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ORIGINAL ARTICLE

Comparison of Wright's Formula and the Dunn Method for Measuring the Umbilical Arterial Catheter Insertion Length

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Background: Umbilical artery catheterization is the standard procedure for arterial access in neonatal intensive care units. An umbilical arterial catheter (UAC) needs to be placed accurately during the initial insertion because malpositioning increases catheter-related complications and subsequent repositioning exposes newborns to unnecessary handling, further radiologic exposure, and an increased risk of infection. To measure the UAC insertion length in newborns, we compared the conventional practice (i.e., the Dunn method) with a new formula: Wright's formula.
Methods: The study enrolled 119 newborns. A nomogram derived from Dunn was used during the first study period and the new formula devised by Wright (4 × birth weight + 7 cm) was used during the second study period. The catheter tip position on the initial radiograph was evaluated as correct (i.e., T6—T10), overinsertion (i.e., <T6), or underinsertion (i.e., >T10).
Results: The demographic profiles were not different between the two groups, which included sex; birth weight; and the number of preterm births, low-birth-weight (LBW) newborns, and very-low-birth-weight (VLBW) newborns. When using Wright's formula and the Dunn method, 83% of newborns and 61% of newborns, respectively, received a correct insertion ($p < 0.05$). The success rate for positioning the UAC tip between T7 and T8 was approximately two-fold higher when using Wright's formula than when using the Dunn method. In particular, the rate of correct insertion was significantly higher with Wright's formula in term newborns, LBW newborns, VLBW newborns, and small for gestational age (SGA) newborns ($p < 0.05$); however, the rate of overinsertion with the Dunn method was much higher in term newborns, LBW newborns, VLBW newborns, and SGA newborns ($p < 0.05$).

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Conclusion: The use of Wright's formula overall results in superior correct placement of the UAC tip. It may be a more accurate and practical method than the conventional practice for measuring the UAC insertion length in newborns.

1. Introduction

In critically ill newborns, catheterization of the umbilical artery is the standard of care for rapid vascular access, accurate laboratory determinations, invasive monitoring, and administering fluid and medications.[1,2] However, the advantages of an umbilical arterial catheter (UAC) must be balanced against potential hazards such as reinsertion-associated infection and further radiologic exposure, thrombosis, cardiac arrhythmia, inhibition of intestinal blood flow, intraventricular hemorrhage, myocardial perforation, and pleural or pericardial effusion.[3–18] These complications can result from malpositioning of the catheter tip. Hence, the UAC needs to be placed accurately during the initial insertion.

Proper positioning of the UAC between the T6 and T10 levels is considered safe.[19] To date, the most widely used method for measuring the UAC insertion length is the Dunn method, which is based on the measurement of the shoulder–umbilicus length and uses a nomogram to determine the insertion length.[20] However, the Dunn method always requires a nomogram sheet; therefore, the UAC insertion length is not readily obtainable in emergency situations. Furthermore, the flexor tone of the newborn and the multiple attachments to the skin make it difficult to measure the shoulder–umbilicus length accurately.[8] As a complementary alternative, Shukla and Ferrara [21] devised an easy-to-apply formula, based on body weight to aid in correctly placing the UAC:

$$\text{UAC insertion length(cm)} = 3 \times \text{birth weight(Bwt, in kg)} + 9. \quad (1)$$

However, this calculation produces a consistent overestimation of the catheter insertion length in very-low-birth-weight (VLBW) newborns.[22] Wright et al[22] recently suggested a new equation:

$$\text{UAC insertion length(cm)} = 4 \times \text{Bwt(kg)} + 7. \quad (2)$$

This formula has led to more accurate placement, compared to Shukla's formula.[21] Several formulas have been proposed to improve the accuracy and feasibility of measuring the UAC insertion length.[21,22,24] However, there are no data on the accuracy of Wright's formula in comparison to the existing method guided by Dunn's nomogram in all newborns, including term newborns and low-birth weight (LBW) newborns. We undertook this study to compare the accuracy of these two methods for measuring the UAC insertion length in all newborns, (i.e., term newborns, LBW newborns, and VLBW newborns).

2. Materials and methods

2.1. Study design and patients

The objective of this study was to compare the accuracy of the UAC insertion length in newborns when using two different measurement methods: the Dunn method[20] and Wright's formula.[22]

In this prospective observational study, we compared the UAC position before and after implementing Wright's formula in the neonatal intensive care unit (NICU) of Kangwon National University Children's Hospital (Chuncheon, South Korea). From November 2011 to July 2012 (i.e., the first study period), the Dunn method was used to determine the UAC insertion length. From August 2012 to May 2013 (i.e., the second study period), the Wright formula was used. The newborns enrolled in the study were admitted to the NICU and required UAC insertion on admission. Parental consent was unnecessary because the two methods are accepted for measuring the UAC insertion length.

In the first study period, we measured the length from the tip of the newborn's shoulder to the umbilicus and determined the insertion length using a nomogram derived from Dunn,[20] and then adding the length of the umbilical stump. In the second period, we calculated the UAC insertion length using Wright's equation[22]:

$$[4 \times \text{Bwt(kg)} + 7\text{(cm)}], \quad (3)$$

and then adding the length of the umbilical stump.

A single lumen 5-G radio-opaque umbilical catheter was used. The catheter was inserted under aseptic precautions and fixed accordingly. All warmers in our NICU have a separate radiographic cassette insertion provision. The depth of the UAC tip was confirmed by an anteroposterior chest X-ray image. The position of the UAC tip was measured by the corresponding vertebra level, according to the prepared protocol. Four doctors were involved in placing the catheters. Two physicians separately confirmed the position of the catheter on the X-ray image.

2.2. Data acquisition

For demographic profiles, the following data were collected: gestational age (GA), Bwt, sex, appropriate for gestational age (AGA), small for gestational age (SGA), and large for gestational age (LGA). The newborns were divided into the gestation subgroups of "term" and "preterm"; divided into Bwt subgroups of $>$2500 g, 1501–2500 g, and $\leq$1500 g; and divided into the subgroups of Bwt against gestation, SGA, and LGA. Umbilical arterial catheter