Open Access

Original Article

Estimation of Accuracy of Umbilical Venous Catheter Insertion Depth using Body Weight or Body Measurement at a Tertiary Care Hospital in Peshawar

Shumaila Murtaza, Asma Razzaq*, Syed Awais Ul Hassan Shah, Asbah Rahman, Sadaf Ibrahim, Shakeel Ahmad**

Department of Pediatrics, Combined Military Hospital Peshawar/National University of Medical Sciences (NUMS) Pakistan, *Department of Pediatrics, Pak Emirates Military Hospital/National University of Medical Sciences (NUMS), Rawalpindi Pakistan, **Department of Pediatrics, Pakistan Air Forces Hospital, Peshawar Pakistan

ABSTRACT

Objective: To determine the accuracy of Umbilical Venous Catheter (UVC) depth of insertion using the body weight or body measurement method.

Study Design: Quasi-experimental study.

Place and Duration of Study: Neonatal Intensive Care Unit of Combined Military Hospital, Peshawar Pakistan, from Jan to Jun 2023.

Methodology: A total of 60 neonates who were passed UVC were included in the study. UVC depth insertion estimation was done by either Shukla method or by Dunn Normogram. Group-A had UVC depth of insertion estimated by body weight, while the Group-B had estimation using body measurement. Various demographic and clinical factors were recorded. The accuracy of UVC placement was then determined on an antero-posterior chest radiograph.

Results: Mean gestational age of 60 babies was 35.10±1.88 weeks and mean weight was 2.10±0.43kg. Of these 24(56.7%) were male babies, 41(68.3%) were born prematurely, 35(58.3%) had UVC placed on first or second day of life. Overall, success of a well-aligned UVC was 66.7% i.e. 40 neonates. UVC was well aligned in 16(53.3%) of the neonates measured by Shukla method, and 24(80%) plotted by Dunn Normogram. There was a statistically significant difference between methods (p=0.02).

Conclusion: The study concluded that a majority of Umbilical Venous Catheter (UVCs) are well aligned irrespective of the method used. When compared, the assessment by body measurement method fares significantly better than body weight method.

Keywords: Central Venous Catheterization, In-Dwelling Catheter, Neonate, Umbilical Cord, Umbilical Veins.

How to Cite This Article: *Murtaza S, Razzaq A, Shah SAH, Rahman A, Ibrahim S, Ahmad S. Estimation of Accuracy of Umbilical Venous Catheter Insertion Depth using Body Weight or Body Measurement at a Tertiary Care Hospital in Peshawar. Pak Armed Forces Med J 2026; 76(2): 221-225. DOI: https://doi.org/10.51253/pafmj.v76i2.12189*

INTRODUCTION

Pakistan has one of the highest neonatal mortality rates in the world. For any 1000 live births 42 babies die in Pakistan.[1] WHO aims to reduce neonatal mortality worldwide and bring it down to 12 per 1000 by the year 2030 and 10 per 1000 by 2035.[2] For this purpose a detailed Every Neonate Action Plan has been devised. Unlike previous guidelines, this time focus is not only on access to medical facility but also improving the quality of medical care.[3]

UVC is a common procedure in a neonatal unit of any tertiary care hospital. It may be used for emergency resuscitation of neonates but are mostly a mode of acquiring a painless central venous line.[4] UVCs are especially useful in premature and small for gestational age babies in whom peripheral lines through skin pricks are particularly painful and difficult. A majority of neonatal deaths occur amongst premature babies born before completion of gestational period.[5] In such babies, UVCs are essential for provision of drugs as well as nutrition during the early neonatal period. UVCs have been used for more than half a century but there is no consensus regarding the length of insertion or the total duration of dwelling time.

Estimation of depth of insertion of UVC was first attempted by Dunn. Results included a Normogram, and the mode of reference taken was body measurement.[6] However, in 1986. Fererra. attempted estimation using body weight as reference.[7] The possible advantage was that this would reduce the margin of error brought by an additional measurement and birth weight is recorded for all neonates as a routine procedure.[8-10]

We conducted this study to determine the accuracy of Umbilical Venous Catheter (UVC) depth of insertion using the body weight versus body measurement method

Correspondence: Dr Shumaila Murtaza, Department of Pediatrics, Combined Military Hospital Peshawar Pakistan

Received: 07 May 2024; revision received: 04 Aug 2024; accepted: 05 Aug 2024

METHODOLOGY

This quasi-experimental study was conducted at Neonatal Intensive Care Unit of Combined Military Hospital, Peshawar Pakistan, from January to July 2023. Ethical review board approval was obtained prior to the study from the hospital Ethical Review Committee (vide letter number 00250/23 dated 31-08-2022).

Inclusion Criteria: All inborn neonates, of either gender, undergoing Umbilical Venous Catheter (UVC) placement were included.

Exclusion Criteria: Neonates that had UVC placed for the purpose of resuscitation, those with major malformations of the thoracic or abdominal cavity, those with any dysmorphic features, and those with birth weight below the 3rd centile for gestational age were excluded.

Sample size was calculated taking accurate placement of umbilical catheters in 91% of patients by body weight method and 50% of patients by body measurement method, which came to 60.[11] Non-probability consecutive sampling technique was employed to collect data. Informed consent of all parents was taken. Figure-2 shows the patient flow.

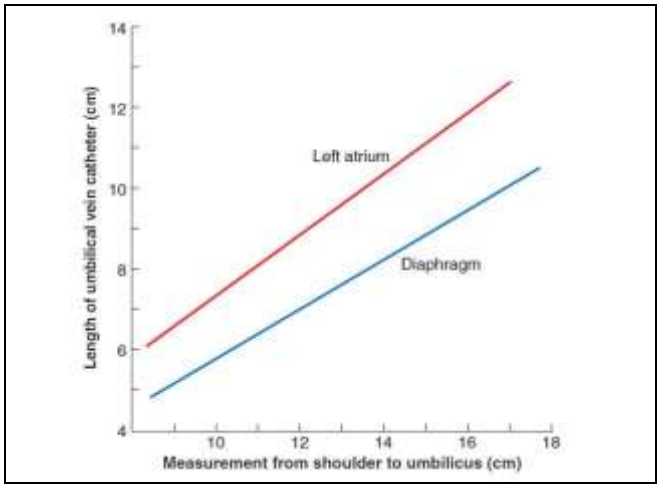

Figure-1: Dunn Normogram for Estimation of Depth of Umbilical Venous Catheter Insertion using Body Estimation

Accuracy of UVC depth estimation was compared between neonates who were placed UVC by body weight method (Group-A) and those with body measurement method (Group-B). Estimation of insertion depth by birth weight, for Group-A, was done using the Shukla formula. This formula calculates the UVC length as 1.5 times the body weight at birth in kilograms and addition of 5.6cm. In Group-B UVC was placed by estimation of insertion depth by body measurement using the Dunn method, in which the child is measured from the shoulder tip or the lateral end of clavicle perpendicularly downwards up till the level of umbilicus. This length in centimeters is known as the shoulder to umbilicus length and is then plotted onto the x-axis of the Dunn Normogram (Figure-1).[12] The umbilical catheter is then determined from the Y-axis of the normogram at a level in between the diaphragm and right atrium. In both methods, the length of the umbilical stump of that particular neonate is added to obtain the final length of insertion.

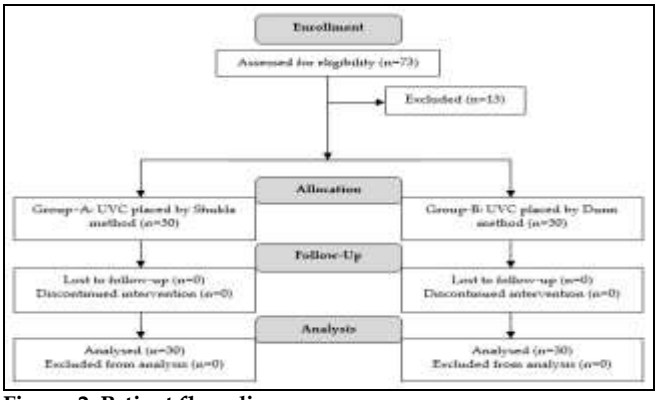

Figure-2: Patient flow diagram

Confirmation of tip placement was done with an anterior posterior chest radiograph done by a portable machine at the bedside. All catheters with a tip at or within 1.0cm above the diaphragm were taken as well-aligned. Basic demographic data, including gestational age, number of completed weeks and weight in kilograms at the time of birth, and clinical features pertaining to neonates under study were recorded. Prematurity was defined as any baby born before 37 completed weeks of gestation. Day of life at which UVC is placed was documented. Neonates catheterized at first or second day of life were placed in one category while all neonates catheterized on third day of life or later were noted separately.

Gender, prematurity, day of life (early or late) and success rate of UVC placements were expressed as frequencies and percentages. Statistical analysis was performed by using Statistical Package for Social Sciences (SPSS) 23. Both groups were analyzed for differences in weight and gestational age by independent samples t-test. Pearson chi-square was used to assess if there was a difference across groups with respect to gestational age, chronological age,

gender and UVC placement success rate. A *p*-value of less than or equal to 0.05 was considered statistically significant.

RESULTS

A total of 60 neonates were included in the study. Thirty babies had UVC measurement by Shukla method, while 30 had body measurements plotted on the Dunn Normogram for estimation of insertion depth. The mean gestational age was 35.10±1.88 weeks and mean weight was 2.10±0.43kg. Baseline demographic data showed that 24(56.7%) of these were male babies and 26(43.3%) were female. 41(68.3%) of babies were born prematurely while 19(31.7%) were full term babies. 35(58.3%) of these neonates had UVC placed on first or second day of life while 25(41.7%) had UVC placed on day three of life or later. Overall, success of a well-aligned UVC was 66.7% i.e. 40 babies irrespective of the method used. Table-I summarizes the basic characteristics of our sample population.

Table-I: Characteristics of Study Participants (n=60)

Gestational Age (weeks)	
Mean+SD	35.10±1.88 weeks
Range (min-max)	(31.0-39.0)
Weight (kgs)	
Mean+SD	2.10±0.43 kgs
Range (min-max)	(1.3-2.8)
Gender	
Male	34(56.7%)
Female	26(43.3%)
Prematurity	
No	41(68.3%)
Yes	19(31.7%)
Day of life	
less than 3 days	35(58.3%)
3 days or more	25(41.7%)
UVC placement	
Well-aligned	40(66.7%)
Misaligned	20(33.3%)

**UVC= Umbilical Venous Catheter*

Table-II illustrates the comparison of various characteristics between the groups and their statistical significance. The *p*-value was 0.685 and 0.929 respectively for gestational age and weight, hence statistically non-significant. Similarly, gender, chronological age and prematurity were equally distributed amongst both groups. The p-value was 0.795, 0.793 and 0.781 respectively and hence considered non-significant. UVC was well aligned in 16(53.3%) of the babies measured by Shukla method and 24(80%) plotted by Dunn Normogram. The difference was statistically significant (*p*=.002).

Table-II: Relationship of various factors with Method of Umbilical Veinous Catheter Insertion

Associative factors	Group-A n=30 n (%)	Group-B n=30 n (%)	*p*-value
Gestational Age			0.685*
Mean±SD	35.20±1.83 weeks	35.00±1.97 weeks	
Weight			0.929*
Mean±SD	2.107±0.450 kgs	2.097±0.420 kgs	
Gender			0.795**
Male	18(60.0%)	16(53.3%)	
Female	12(40.0%)	14(46.7%)	
Day of life			0.793**
less than 3 days	17(56.7%)	18(60.0%)	
3 days or more	13(43.3%)	12(40.0%)	
Prematurity			0.781**
Yes	20(66.7%)	21(70.0%)	
No	10(33.3%)	09(30.0%)	
Umbilical Veinous Catheter placement			0.028**
Yes	16(53.3%)	24(80.0%)	
No	14(46.7%)	06(20.0%)	

** Independent T-test. ** Pearson Chi-square test*

DISCUSSION

Our findings revealed that 33% Umbilical Veinous Catheters (UVCs) were not well aligned irrespective of the method adopted. Quality medical care requires standardization. Standardization of evidence-based practice is the corner stone to providing equitable neonatal care across Pakistan as has been highlighted by Haque *et al*.[13] Therefore it is vital that we determine the method that best suits our population and adopt it nationwide. Goh *et al.,* in their study of catheter related complications revealed that as many as one-third of all UVCs placed were malpositioned.[14] This is in coherence with our findings.

Overall success rate in our study, irrespective of the method of measurement chosen, was 66.7%. These are not the only methods adopted worldwide. As is expected any formula using body weight or measurement would need to be adjusted as per local population of that particular ethnicity.[15] Researchers in USA have come up with new formulas and developed software that can be used to calculate the length of insertion with a mobile.[16] The success rate of prediction by this application is 76% for venous catheters which is almost similar to overall success rate in or study. However, when compared to the Dunn method in our population, it does not fare well.

It is not only the method of depth of insertion that had a subject of speculation, but research has also been conducted on whether radiography is the best method of confirmation of tip location. A meta-

analysis by Cao *et al.,* in 2021 concluded that ultrasonography or echocardiography is better than simple radiographs.[17] However in Pakistan, these modalities may not be available at many centers. Moreover, both require considerable human hours and expertise which are both in dearth at neonatal units across Pakistan.

A 2019 study by Lean *et al.,* published in Archives of Diseases of Childhood Illnesses, fetal and neonatal edition compared five different methods of predicting depth insertion.[18] The accuracy of these formulas ranged from 44.9% to 55.7%. Formulas based on birth weight had the highest rate of correct estimation.

A review of literature pertaining to various aspects of UVC including depth of insertion estimation, dwelling time, choice of equipment, securing method and post procedural care was conducted in Italy in 2022.[19] While further highlighting the lack of standard protocols, it discussed the various methods of depth insertion currently in practice. It proclaimed that amongst the two discussed in our study, Shukla's method produced better results than Dunn's method. This is contrary to findings of our study. However, no statistical figures were provided by the researchers of this study to support their statement.

An extensive prospective observational study by Vejharis *et al.,* compared the body weight and body measurement methods for estimation of depth insertion of both UVCs and Umbilical Arterial Catheters in neonates.[20] Even though it was not as significant as in our study, it concluded that Dunn group had a considerably higher rate of success (41%) for venous catheters. They also proposed that Shukla's method was better when used for estimation of arterial catheters as compared to venous.

In our study, a majority of patients were premature in both experimental groups. Previously, Surak *et al.,* proved in 2021 that a misaligned UVC is more likely to occur in late preterm and term babies.[21] Similar effect was documented with increasing chronological age and in babies who were not small for gestational age. Such themes were not explored for their relationship with accuracy in our study. However, these factors were equally distributed amongst both experimental groups hence not significant for group analysis.

Further research would reveal if the results of our study are reproducible across all provinces and ethnicities of Pakistan and also exclusive focus on preterm or small for gestational age babies would further assist decision making regarding such neonates.

LIMITATIONS OF STUDY

We confirmed the correct placement of UVC with a chest roentgenograph. Whereas, the gold standard is bedside ultrasonography. We recognize this limitation; however, our method of confirmation was chosen due to lack of resources and lack of expertise. We hope that future studies will employ gold standard for confirmation.

CONCLUSION

In our study, the Dunn Normogram using body measurement as reference was better as compared to the Shukla method using body weight at birth for estimation of depth insertion of a Umbilical Veinous Catheter.

ACKNOWLEDGEMENT

The authors would like to thank the nurses working in our neonatal unit as they are a vital element for providing good neonatal care.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SM & AR: Data acquisition, data analysis, critical review, approval of the final version to be published.

SAHS & AR: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

SI & SA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Muzzamil M, Nisa M, Raza S. The survival rate of neonates in Pakistan: Problems in health care access, quality and recommendations. Health Promot Perspect 2022; 12(4): 355–357. http://dx.doi.org/10.34172/hpp.2022.46
2. Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, et al. Global, regional, and national causes of child mortality in 2000-13, with projections to inform post-2015 priorities: an updated systematic analysis. Lancet 2015; 385(9966): 430–440. http://dx.doi.org/10.1016/S0140-6736(14)61698-6
3. World Health Organization. Every newborn: an action plan to end preventable deaths 2014. (Internet). Accessed on March 25th 2024. Available from: https://www.who.int/initiatives/every-newborn-action-plan
4. Lewis K, Spirnak PW. Umbilical Vein Catheterization. 2023 Mar 19. In: StatPearls Treasure Island (FL): StatPearls Publishing 2023. (Internet). Accessed on March 25th 2024. Available from: https://www.ncbi.nlm.nih.gov/books/NBK549869/

5. Nisar YB, Dibley MJ. Determinants of neonatal mortality in Pakistan: secondary analysis of Pakistan Demographic and Health Survey 2006-07. BMC Public Health 2014; 14(1): 663. http://dx.doi.org/10.1186/1471-2458-14-663
6. Dunn PM. Localization of the umbilical catheter by post-mortem measurement. Arch Dis Child 1966; 41(215): 69–75. http://dx.doi.org/10.1136/adc.41.215.69
7. Shukla H, Ferrara A. Rapid estimation of insertional length of umbilical catheters in newborns. Am J Dis Child 1986; 140(8): 786–788.
8. Kaur A, Manerkar S, Patra S, Kalamdani P, Kalathingal T, Mondkar J. Ultrasound-guided umbilical venous catheter insertion to reduce rate of catheter tip malposition in neonates: A randomized, controlled trial. Indian J Pediatr 2022; 89(11): 1093–1098. http://dx.doi.org/10.1007/s12098-022-04295-w
9. Bhutta Z. Priorities in newborn care and development of clinical neonatology in Pakistan. J Coll Physicians Surg Pak 1997; 7(6): 231–234.
10. Reynolds RD, Pilcher J, Ring A, Johnson R, McKinley P. The Golden Hour: care of the LBW infant during the first hour of life one unit's experience. Neonatal Netw 2009; 28(4): 211–219. http://dx.doi.org/10.1891/0730-0832.28.4.211
11. Kieran EA, Laffan EE, O'Donnell CPF. Estimating umbilical catheter insertion depth in newborns using weight or body measurement: a randomised trial. Arch Dis Child Fetal Neonatal Ed 2016; 101(1): F10-15. http://dx.doi.org/10.1136/archdischild-2014-307668
12. Gomella T, Eyal F, Bany-Mohammed F. Gomella's neonatology, eighth edition. 8th ed. Columbus, OH: McGraw-Hill Education; 2020.
13. Haque K, Waqar T. Collaborative Network of Neonatal Services to Reduce Neonatal Mortality and Improve Outcome: Army Medical Corps Could Lead the Way. Pak Armed Forces Med J 2020; 70(4): 1214-1219.
14. Goh SSM, Kan SY, Bharadwaj S, Poon WB. A review of umbilical venous catheter-related complications at a tertiary neonatal unit in Singapore. Singapore Med J 2021; 62(1): 29–33. http://dx.doi.org/10.11622/smedj.2019140
15. Sletner L, Rasmussen S, Jenum AK, Nakstad B, Jensen OHR, Vangen S. Ethnic differences in fetal size and growth in a multi-ethnic population. Early Hum Dev 2015; 91(9): 547–554. http://dx.doi.org/10.1016/j.earlhumdev.2015.07.002
16. Tambasco CJ, Shabanova V, Peterec SM, Bizzarro MJ. A novel and accurate method for estimating umbilical arterial and venous catheter insertion length. J Perinatol 2021; 41(7): 1633–1637. http://dx.doi.org/10.1038/s41372-021-01121-7
17. Cao J, Zhang Y, Yin Y, Liu Y. Accuracy of chest radiography compared to ultrasound for positioning the umbilical venous catheter in neonates: A meta-analysis and systematic review. J Vasc Access 2021; 11297298211046756. http://dx.doi.org/10.1177/11297298211046755
18. Lean WL, Dawson JA, Davis PG, Theda C, Thio M. Accuracy of five formulae to determine the insertion length of umbilical venous catheters. Arch Dis Child Fetal Neonatal Ed 2019; 104(2): F165–169. http://dx.doi.org/10.1136/archdischild-2017-314280
19. D'Andrea V, Prontera G, Rubortone SA, Pezza L, Pinna G, Barone G, et al. Umbilical venous catheter update: A narrative review including ultrasound and training. Front Pediatr 2021; 9: 774705. http://dx.doi.org/10.3389/fped.2021.774705
20. Verheij GH, TePas AB, Witlox RSGM, Smits-Wintjens VEHJ, Walther FJ, Lopriore E. Poor accuracy of methods currently used to determine umbilical catheter insertion length. Int J Pediatr 2010; 873167. http://dx.doi.org/10.1155/2010/873167
21. Surak A, Miller M, Roukema H. Predictors of umbilical venous catheter misalignment. Pediatr Rep 2022; 14(4): 396–400. http://dx.doi.org/10.3390/pediatric14040047