Original Article

Comparison of effectiveness of two umbilical venous catheter placement methods

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Abstract

Introduction. Umbilical catheterization is the cannulation of the umbilical vessels in critical ill neonates. Methods differ in accuracy and it is not always adequate; the most used are the Shukla and Dunn methods. In the neonatology units of El Salvador, a standard method of placing umbilical venous catheters has not been studied, therefore a randomized trial of two methods was carried out to compare effectiveness. **Objective.** Determine the effectiveness of umbilical venous catheter placement using two methods, Shukla and Dunn, in patients admitted to the neonatal intensive care unit of the National Women's Hospital from october 1st to 31st, 2020. **Methodology.** Randomized clinical trial. The population was all newborns who were admitted to intensive care and had an umbilical venous catheter placed; simple randomization was performed for both catheterization methods. effectiveness is the correct position of the catheter in a single placement attempt. **Results.** There were 60 neonates in the study. The male sex was predominant (53.3 %). 37 neonates were younger than 32 weeks. 58.3 % presented respiratory distress syndrome 30 were catheterized with the Dunn method and 30 with the Shukla method. Better effectiveness is determined with Shukla (86.6 %) vs. Dunn (63.4 %). **Conclusion.** Better effectiveness is determined with the Shukla method and more failures with the Dunn method.

Keywords
Catheters; Umbilical Veins, Infant, Newborn.

Resumen

El cateterismo umbilical es la canalización de los vasos umbilicales en neonatos delicados. Los métodos difieren en cuanto a la exactitud y el método elegido no siempre es el adecuado; los más utilizados son los métodos de Shukla y Dunn. En las unidades de neonatología de El Salvador no se tiene estudiado un método estándar de colocación de catéteres venoso umbilical, por lo cual, se realizó un ensayo aleatorizado de dos métodos para comparar la efectividad. **Objetivo.** Determinar la efectividad de colocación de catéter venoso umbilical por medio de dos métodos, de Shukla y Dunn en los pacientes que ingresaron en la Unidad de Cuidados Intensivos Neonatales del Hospital Nacional de la Mujer del uno al 31 de octubre de 2020. **Metodología.** Ensayo clínico aleatorizado. La población fue todos los recién nacidos que ingresaron a cuidados intensivos y se les colocaba un catéter venoso umbilical; se realizó aleatorización simple para ambos métodos de cateterismo; se consideró como posición efectiva si la punta del catéter radiopaco estaba en la posición de las vértebras T6 y T9. **Resultados.** Fueron 60 neonatos en el estudio. Hubo un predominio del sexo masculino (53,3 %). Treinta y siete neonatos fueron menores de 32 semanas. El 58,3 % presentó síndrome de distress respiratorio. Se cateterizaron 30 con el método Dunn y 30 con el método Shukla. Se determinó mejor efectividad con Shukla (86,6 %) comparado con Dunn (63,4 %). **Conclusión.** Se determinó mejor efectividad con el método Shukla y más fallas con el método Dunn.

Palabras clave
Catéteres, Venas Umbilicales, Recién Nacido.

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Comparación de dos métodos de colocación de catéter venoso umbilical.

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Introduction

Umbilical catheterization (UC) is an invasive procedure for cannulation of the umbilical cord vessels as a vascular access route for newborns (NB), for blood sampling, hydration, parenteral nutrition, and administration of medications after delivery.[i,ii] The UC is the route of choice in the critically ill NB, according to international standards and the clinical guidelines of the Ministry of Health of El Salvador.[iii,iv]

There are several techniques for estimating the length of umbilical venous catheter insertion. Dunn's nomogram measures length by drawing a line from the highest part of the shoulders to the umbilical stump (shoulder-oblique distance).[v,vi] This measurement in centimeters is plotted on the graph up to the intersection with the marked line, from which the length of the catheter to be inserted is obtained; subsequently, the centimeters protruding from the umbilical stump are added. The correct catheter tip placement is between the diaphragm and the left atrium.[vi]

In Shukla's method, birth weight is used using the following equations.[vi,vii]

Length of umbilical arterial catheter=

$$3 \times Weight\ in\ Kg + 9$$

Length of umbilical venous catheter=

$$\frac{Lenght\ of\ umbilical\ arterial\ catheter}{2} + 1\ cm$$

Other formulas have been proposed, such as Shukla's version modified by Verheij et al, which proposes the use of the distance from the umbilicus to the middle xiphoid, among others. There is currently no formula that guarantees the effectiveness of adequate catheter placement.[viii]

Another method suggested for the adequate placement of the umbilical catheter is through ultrasonography, which allows guiding the catheter tip; however, this method is not performed in the institutions of the country, so the formulas exposed are still used, and thoracoabdominal radiography is used to verify the position of the catheter tip.

Incorrect positioning of the catheters makes it necessary to remove the catheter and reposition a new one, which implies a second procedure and leads to a new risk of invasive procedure for the newborn, as well as increased manipulation with risks of infection and embolism.[x]

In the neonatology units of El Salvador, there is no standard method defined for umbilical venous catheter (UVC) placement, which is why the study aimed to determine the effectiveness of UVC placement by comparing the Shukla and Dunn methods in patients admitted to the Neonatal Intensive Care Unit (NICU) of the National Women's Hospital from October 1st to 31st, 2020.

Methodology

A randomized clinical trial was conducted to compare the effectiveness of CVU placement by comparing two methods of neonatal umbilical catheterization: Dunn's method and Shukla's method. The study was conducted from October 1st to 31st, 2020, in the Neonatal Intensive Care Unit (NICU) of "Dra. María Isabel Rodríguez" National Women's Hospital.

The study population corresponds to neonates who required umbilical vein catheter placement according to newborn care protocols. The patient eligibility criteria were all neonates who were admitted to the NICU in the first 24 hours of life and required umbilical catheter placement; neonates with major congenital malformations (those that represented a vital risk, required surgery, involved severe esthetic sequelae or were incompatible with life) and those who, due to anatomical reasons of the umbilical vein lumen, could not have the catheter inserted were excluded.

The simple randomization method with allocation concealment using sealed opaque envelopes was used to compare the effectiveness of both methods. The sample size was based on the average monthly number of neonates admitted and catheterized in the NICU each month (on average 60 admissions per month). Sixty opaque, sealed envelopes were prepared, containing a card indicating the umbilical catheterization method to be applied; 30 envelopes with Dunn's method and 30 envelopes with Shukla's method. The umbilical catheterization was performed by neonatology specialists with experience in the placement of catheters, and the neonatology service personnel were trained in the study methodology, receiving induction and training in both techniques.

When the newborn was admitted to the NICU, the physician proceeded to randomly remove an envelope, opened it and took out the card indicating the umbilical catheterization technique to be used. Afterwards, he/she would write down the patient's file number and name on the back of the card, then place it in another box containing the data; likewise, the record was left in the file of each neonate. The position of the tip of the catheter inserted in the umbilical vein was immediately verified using an X-ray. It was considered as correct or "effective" position if the tip of the radiopaque catheter was located in the position of the thoracic vertebrae T6 and T9.[ii,viii,ix,x]

The variables studied were sex, birth weight (very low birth weight between 1000 g and 1499 g and low birth weight between 1500 g and 2499 g), gestational age at birth (extreme preterm < 28 weeks, very preterm infants between 28 and 32

weeks and late preterm infants between 32 and 37 weeks), the basic cause of admission (diagnosis), the method of UC used (Dunn or Shukla) and complications (intestinal perforation, myocardial perforation, cardiac arrhythmias, bleeding and infection).

The data were entered into an Excel spreadsheet and transferred to the SPSS version 22 statistical program for analysis; in addition, the OpenEpi web calculator was used. For descriptive statistics, frequencies, percentages, and means were used. Tables were divided by sex, weight, and gestational age for each method. The comparison of the methods was performed with the elaboration of 2×2 tables with Fisher's exact test, relative risk values, and risk differences; a p-value < 0.05 was occupied for a statistically significant value.

To safeguard the identity of each patient (as established by the Helsinki norms), a database identified only with the file number was created and handled only by the investigators. Each mother or representative signed the informed consent form and authorized the procedure. This study was reviewed and approved by the local ethics committee of the Hospital Nacional de la Mujer. The clinical records for data collection were used within the hospital facilities.

Results

During the study period, 68 newborns were admitted to the NICU; of these, eight were excluded: four neonates with major congenital malformations and four neonates with umbilical vein lumen abnormalities that prevented umbilical catheter placement (Figure 1). Sixty newborns were studied. Regarding sex, 53 % were male (32) and 47 % female (28).

Regarding birth weight, the largest number of patients was low birth weight newborns, 38.3 % (23); 37 % (22) were very low birth weight, 15 % (9) were extremely low birth weight, and the remaining 10 % (6) were normal birth weight. In the group of neonates in which the Shukla method was used, there were cases of inadequate position in males; 18.2 % (2/11) of the neonates had very low birth weight, while 16.7 % (2/12) had low birth weight. Regarding the group of neonates in whom the Dunn method was used, the catheter was found to be inadequately placed in 45.4 % (5/11) of the low-weight neonates, predominantly male, while in the normal-weight neonates, 75 % (3/4), all female, had an inadequate placement; in contrast, in the very low-weight neonates the percentage was 18.2 % (2/11), all male. Finally, extremely low-weight neonates had an inadequate position in 25 % (1/4), and it was male (Table 1).

Regarding gestational age, 93.3 % were preterm neonates, the predominant gestational age was found in very preterm neonates with 48.3 % of neonates (29/60) followed by late preterm with 31.7 % (19/60), 13.3 % (8/60) were extreme preterm and the remaining 6.7 % (4/60) were term neonates, no postterm neonates were found.

In 13.3 % (4/30) of the neonates who used the Shukla method, the catheter was inadequately placed, all were very premature newborns, which corresponds to 25 % (4/16) of the patients in this gestational age group, with equal percentages in both sexes.

In the group of neonates in which the Dunn method was used, there were cases

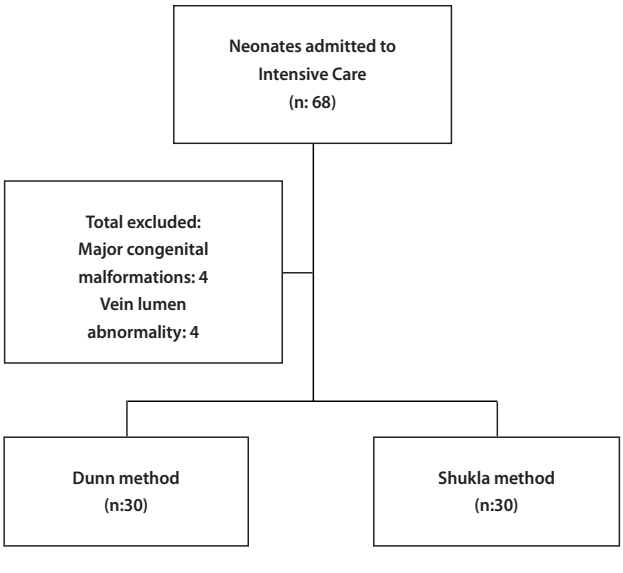

Figure 1. Number of patients admitted to the NICU who met the study inclusion criteria and the reasons for non-inclusion.

of inadequate position in all gestational age categories. In all term neonates, an inadequate position was found, predominantly in the female sex, followed by extreme preterm infants with 33.3 % (1/3), identified in one male neonate while very preterm neonates presented an inadequate position in 30.8 % (4/13) in equal numbers in both sexes. Finally, in late preterm infants, an inadequate position of the catheter tip was identified in 27.3 % (3/11), with a higher value in males (Table 2).

The Shukla method represented 86.6 % (26/30) of catheters in correct or "effective" position, against 63.2 % (19/30) with the Dunn method (Figure 2); it is worth mentioning that all the catheters in inadequate position of the Shukla method corresponded to high positions between T3-T5; while those of the Dunn method 9.1 % (1/11) were in high position and 90.9 % (10/11) in low position (between T10-L5).

Finally, it can be seen that of the 45 neonates who had the catheter properly placed, 58.8 % (26/45) corresponded to UC performed according to the Shukla method. The Shukla method seems to have a higher probability of success in terms of adequate cannulation. The Fisher's exact test obtained a p-value = 0.03, a risk ratio of correct placement of 1.368 (CI: 1.007- 1.859 and with $p < 0.05$) and a proportion of correct placement in a stable population attributable to the umbilical venous catheter placement method of 15.56 %, compared to the Dunn method (Table 3). An incorrect or "ineffective" position represents one more procedure and undergoes an invasive procedure twice.

Discussion

Intravascular catheters are widely used in the NICU. Methods of intravascular access in the newborn include peripheral catheters, arterial or venous umbilical catheters, central venous catheters, and peripherally installed central venous catheters (PICCs).

Umbilical catheterization continues to be the method of choice for administering fluids, medications and nutrition in neonates admitted to an intensive care unit to date, as it is the quickest and safest access route to use.[xi] Newborns who, due to their disease process, require admission to the NICU are immediately placed in an incubator and positioned for the umbilical catheterization procedure upon arrival at the unit. Anomalous catheter positions, especially umbilical catheters, are frequent, since their placement is not guided by images.[xii,xii,xiv]

Incorrect positioning or malpositioning of the umbilical venous catheters can occur before reaching the desired position and can be found in the umbilical recess, before reaching the left portal vein, and when trying to advance the catheter, it can be pushed back into the umbilical vein. When the catheter reaches the umbilical recess, it should pass through the left portal into the ductus venosus; however, at this point it

Table 1. Distribution of neonates by weight and sex according to the method of umbilical catheterization used. n: 60.

	Method of catheterization / Weight-sex				
	Shukla		Dunn		Total
Birth weight/sex	Correct or "effective" position	Incorrect or "Not effective" position	Correct or "effective" position	Incorrect or "Not effective" position	
Extremely low weight	-	-	-	-	9
Female	2	0	1	0	3
Male	3	0	2	1	6
Very low weight	-	-	-	-	22
Female	4	0	4	0	8
Male	5	2	5	2	14
Low weight	-	-	-	-	23
Female	7	0	3	2	12
Male	3	2	3	3	11
Normal weight	-	-	-	-	6
Female	1	0	1	3	5
Male	1	0	0	0	1
Total	26	4	19	11	60

Table 2. Comparison of umbilical catheterization according to gestational age.

Method of catheterization / Gestational age -Sex					
	Shukla		Dunn		Total
Birth weight/sex	Correct or "effective" position	Incorrect or "Not effective" position»	Correct or "effective" position	Incorrect or "Not effective" position	
Extreme preterm	-	-	-	-	8
Female	2	0	1	0	3
Male	3	0	1	1	5
Very preterm	-	-	-	-	29
Female	5	2	4	2	13
Male	7	2	5	2	16
Late preterm	-	-	-	-	19
Female	5	0	3	1	9
Male	3	0	5	2	10
Term newborn	-	-	-	-	4
Female	1	0	0	2	3
Male	0	0	0	1	1
Total	26	4	19	11	60

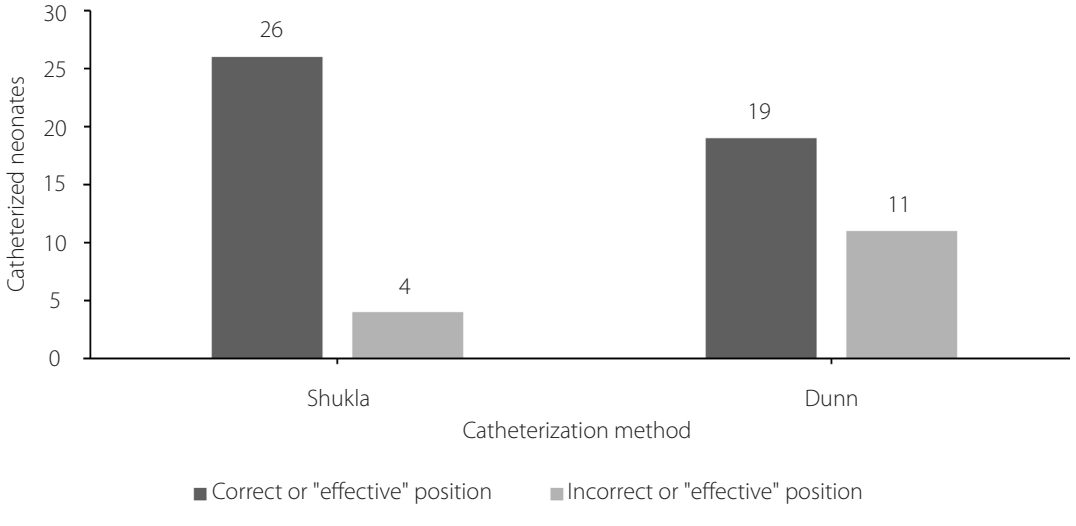

Figure 2. Comparison of two methods of neonatal umbilical venous catheter placement.

Table 3. 2 × 2 comparison table of both methods. N: 60

		Correct position/ Effective	Incorrect position/ Not effective	Total
Method of placement of umbilical venous catheters	Shukla	26	4	30
	Dunn	19	11	30
	Total	45	15	60

Fisher's exact test with p = 0.03
Risk ratio of 1.368 (CI: 1.007- 1.859) p < 0.05
Risk difference of 23.33 %
Attributable risk of 0.23
Population etiologic fraction (PEF) 15.56 %.%

may be deflected into the left portal or right portal or even the main portal, then it may pass into the superior mesenteric and splenic vein. The catheter in the portal portal vein may cause portal thrombosis.[xv,xvi]

Most of the patients under investigation are of low weight and very low weight due to the complexity of the hospital where the study was carried out. Both methods studied are used in the NICU of the hospital where the trial was performed. The catheters that are in the wrong position (liver, right atrium, right ventricle or are left angled) must be changed in order to reduce complications.

Dunn's[v] method registered more inadequate positions, making it necessary to reposition the umbilical venous catheter, which increases material costs and exposure to the risk of the new procedure.

It has been noted in the formulas that have been developed to allow proper positioning of UVC, they are generally based on birth weight. However, no significant difference in terms of demographic characteristics was found in the study conducted, similar to other studies in the literature.[xii-xv]

Umbilical catheterization is associated with multiple complications, including generalized infectionxv,xvi , which is associated with increased mortality, mainly in very premature neonates and in those with very low birth weight; furthermore, complications related to catheter placement, such as migration of the catheter tip into the peritoneal, pleural or pericardial spaces have been described.[xvii-xxii]

UVC placement has been commonly used for vascular access in critically ill neonates of all birth weights at delivery and postpartum. For decades, the standard for accuracy of placement, relied on radiological examinations to know the effective position; in addition, echocardiography method has been used to indicate the position of the catheter tip in the right central atrium (RCA) and/or thoracic atrium inferior vena cava junction-RA (TIVC-RA), two safe locations for the UVC tip; however, there is no international agreement.[xxiii, xxiv]

Currently, in order to verify the accuracy of umbilical catheter placement based on visualization of the catheter tip, it is performed by ultrasound method, even for very low birth weight infants; it is suggested that echocardiography may be useful to verify that misplacement has not occurred or that the catheter has not migrated from the CVU tip into the left atriumxxv.[xxv]

Thus in the 2020 International Clinical Practice Guideline on Bedside Ultrasound and the 2015 Cochrane Review[xxvi,xxvii], internal jugular vein cannulation in children and neonates is recommended to be ultrasound-guided with a quality of evidence grade A. Oulego-Erroz *et al.* recommend ultrasound-guided cannulation of the subclavian vein and brachiocephalic trunk in children and neonates, improving the success rate with fewer needle passes.[xxviii]

The study has limitations, since there was no ultrasound equipment to perform the evaluation of the UVC tip position in real time, only radiographic studies were available (anteroposterior radiography taken in the newborn incubator), which were performed more than 30 minutes from insertion to reading, to obtain the position of the UVC tip. In addition, there are no authoritative guidelines on the procedures to be performed with the position of the UVC tip, and the frequency of tip surveillance is performed in cases of unexpected migration of the UVC.

A study comparing the accuracy of umbilical venous catheter tip position using radiographic and ultrasound studies is recommended to provide guidelines for the placement and measurement of catheter placement in NICUs.

It is necessary to implement the ultrasound study in all NICUs within the guidelines of care to achieve a better placement of umbilical catheters and thus achieve better health safety for our newborns we serve.

Conclusion

When comparing the efficacy of both methods, a higher percentage of inadequate position was found with Dunn's method, which leads these patients to undergo catheterization again, exposing them to more risks and complications for a second procedure. Regarding the usefulness of both methods, it can be said that both have some value in the evaluation of umbilical vein cannulation.

At the local level, radiological examination remains the main tool for monitoring catheter position; early recognition of malpositioning can be useful in preventing possible complications. It is necessary to be familiar with the imaging recommendations for the expected position of the various catheters and also for those that acquire anomalous positions.

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