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Original Research Article

Accuracy of Shukla's formula for depth of insertion of umbilical venous catheter

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ABSTRACT

Background: The use of umbilical venous catheter (UVC) is an essential part of neonatal care allowing delivery of intravenous fluids, nutrition, and medication. It is important to know the position of the UVC tip accurately at the first attempt to prevent complications and minimize handling. We aimed to determine the precision and accuracy of Shukla's formula developed to guide UVC placement and to evaluate the probability of UVC placement at desired radiological markings using weight-based Shukla's formula.
Methods: This study was carried out at NICU in NRI medical college, a tertiary care center in Chinakakani, Andhra Pradesh, India. A prospective observational study was done from December of 2021 to September 2022. With an aim to study the accuracy of Shukla's formula in assessing the depth of insertion of UVC, depth was calculated and position of the tip of the catheter confirmed by x-ray.
Results: We have taken 138 neonates in our NICU unit with mean gestational age of 33.91 wks. and with mean birth weight of 1.91 kg. Out of 138 infants 99 had a successful ideal UVC placement using Shukla's formula. In reference to gestational age out 83 newborns in gestational age between 32-36 weeks 62 had ideal placement of UVC. In reference to birth weight ideal position of the UVC was seen in 73% of newborns.
Conclusions: Shukla's formula provided a reasonably accurate probability of achieving ideal UVC position in most of our babies: accurate in 72%.

Keywords: UVC, Shukla's formula, Depth of insertion, NICU, UVC

INTRODUCTION

Umbilical venous catheter (UVC) placement is a common neonatal procedure. The use of UVC is an essential part of neonatal care allowing delivery of intravenous fluids, nutrition, and medication. An UAC allows blood to be taken from an infant at different times, without repeated needle sticks. It can also be used to continuously monitor a baby's blood pressure. An UVC allows fluids and medicines to be given without frequently replacing an intravenous (IV) line.[1]

Indications for insertion of UVC are: central venous access for low-birth-weight infants to avoid multiple peripheral cannulations, delivery of drugs and parenteral nutrition, emergency vascular access for resuscitation of infants at birth, exchange transfusion.[2] Few of the contraindications are: Abnormalities of the abdominal wall, necrotising enterocolitis, peritonitis. Complications which we may be due to UVC catheterization: sepsis, embolism, venous thrombosis, pericardial effusion, pleural effusion, portal hypertension, displacement leading to blood loss, breakage of catheter on removal, intra-abdominal extravasation.[2-9]

It is important to position the UVC tip accurately at the first attempt to prevent complications and minimise handling. Catheters positioned too low need to be removed, but catheters positioned too high may be withdrawn in a sterile fashion to a safe position. We aimed to determine the precision and accuracy of Shukla's formula developed to guide UVC placement.

Depth of insertion of UVC is generally calculated either by using surface markings/ BW of baby. Some well-known internationally used formulas are: Using surface markings: 1. Dunn method using vertical shoulder-umbilical distance (Dunn vertical), 2. Dunn method using diagonal shoulder-umbilical distance (Dunn diagonal), 3. Umbilical to nipple distance-1 cm (UN-1) and 4. Umbilical to inter mammary distance (UIMD). Using birth weight (BW): 1. ((BW×3+9)/2) +1 (Shukla's method) and 2. (BW×3+9)/2 (Modified Shukla).[10-14]

Aim of the study was to evaluate the probability of UVC placement at desired radiological markings using weight-based Shukla's formula.

METHOD

Study place

This study was carried out at NICU in NRI medical college, a tertiary care center in Chinakakani, city of Andhra Pradesh, India.

Study design and period

A prospective observational study was done from December of 2021 to September 2022.

Selection criteria

All the neonates admitted to our NICU unit during the above period requiring UVC. All babies with congenital anomalies affecting thorax or abdomen and babies with skeletal dysplasia are excluded to maintain uniformity.

Study size

A total of 138 neonates admitted to our NICU unit required UVC insertion.

Procedure

Formula was used to calculate the UVC placement depth. Then catheter tip localization was done and confirmed radiologically by x rays. X-rays were taken both in anteroposterior view and lateral view.[15] Theoretical positions using formulae were compared with actual measurements on the x ray were then classified as ideal, high, low or malposition by T9-T10 method.[16] Ideal position of UVC was when the tip of the catheter was at the upper border of T9 to lower border of T10. High position was when the catheter tip was above upper border of T9. Low is when the tip is below lower border of T10. Catheter tip was said to be mal positioned anywhere else apart from IVC of ductus venosus.

Mothers were interviewed for relevant data which was recorded in a predetermined forum. Data were collected for following variables: gestational age, birth weight, UVC depth as calculated by Shukla's formula, Gender of baby, SGA or AGA, location of tip as seen in radiological studies. Then mean and standard deviation were calculated depending on underlying distribution of the data. A prospective observational study was done. Probability of achieving ideal UVC position in the neonates were calculated. Probability of ideal position in reference to different variables were calculated. Results were compared with previous studies.

Table 1: Baseline collections of data.

Variables	Min	Max	Mean	SD
Gestational age (weeks)	27	40	33.91	2.85
Birth weight (kg)	0.62	4.20	1.92	0.64
UVC calculated	6.4	11.8	8.38	0.96

Table 2: Data collected in reference to birthweight, gestational age, AGA/SGA, position.

Variables		N	Percentage (%)
Birth weight (kg)	0.50-1.49	37	26.8
	1.50-2.49	69	50.0
	2.50-3.49	31	22.5
	3.50-4.50	1	0.7
Gestational age (Weeks)	27-31	23	16.7
	32-36	83	60.1
	37-40	32	23.2
AGA/SGA	AGA	99	71.7
	SGA	38	27.5
	LGA	1	0.7
Position	Low	26	18.8
	Normal	99	71.7
	High	13	9.4

Table 3: Data collection regarding position of UVC.

Variables		Position			Total
		Normal	High	Low	
Gender	Male	58	10	14	82
	Female	41	3	12	56
	Total	99	13	26	138
Gestational age (weeks)	27-31	17	2	4	23
	32-36	62	6	15	83
	37-40	20	5	7	32
	Total	99	13	26	138
Birth weight (kg)	0.5-1.49	26	2	9	37
	1.50-2.49	50	8	11	69
	2.50-3.49	22	3	6	31
	3.50-4.50	1	0	0	1
	Total	99	13	26	138
AGA/SGA	AGA	72	10	17	99
	SGA	26	3	9	38
	LGA	1	0	0	1
	Total	99	13	26	138

RESULTS

Ideal position of UVC

The 99 out of 138 newborns requiring UVC placement whose depth of insertion was calculated by Shukla's formula born and confirmed by the position of catheter tip on x-ray was at ideal position which is 72% i.e., majority of the newborns who were catheterized.

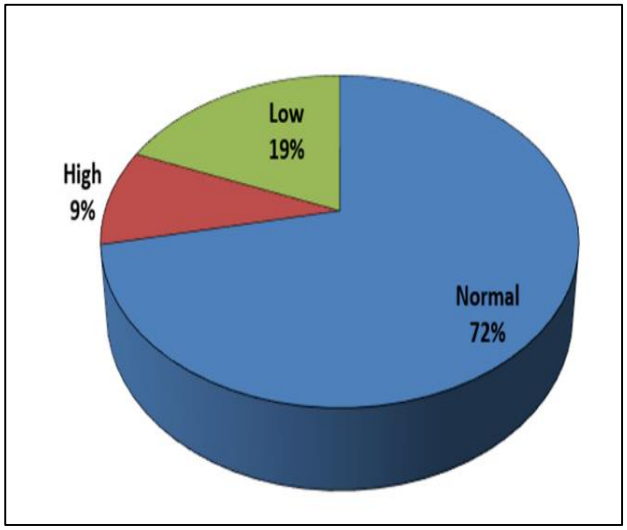

Figure 1: Percentage of successful ideally positioned UVC insertion.

Ideal position vs gender

Out of 56 females, UVC was in ideal position in 41 i.e., 73.2%. And out of 82 males, UVC was in ideal position in 58 i.e., 70.7%. Hence, our study showed no significant difference in position of the UVC tip in reference to gender.

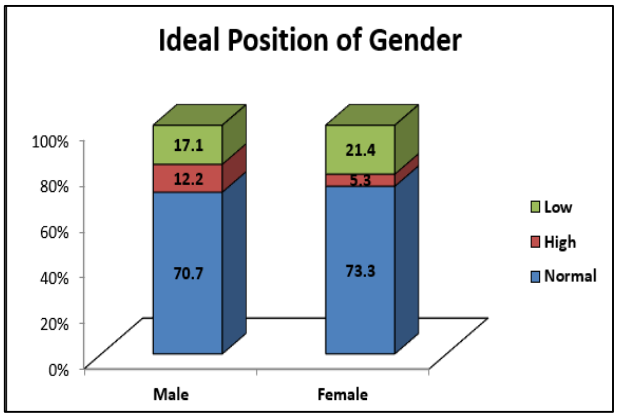

Figure 2: Ideal position versus gender.

Ideal position vs gestational age

Out of 83 infants in gestational weeks 32 to 36 weeks, 62 had ideal UVC placement i.e., 75%.

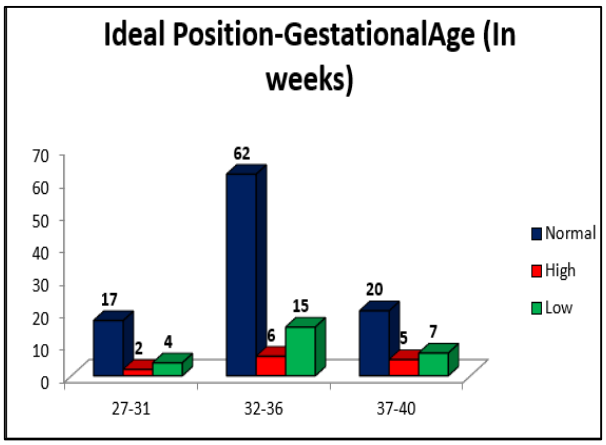

Figure 3: Ideal position versus gestational age.

Ideal position vs birth weight

In infants with birth weight between 1500 gm and 2500 gm ideal position of the UVC was seen in around 73% newborns.

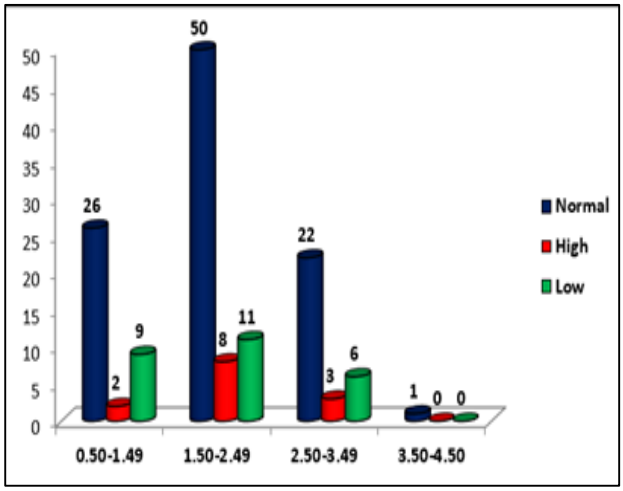

Figure 4: Ideal position versus birth weight.

DISCUSSION

Shukla's formula provided a reasonably accurate probability of achieving ideal UVC position in most of our babies: accurate in 72% with our median gestational age and weight were 33.91(27-40) weeks and 1.92 (0.620-4.20) kg compared to study done by Wei which had accuracy of 52.9% by using weight-based Shukla's formula. According to Lean et al of 118 eligible infants, 70 had the UVC tip in a position where measurements could be used. Their median (IQR) gestational age and weight were 28.5 (26-36) weeks and 1035 (745-2788) gm, respectively. A formula based on birth weight had the highest rate of correct position (52.9%).[17]

Risk of over insertion is less in our study 9.4%, when compared with Wei et al which is about 42.9% and according to Gomella et at where over insertion with Shukla's formula is 73%.[14,17] Low position in our study is high 19%, as compared to 1% according to Wei et al and 4.3% according to Gomella et al.[14,17]

The two most commonly used methods to predict the accurate depth of UVCS are the method of Dunn (based on measurement of the shoulder umbilicus length) and the method of Shukla.[10-13] According to Ayman, the probability of inserting ideal position of UVC by birth weight-based Shukla's formula (32.9%) is same as by surface marking method (40.2%).[18]

In a study conducted exclusively in pre-terms by Akar et al where UVC length was calculated using Shukla's formula, length of the catheter calculated according to the Shukla formula was intracardiac in 88.2% of premature infants.[19]

According to Shareef et al who compared Dunn's method using surface markings with Shukla's formula using birth weight. Dunn's method was more accurate than Shukla's method for determining the optimal insertion length of UVCs (45% vs. 25%, p=0.04); especially in infants with birth weight <1500 gm (59% vs. 11%, p=0.00296). Whereas, a significantly higher rate of highly positioned catheter tips was demonstrated in Shukla's method than in Dunn's method (73% vs. 51%, p=0.0264); and especially in infants with birth weight <1500 gm (89% vs. 35%, p=0.00104). This study showed that Dunn's method resulted in a higher rate of ideal insertion length of UVCs than Shukla's method. The rate of correctly positioned catheter tip was significantly high in Dunn's method especially in infants with birth weight <1500 gm. whereas, the rate of highly positioned catheter tip was significantly high in Shukla's method particularly in infants with birth weight <1500 gm.[20]

Gupta et al. conducted in 2015 and observational study compared Shukla's formula with other four morphometric measurements at varying birth weights and reported that in infants with birth weights ≤ 1500 gm, Shukla's formula resulted in (46%) correctly positioned UVC tips which is significantly higher than that observed in our study and (49%) catheter tips that positioned at high levels, a result which is significantly lower than the present study.[21]

Given the limited reliability of chest X-ray in determining the correct position of UVCs, ultrasonography should become one of the routine skills of all caregivers in neonatal wards involved in the placement of umbilical catheters. Specialists practicing in neonatal intensive care units could improve themselves and evaluate UVC with echocardiography, making this a routine part of clinical practice. Echocardiography-guided fixation of the catheter will reduce the complications related to catheter malposition.

CONCLUSION

Shukla's formula provided a reasonably accurate probability of achieving ideal UVC position in most of our babies: accurate in 72%.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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