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Dunn method suitability in umbilical catheter length prediction on Newborns compared to Shukla

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ABSTRACT: Umbilical vessels catheters, especially Umbilical vein catheters (UVCs) are commonly inserted in newborns hospitalized in neonatal intensive care units (NICU). It is a suitable method for controlling electrolytes, blood gases, measuring central venous pressure, continuous monitoring of blood pressure and frequent blood sampling and continuous infusion of fluids. Despite the benefits and applications of umbilical venous catheter, it is associated with complication due to insertion of umbilical venous catheter in an inappropriate location. These complications can be life-threatening. Due to increasing use of Dunn and Shukla techniques, the present study aims to examine the accuracy of Umbilical vein catheters using Dunn and Shukla techniques in predicting the length of umbilical catheters in newborns hospitalized in the neonatal intensive care unit (NICU) of Children's Hospital of Bandar Abbas, Iran. This prospective observational study examines the success of Umbilical vein catheters by Dunn and Shukla methods in 2012. The population consisted of all newborns hospitalized in NICU at Children's Hospital. For this purpose, 100 infants hospitalized in NICU at Children's Hospital were divided into Dunn (42 patients) and Shukla (58 patients) groups to compare the accuracy of catheterization by these two methods. After inserting catheter, plain abdominal x-ray was prepared to determine the location of catheter tip. Data were statistically analyzed using SPSS 16.There was no significant difference between two groups in terms of birth weight, gender, gestational age and mean duration of umbilical venous catheter placement. After gathering required data on accuracy of umbilical venous catheter insertion, the accuracy was divided into three levels of correct, low and high. The frequencies of three levels were separately analyzed in both groups using Chi-square test. The results showed that rate of corrected catheter insertion were higher in compare with low or high catheter insertion in Shukla group. This finding was not observed in Dunn group. Also, the accuracy of Umbilical vein catheters (UVCs) was investigated in terms of gestational age and birth weight. The results showed that Shukla method was more appropriated than dunn method in birth weight less than 1500 g. and Shukla method led to better results of correct catheter insertion compared with low and high catheter insertion in birth weight less than 1500 g. ($X2= 11.40$, $p <0.003$). Our results showed that Shukla method was more appropriated than dunn method in gestational age less than 36 weeks and Shukla method led to better results of correct catheter insertion compared with low and high catheter insertion in gestational age less than 36 weeks ($x2= 9.34$, $p <0.009$).
Conclusion: The results of the present study showed that Shukla method is more suitable than Dunn method. Moreover, Shukla method led to more accurate results in lower birth weights and gestational ages.

Keywords: Umbilical Venous Catheter, Shukla Method, Dunn Method

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INTRODUCTION

Umbilical vessels catheters, especially Umbilical vein catheters (UVCs) are commonly inserted in newborns hospitalized in neonatal intensive care units (NICU). These catheters are commonly used since 1959. It is a suitable method for controlling electrolytes, blood gases, measuring central venous pressure, continuous monitoring of blood pressure and frequent blood sampling and continuous infusion of fluids (Möller Et al., 1995). Despite the benefits and applications of umbilical venous catheter, its potential complications must also be considered. The complications including subsequent infection of umbilical venous catheterization, intestinal necrosis, thrombosis, ascites, hydrothorax, cardiac tamponade, cardiac arrhythmias and pleural effusion and pericarditis can be life-threating (Bradshaw et al., 2006; Furdon et al., 2006; Baker et al., 1969).

The complications may be due to insertion of catheter in an inappropriate location. Thus, it is vital to determine the appropriate penetration length of umbilical venous catheter. Thus, imaging procedures such as plain abdominal x-ray and sonography are needed after catheter insertion to specify the location of catheter tip (Nash et al.,

2006; Narla et al., 1991; Neal et al., 1972). In addition to preventing complications, insertion of umbilical venous catheter in an appropriate location is essential for umbilical catheterization effectiveness. There are different methods to determine the length of catheter which must be inserted in umbilical vessels. Among them, Dunn and Shukla methods have been widely used in the world (Korver et al., 2007; Pabalan et al., 2007). These two methods have also been approved in Iran.

Dunn method is based on the distance from shoulder to umbilicus. After measuring the distance based on monogram, the penetration length of umbilical venous catheter is determined. Dunn method was used to insert umbilical venous catheter in 50 newborns. Acceptable results were obtained and the catheter tip was inserted in an appropriate location (Korver et al., 2007). In Shukla method, the penetration length of umbilical venous catheter is determined based on birth weight (Verheij et al., 2007). According to previous studies, Shukla method also has a remarkable accuracy. However, the accuracy of these two methods in estimating the length of umbilical venous catheter has not still demonstrated (Verheij et al., 2007). Given the above-mentioned side effects due to insertion of umbilical venous catheter in an inappropriate position as well as the increasing use of these two methods, the present study aims to examine the accuracy of Umbilical vein catheters (UVCs) in predicting the length of umbilical catheters in newborns hospitalized in neonatal intensive care unit (NICU) at Children's Hospital of Bandar Abbas, Iran.

MATERIALS AND METHODS

This prospective observational study examines the success of Umbilical vein catheters (UVCs) by Dunn and Shukla methods in 2012. The statistical population consisted of all newborns hospitalized in NICU at Children's Hospital of Bandar Abbas. Our sample was selected using random sampling method. The sample size was 103 newborns. The subjects were divided into Shukla and Dunn groups based on the type of umbilical venous catheterization. A sample size of 60 and 43 was calculated respectively for Shukla and Dunn groups with a confidence level of 95% and power of 80%. We included all newborns hospitalized in NICU connected to ventilators who needed frequent sampling for blood gas analysis and laboratory specimens and newborns who peripheral IV line was not possible for them. Newborns with omphalitis, coagulation disorders, bleeding, peritonitis, jaundice, omphalocele and NEC were excluded.

In the first phase of the present study from April to September 2012, the catheter length for all newborn was determined using the Formula (Shukla) method. In this case, the length of umbilical venous catheter was calculated as follows: ((birth weight×3+9)/2) +1. In the second phase of study from October to March, the catheter length was measured using Chart method (nomograms of Dunn). In this case, the distance from shoulder to umbilicus was measured to insert catheter. Then, the penetration length of umbilical venous catheter was determined based on standard tables.

To determine of catheter location tip, radiographs of anterior-posterior chest and abdomen were prepared. Lateral radiographs of the chest were not routine. The ideal location for placement of the catheter tip was between the ninth and tenth spine vertebra level. Catheters with a tip above the ninth vertebrate and below tenth vertebrate were considered as High and Low, respectively. Ultrasonography was not performed routinely for all infants to rule out complications of catheterization. Thus, complications were ruled out only based on plain abdominal x-ray and clinical symptoms. To avoid bias, radiographs were reported by a neonatologist without specifying catheterization method.

The primary outcome was the number of successful UVCs which was confirmed by X-ray. The secondary outcome was catheterization complications. After identifying subjects qualified to participate in the study, information such as name, gestational age at birth, gender, weight, catheterization procedure (Shukla or Dunn) , and catheter-related complications such as thrombosis, pleural and pericardial effusion, myocardial perforation, and cardiac arrhythmias Were recorded.

Both Chart and Formula methods have been approved in Iran. Parental consent was not required for the type of catheterization and only an Informed consent was obtained for entrance to study. For neonates with a weight less than 3.5 kg, catheters No. 5 and for those with a weight more than 3.5 kg, catheters No. 8 (Made in France) were used for catheterization. Collected data were done by SPSS 16 and analyzed using t-test and Chi-square methods.

RESULTS

In this study, 103 infants were studied in two similar groups. Of this, three cases were excluded, because the catheter was incorrectly placed in umbilical artery. In 58 cases (58%) was using Formula (Shukla) method. And in 42 (42%) neonates, using Chart method. Of 100 infants, 58 were male and 42 were female. The minimum and maximum gestational age was 25 and 42 weeks, respectively. The minimum and maximum birth weight was 500 and 3800 g, respectively. To verify the accuracy of insertion of catheter in ideal location and its possible complications, plain abdominal x-ray were used. In Chart group, the umbilical venous catheter was in correct, low and high positions in 19, 14 and 9 cases, respectively. In Formula group, the umbilical venous catheter was in correct, low and high positions in 32, 10 and 16 cases,

respectively. Umbilical venous catheter-related complication of hemorrhage was observed in two cases.

The Chi-square test was used to compare the observed frequencies at three levels of correct, high and low.

Table 1 show there is a significant difference between frequencies of three levels in Formula group (x^2=13.37, p <0.001). However, no significant difference was found between frequencies of three levels in Chart group (x^2=3.57, p <0.168). More cases of correct insertion of catheter were observed in Formula group compared with low or high insertion. This result was not observed in Chart group.

Another analysis was done to determine the role of birth weight in correct insertion of catheter. The correct insertion was compared with low or high insertion in Formula and Chart groups separated by weight lower and higher than 1500 g. Analysis results are presented in following charts and table.

Table 2 shows, the Formula method led to better results of correct catheter insertion compared with low and high insertion in neonates with a weight less than 1500 g (x^2=11.40, p <0.003).also, the Formula method led to more cases of correct catheter insertion compared to low and high insertion; a finding that was not observed in Chart method.

Another analysis was done to determine the role of gestational age in correct insertion of catheter. The correct insertion was compared with low or high insertion in Formula and Chart groups for newborns with a gestational age lower and higher than 36 weeks. The Chi-square test was used to compare the observed frequencies at three levels of correct, high and low. The results are presented in Table 2. The Chi-square test was used to compare the observed frequencies at three levels of correct, high and low. The results are presented in Table 3. Table 3 shows, the Formula method led to better results of correct catheter insertion compared with low and high insertion in gestational age of lower than 36 weeks (x^2= 9.34, p<0.009).

Table1.compare the frequencies Shukla and Dunn method at three levels of correct, high and low

Group	χ^2	Df	P
Dunn-method	3.571	2	**0.168**
Shukla-method	13.379	2	**0.001**

Table2. Frequencies of correct, high and low insertion in Shukla and Dunn methods separated by weight lower and higher than 1500 g

Group	Group	χ^2	Df	P
<1500 gr	Dunn-method	1.80	2	**0.40**
	Shukla-method	11.40	2	**0.003**
>1500 gr	Dunn-method	3.71	2	**0.15**
	Shukla-method	2.36	2	**0.30**

Table3. Frequencies of correct, high and low insertion in Shukla and Dunn methods for gestational age upper and lower than 36 weeks

Group	Method	χ^2	df	P
<36 weeks	Dunn-method	2.16	2	**0.33**
	Shukla-method	9.34	2	**0.009**
>36 weeks	Dunn-method	3	2	**0.22**
	Shukla-method	9.34	2	**0.009**

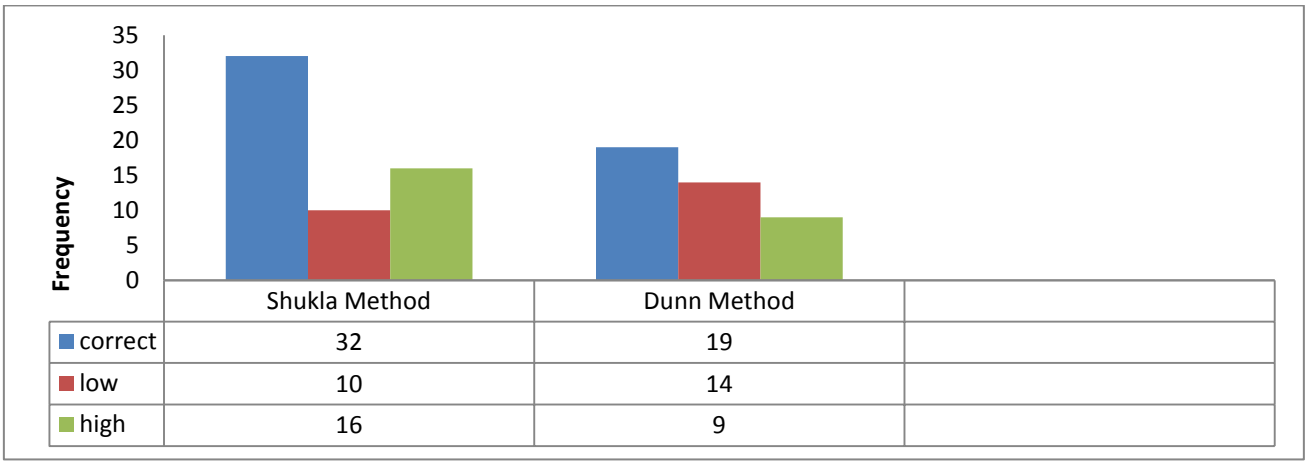

Fig 1.Frequency of Shukla and Dunn method at three levels of correct, high and low

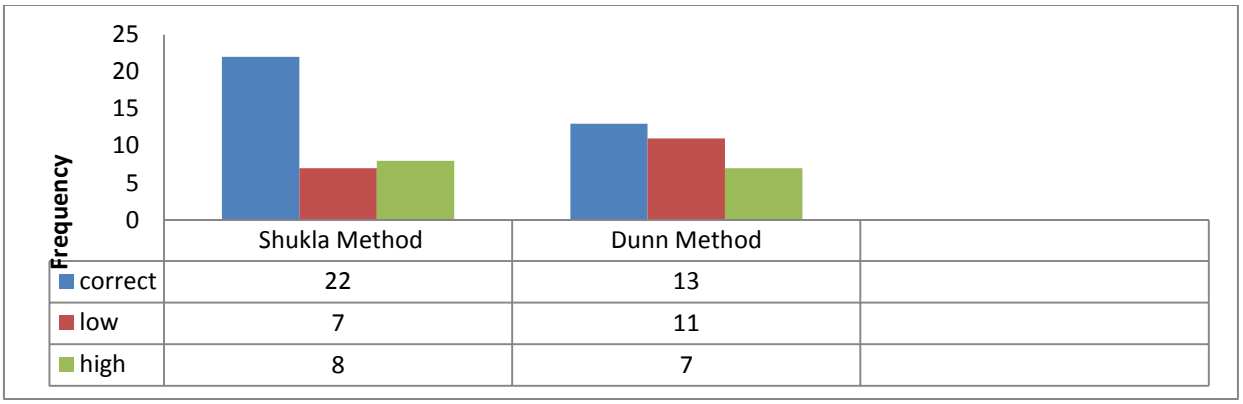

Fig2. Frequencies of right, high and low insertion in Shukla (Formula) and Dunn (Chart) methods for neonates weighed lower than 1500 g

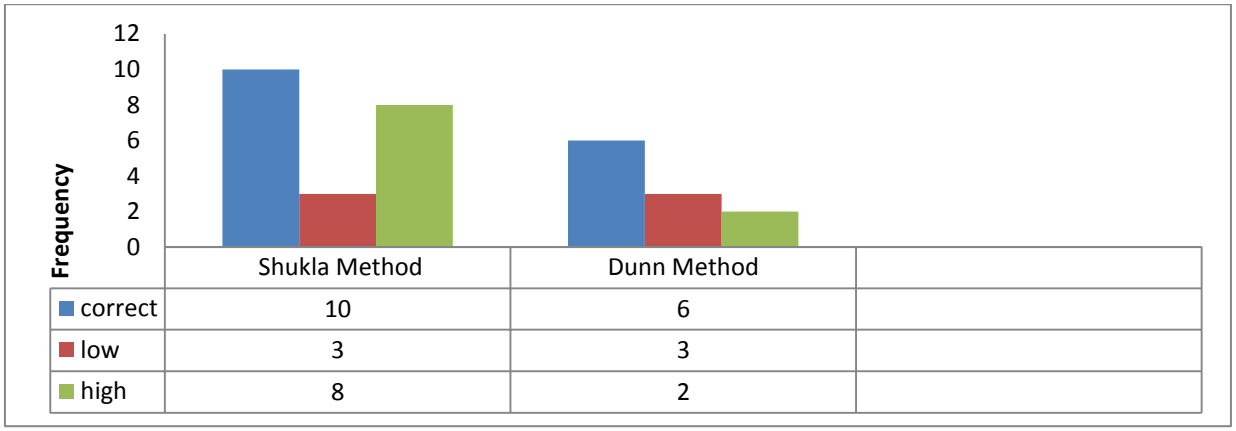

Fig 3. Frequencies of right, high and low insertion in Shukla (Formula) and Dunn (Chart) methods for neonates weighed up1500 g

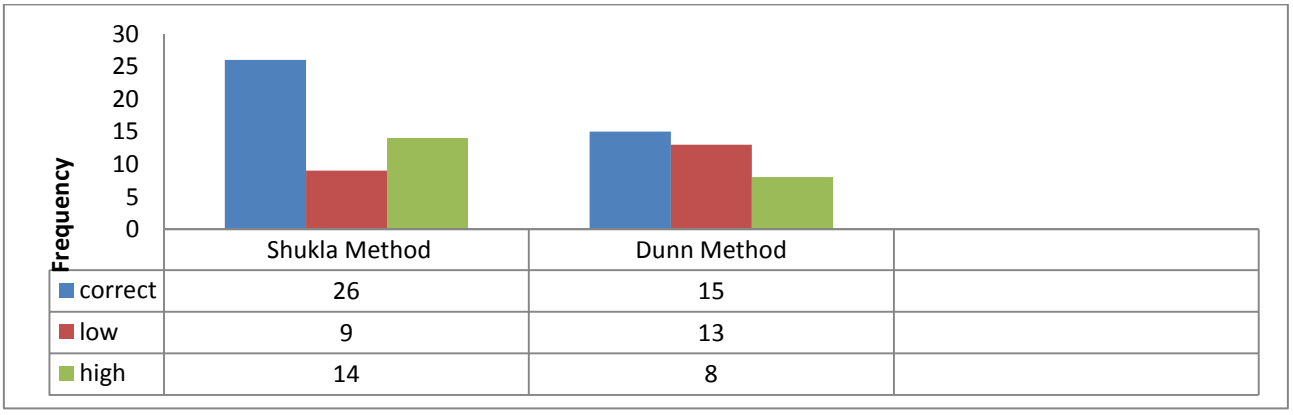

Fig 4. The frequencies of correct, low and high insertion of catheter in the group with gestational age lower than 36 weeks

DISCUSSION

The present study compared the accuracy of two commonly used methods of Dunn and Shukla in predicting the length of umbilical catheters in age and weight groups of neonates hospitalized in NICU of Children's Hospital of Bandar Abbas, Iran. The results showed that the accuracy of catheterization using Formula method is higher than Chart method. However, the results of Verheij et al. (2010), showed that the Chart method was more accurate than Formula method in assessing the appropriate length of umbilical venous catheter (Verheij et al., 2007).

In the present study, about 51% of umbilical venous catheters were inserted in a correct location. This finding is in agreement with the results of Biban et al. who investigated the effectiveness of UVCs using Chart and Formula methods. His results showed that 50% of catheters were in a correct location (Biban et al., 1999). This confirms the results of the present study.

The results showed more cases of correct insertion of venous catheter compared with low or correct insertion in Formula group. But such a finding was not observed in Chart group. However, Verheij et al. found that Chart method is more suitable for insertion of umbilical venous catheter such that number of high insertion was more than correct or low insertion (Verheij, 2007). Meberg conducted a retrospective study entitled "umbilical venous catheter placement in an inappropriate position." The results showed that the number of venous catheters placed in Low position was more than venous catheters placed in correct and high positions (Meberg et al., 2010). One possible explanation is that the position of catheter tip in Shukla and Dunn study was in the right atrium like the present study (Dunn et al., 1966; Shukla et al., 1986). But, the position of catheter tip in Greenberg's study and Hermansen's study was at the junction of the inferior vena cava and right atrium (Greenberg et al., 1995; Hermansen and Hermansen, 2005).

Birth weight is one of the factors affecting the accuracy of umbilical venous catheter insertion. In this study, the mean birth weight of newborns was 1475 g. To investigate the role of birth weight in correct insertion of catheter, two groups of infants with a weight less and higher than 1500 g were compared. The results showed that Formula method led to better results in newborns with a weight less than 1500 g. In other words, Formula method was more accurate for lower weights. Another factor influencing the accuracy of Umbilical vein catheters (UVCs) is gestational age. To investigate the role of gestational age in correct insertion of venous catheter, newborns with gestational above and below 36 weeks were compared. The results showed that Formula method led to better results in the group with gestational age less than 36 weeks. In other words, formula method was more accurate in lower gestational ages. According to verheij et al. there was a direct relationship between higher birth weights and the accuracy of umbilical venous catheter placement by Formula method (Verheij, 2007). The inconsistency could be due to low sample size (Lopriore et al., 2008; Verheij et al., 2013).

In the present study, two cases of hemorrhage were observed after catheterization. In a study conducted by Van Vliet et al., 11.5% of complications were hemorrhage due to UVCs. (Van Vliet and Gupta, 1973). this indicates the need for necessary measures to avoid this complication.

In one case, after umbilical venous catheterization, chest and abdomen x-ray revealed that the catheter is placed in the liver. After trying, initial result was repeated. Further evaluation showed that patient had congenital liver anomaly. Since there is no similar report in other studies, this could suggest further studies for diagnostic use of UVCs in cases of suspected liver anomalies.

The present study had three limitations. First, only chest x-ray was used. Although this method was suitable for determining the precise location of umbilical venous catheter, more accurate diagnostic procedures such as sonography was required to diagnose catheter-related complications such as thrombosis. Second, catheterization was done by almost 16pediatrics. This may effects on the quality of catheterization. The last limitation was short duration of catheter placement in the umbilical vein. Seven to ten days and more than 28 days placement are considered as short-term and long-term catheter placement, respectively (Weber, 1974). In this study, in 99% of cases, catheterization was short-term and just in one case catheterization lasted 13 days. Therefore, the comparison between short-term and long-term catheterization will not be significant.

According to the results of the present study, catheterization by Formula method is more accurate than Chart method. Furthermore, Formula method is more accurate in lower gestational ages and birth weights. It is recommended to conduct studies with larger sample size to confirm findings of the present study. To determine the precise location of the catheter, more accurate diagnostic methods such as sonography should be used. Employing fixed pediatrics for catheterization could help further validation of the results. Finally, the duration of catheter placement should be based on available standards. In this way, duration of short-term and long-term catheterization could be compared. However, there is still a critical need for new catheterization method; a method that may overcome the limitations of these two methods.

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