,d]	.105[c,d]

a. Test distribution is Normal
b. Calculated from data

c. Lilliefors Significance Correction
d. This is a lower bound of the true significance

Based on TABLE XVIII it can be concluded that the data are normally distributed because the significance value is more than 0.05. Based on TABLE XIX, it can be concluded that from the data generated, Ho is received. Where Ho is there is no difference in the results of the use of different technologies for the vertical form of infusion pump and horizontal form infusion pump.

TABLE XIII T-Test Occlusion Test 50 ml / h PAIRED SAMPLES TEST

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Internal of the Difference				
					Lower	Upper			
Pair 1	Vertikal - Horizontal	.06600	.10854	.04854	-.06876	.20076	1.360	4	.246

2) Setting Flowrate 100 ml/h

Based on TABLE XX below it can be concluded that the data are normally distributed because the significance value is more than 0.05. and T-test results based on the TABLE XXI occlusion measurements with a set point of 100 ml/h yielded significant results in the form of the vertical infusion pump and a horizontal infusion pump is 0.374. Then it can be concluded that from the data generated, Ho is received. Where Ho is there is no difference in the results of the use of different technologies for the vertical form of infusion pump and horizontal form infusion pump.

TABLE XIV OCCLUSION NORMALITY TEST 100 ML / H ONE-SAMPLE KOLMOGOROV-SMIRNOV TEST

		Vertikal	Horizontal
N		5	5
Normal Parameter[a,b]	Mean	14.5280	14.5220
	Std. Deviation	.01789	.02168
Most Extreme Differences	Absolute	.345	.245
	Positive	.255	.245
	Negative	-.345	-.244
Test Static		.345	.245
Asymp. Sig. (2-tailed)		.053[c,d]	.200[c,d]

a. Test distribution is Normal
b. Calculated from data
c. Lilliefors Significance Correction
d. This is a lower bound of the true significance

TABLE XV T-TEST OCCLUSION TEST 100 ML / H PAIRED SAMPLES TEST

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Internal of the Difference				
					Lower	Upper			
Pair 1	Vertikal - Horizontal	.00600	.01342	.00600	-.01066	.02266	1.000	4	.374

3) Setting Flowrate 200 ml/h

Normality test results on occlusion measurements with a set point of 200 ml/h, with many measurements on vertical and horizontal infusion pumps, as many as 5 measurements. Based on TABLE XXII bellow, it can be concluded that the data are normally distributed because the significance value is more than 0.05.

The results of the t-test based on the above table on occlusion measurements with a set point of 200 ml/h yielded significant results in the form of a vertical infusion pump and a horizontal infusion pump can be concluded that from the data generated, Ho is received. Where Ho is there is no difference in the results of the use of different technologies for the vertical form of infusion pump and horizontal form infusion pump.

TABLE XVI OCCLUSION NORMALITY TEST 200 ML/H ONE-SAMPLE KOLMOGOROV-SMIRNOV TEST

		Vertikal	Horizontal
N		5	5
Normal Parameter[a,b]	Mean	14.5980	14.5980
	Std. Deviation	.03033	.03033
Most Extreme Differences	Absolute	.324	.324
	Positive	.324	.324
	Negative	-.276	-.276
Test Static		.324	.324
Asymp. Sig. (2-tailed)		.095[c,d]	.095[c,d]

a. Test distribution is Normal
b. Calculated from data
c. Lilliefors Significance Correction
d. This is a lower bound of the true significance

TABLE XVII T-TEST OCCLUSION TEST 100 ML / H PAIRED SAMPLES TEST

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Internal of the Difference				
					Lower	Upper			
Pair 1	Vertikal - Horizontal	.00000	.05148	.02302	-.06392	.06392	0.000	4	1.000

IV. DISCUSSION

Measurement of vertical infusion pump output and horizontal infusion pump have been fully measured and tested in this study. By measuring the number of drops and occlusion with several parameters (50 ml / h; 100 ml / h; 200 ml / h).

By comparing the output of the vertical infusion pump and the horizontal infusion pump, there is no difference in the results of using different technologies for the vertical form of the infusion pump and horizontal infusion pump. This can be known based on the results of the T-test where the significant value is greater than 0.05, which means that the null hypothesis is accepted while the alternative hypothesis is rejected.

V. CONCLUSION

This study shows the difference in technology does not affect the infusion pump output either horizontally or vertically. This study proves that both horizontal infusion pumps and vertical infusion pumps are suitable for supporting hospital needs. This study can be used as a reference for hospitals or other health facilities. In the future, this study can be improved by measuring the drip results by comparing several types of infusion fluids that represent different fluid densities.

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