Simple and Accurate Formula to Estimate Umbilical Arterial Catheter Length of High Placement

Suthida Sritipsukho MD*,
Paskorn Sritipsukho MD**

** Department of Pediatrics, Faculty of Medicine, Thammasat University*
*** Graduate Studies Program, Faculty of Medicine, Thammasat University*

Objective: *The present study aimed to derive the new simple, reliable, and accurate formula based on a body measurement parameter and not on reference graphs, to determine umbilical arterial catheter length of high placement, between the sixth to tenth thoracic vertebral (T6-T10) levels. Accuracy among a variety of formulas was also examined.*

Material and Method: *A prospective recruitment of 40 babies who had an umbilical arterial catheter placed in the NICU, Thammasat University Hospital was studied. Insertional length for high placement was measured. The body measurement parameters were measured twice on each patient to indicate their reliability properties. Three individual umbilical arterial lengths, from umbilical ring to anatomical points of T6, T8, and T10 levels accordingly, were estimated by verifying the catheter tip against those anatomical points on chest and abdominal radiograph. Correlation coefficient (r) between each parameter and the umbilical arterial length to the T8 level was calculated.*

Results: *Suprasternal notch to superior iliac spine length (SSSL) was the selected parameter to derive a new formula because of high reliability coefficient of 0.964, high correlation to the umbilical arterial length to the T8 level (r = 0.906), and its simplicity to measure. The accuracy of the 'SSSL' to position the catheter tip at T6-T10 was 90%.*

Conclusion: *The SSSL is simple and accurate for predetermination of the umbilical arterial catheter length to position the catheter tip at T6-T10. It can be an alternative formula, especially where birth weight and total body length are not available.*

Keywords: *Umbilical arterial catheter, Simple, Accurate, Estimation, Length, high placement*

J Med Assoc Thai 2007; 90 (9): 1793-7
Full text. e-Journal: *http://www.medassocthai.org/journal*

Umbilical arterial catheter has become a standard arterial access in neonatal intensive care unit (NICU) for drawing blood samples, measuring blood pressure, and administering fluid and medications[1,2]. High placement of arterial catheter between the sixth to tenth thoracic vertebral (T6-T10) levels is considered as a practical, safe, and feasible position[3-6]. It is usable for a longer period. When placed high, it is removed as an emergency less often than placed low[6]. Accurate placement of the catheter tip at the first insertion is important. If placed wrongly, then consequent adjustment of the catheter position, withdrawal, or reinsertion is not necessary. There has been a variety of formulas using calculation of a neonatal body measurement parameter and/or plotting with a reference graph to determine insertional length of the catheter[7-10]. In emergency settings, some parameters may be difficult to obtain accurately because of flexor tone of the newborn and multiple monitor attachments to the body. No particular formula has been recommended to estimate the catheter length among Asian babies. Thus, the present study aimed to derive a new simple, reliable, and accurate formula based on a body measurement parameter, and not on a reference graph, to determine the umbilical arterial catheter length. Accuracy among a variety of the formulas was also examined.

Correspondence to : Sritipsukho S, Department of Pediatrics, Faculty of Medicine, Thammasat University (Rangsit Campus), Patumthanee 12120, Thailand. E-mail: Suthida70@yahoo.com

Material and Method

A prospective recruitment of 40 babies without gross anomaly who needed umbilical arterial access in the NICU, Thammasat University Hospital was studied. All the babies had respiratory problems and required monitoring of arterial blood gases. An umbilical arterial catheter was inserted using aseptic technique. Unstable babies during insertion were excluded from the present study because of an ethical reason. The present study was approved by the Faculty of Medicine Thammasat University Human Ethics Committee to perform. A radio-opaque catheter was used to place the catheter tip between T6 and T10 in all babies. Insertional catheter lengths were measured and inserted by various staff on duty in the NICU. Birth weight (BW) was recorded as a parameter with one decimal number of kilograms in all babies. At the first insertion, a variety body measurement parameters were measured as the following: total body length (TBL), shoulder-to-mid umbilicus length, shoulder-to-superior border of pubis length, nipple-to-mid umbilicus length, xyphoid-to-mid umbilicus length, xyphoid-to-superior border of pubis length (XPL), suprasternal notch-to-mid umbilicus length, suprasternal notch-to-mid umbilicus length, suprasternal notch-to-superior border of pubis length (SPL), suprasternal notch-to-left superior iliac spine length (SSSL) and mid umbilicus-to-superior border of pubis length (UPL). All the measurements were recorded with one decimal number of centimeters. Repeated measurement of these parameters, except BW, was performed within 48 hours on each patient by the same physician. Reliability coefficient of each parameter based on twice measurement was calculated. The insertional catheter was measured from the catheter tip to umbilical ring level. Location of the catheter tip was checked by chest and abdominal radiography to place between T6 and T10 levels. Catheter position was adjusted by withdrawal or by re-insertion if the first insertional catheter tip was placed out of T6-T10 levels. Three individual umbilical arterial lengths, from umbilical ring to anatomical points of T6, T8, and T10 levels accordingly, were estimated by verifying the catheter tip against those anatomical points on the radiograph. The umbilical arterial length to each anatomical point on each patient was corrected by directly adding up or subtracting an exact scale on the radiograph. Correlation coefficient (r) between each parameter and the umbilical arterial length to the T8 level was calculated.

One of those parameters was selected to derive the formula based on the following criteria; excellent reliability coefficient, high correlation coefficient (r), and the simplicity of the parameter measurement. Simple operation of the chosen parameter was tried to generate a new formula to estimate the insertional length. Correlation coefficient between the umbilical arterial length to the T8 level and insertional length calculated from the proposed formula was done. The formulas of: Formula 1. XPL + UPL[7], Formula 2. TBL/3[8], Formula 3. SPL[8], Formula 4. 3BW + 9[9], and Formula 5. Based on BW[10] were studied for their accuracies. All data were analyzed by using the STATA version 9.0 statistical package with mean $\pm$ standard deviation for continuous variables and percent for counting number. Reliability and correlation coefficients and percent of accuracy were presented.

Results

Forty Thai babies, 21 boys and 19 girls, with the mean birth weight of 1,630 grams $\pm$ 620 grams (range of 790 grams - 2,900 grams) were studied. Eight babies (20%) had a birth weight of less than 1,000 grams. At the first attempt of catheter insertion, 26 babies (65%) had the catheter tips placed successfully at the high placement.

Suprasternal notch to left superior iliac spine length (SSSL) was selected to derive a new formula (Formula 6) because of the high reliability coefficient of 0.964, the high correlation to the umbilical arterial length to the T8 level (r = 0.906) and its simplicity to measure. By studying those of 40 babies, reliability coefficients and correlation coefficients of the parameters used in the formulae were calculated and compared in Table 1.

Thirty babies (90%) with calculated insertional lengths of 'SSSL' had the catheter tip between T6 and T10 levels correctly positioned. In other words, the

Table 1. Reliability coefficient and correlation coefficient of the parameters (n = 40)

	Reliability coefficient*	Correlation coefficient**
XPL	0.966	0.710
UPL	0.875	0.590
TBL	0.954	0.894
SPL	0.960	0.849
BW	-	0.935
SSSL	0.964	0.906

* Of twice measurement

** Correlation of the parameter to the umbilical arterial length to T8 level accuracy of the formula, SSSL, to predetermine the insertional length of high placement was 90%. Percent accuracy among those formulae to pre-determine the insertional length of high placement is compared in Table 2. The relationship between calculated lengths from the formulas and the umbilical arterial length to T6-T10 levels is shown in Fig. 1.

Discussion

SSSL is the reliable measure in most babies with reliability coefficient of 0.964. Moreover, high correlation of SSSL to the umbilical arterial length to the T8 level is impressive and, therefore, is used to derive the formula to calculate insertional catheter length[11]. The anatomical landmark of both suprasternal notch and superior iliac spine is easily noticeable in most babies when doing the procedure. The present study result does not support using PUL to calculate the insertional length because of relatively low reliability and correlation coefficients presented in Table 1. Measuring parameters involving the umbilicus may be difficult and not reliable. Calculated catheter length from the formula 2 positioned the catheter tip scattered outside T6-T10 with an accuracy of only 39% presented in Table 2.

In Table 2, not only is the good accuracy of 90% of the SSSL to estimate the catheter length of high

Table 2. Accuracy of the formulas (n = 40)

	Correlation coefficient*	Accuracy percent**
Formula 1 (XPL+UPL)[7]	0.629	39%
Formula 2 (TBL/3)[8]	0.894	90%
Formula 3 (SPL)[8]	0.849	73%
Formula 4 (3BW+9)[9]	0.935	94%
Formula 5*** (based on BW)[10]	0.885	52%
Formula 6 (SSSL)	0.906	90%

* Correlation of calculated length from the formula to the umbilical arterial length to T8 level
** Percent of babies that calculated lengths can correctly position the catheter tip at T6-T10 levels
*** For a 1,000gm baby, the length of insertion is 10 cm, and add 1 cm for each additional weight group of 2,250 gm. Above 2,250 gm, the length of insertion is 15 cm for all babies

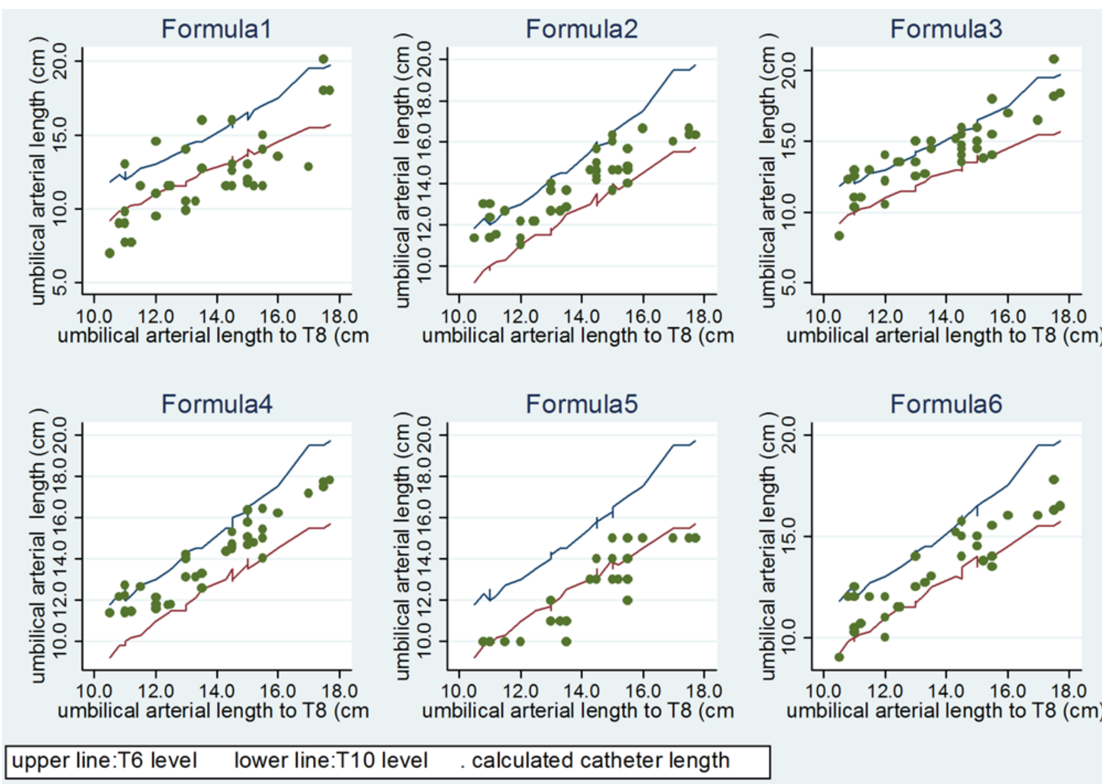

Fig. 1 Relationship between calculated lengths from the formulas and the umbilical arterial length to T6-T10 levels

placement, the better accuracy of 90%-94% of the formulae of 'TBL/3' and '3BW + 9' are also confirmed[8,9]. The SSSL can be an alternative formula, especially where birth weight and total body length is not available. Although the formula proposed by Lin MS et al is not accurate based on the present study result, the calculated length from the formula correlated well to the umbilical arterial length to the T8 level (r = 0.896). This is because of a different definition of the high placement of T7 and T11 of the present study[10]. Most babies had the calculated length at T10 -T11, as shown in Fig. 1.

In practice, the physician has to add up the calculated catheter length with the umbilical cord stump length to obtain the final insertion distance. Radiography after umbilical catheter insertion is still necessary to verify the position of the catheter tip since individual differences in the lengths of the iliac, umbilical arteries and the aorta are evident. In conclusion, the SSSL is simple and accurate for pre-determination of the umbilical arterial catheter length to position the catheter tip at T6 and T10 in the presented population. It can be an alternative formula where birth weight and total body length is not available.

References

1. Prinz SC, Cunningham MD. Umbilical vessel catheterization. J Fam Pract 1980; 10: 885-90.
2. Green C, Yohannan MD. Umbilical arterial and venous catheters: placement, use, and complications. Neonatal Netw 1998; 17: 23-8.
3. Hermansen MC, Hermansen MG. Intravascular catheter complications in the neonatal intensive care unit. Clin Perinatol 2005; 32: 141-56.
4. Kempley ST, Bennett S, Loftus BG, Cooper D, Gamsu HR. Randomized trial of umbilical arterial catheter position: clinical outcome. Acta Paediatr 1993; 82: 173-6.
5. Mokrohisky ST, Levine RL, Blumhagen JD, Wesenberg RL, Simmons MA. Low positioning of umbilical-artery catheters increases associated complications in newborn infants. N Engl J Med 1978; 299: 561-4.
6. Barrington KJ. Umbilical artery catheters in the newborn: effects of position of the catheter tip. Cochrane Database Syst Rev 2000; 2: CD000505.
7. Rubin BK, McRobert E, O'Neill MB. An alternate technique to determine umbilical arterial catheter length. Clin Pediatr (Phila) 1986; 25: 407-8.
8. Shukla H, Ferrara A. Rapid estimation of insertional length of umbilical catheters in newborns. Am J Dis Child 1986; 140: 786-8.
9. Weaver RL, Ahlgren EW. Umbilical artery catheterization in neonates. Am J Dis Child 1971; 122: 499-500.
10. Lin MS, Lim YJ, Ho NK. A quicker simpler method of pre-determination of the length of umbilical artery catheter insertion in Asian babies. J Singapore Paediatr Soc 1989; 31: 79-81.
11. Armitage P, Berry G. Statistical methods in medical research. Oxford: Blackwell Scientific Publications; 1987.

สูตรที่ง่ายและแม่นยำในการประมาณความยาวสายสวนเส้นเลือดแดงสายสะดือของทารก

สุธิดา ศรีทิพย์สุโข, ภาสกร ศรีทิพย์สุโข

***วัตถุประสงค์**: เพื่อสร้างสูตรหรือสมการที่แม่นยำและง่ายต่อการใช้ ในการประมาณความยาวสายสวนเส้นเลือดแดงสายสะดือของทารกให้ปลายสายสวนอยู่ในตำแหน่ง high type หรือระดับกระดูกสันหลังระดับอกที่ T6-T10 โดยไม่ต้องอ้างอิงกราฟ และเพื่อศึกษาเปรียบเทียบความแม่นยำกับสูตรเดิมอื่น ๆ*

***วัสดุและวิธีการ**: เป็นการศึกษาไปข้างหน้าในกลุ่มทารกแรกเกิดในหออภิบาลผู้ป่วยทารกแรกเกิดวิกฤติ โรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ ที่ต้องใส่สายสวนเส้นเลือดแดงสายสะดือจำนวน 40 ราย โดยวัดความยาวของสายสวนซึ่งปลายสายสวนอยู่ในตำแหน่ง high type และวัดขนาดรูปร่างของทารกเพื่อเก็บเป็นตัวแปรความยาวส่วนต่าง ๆ ของร่างกาย โดยวัดซ้ำ 2 ครั้งเพื่อประเมินความน่าเชื่อถือของแต่ละตัวแปร โดยผู้ศึกษาจะประเมินความยาวของเส้นเลือดแดงสายสะดือถึงตำแหน่งระดับกระดูกสันหลังระดับอกที่ 6, 8, และ 10 ตามลำดับของทารกแต่ละคน โดยอ้างอิงกับภาพรังสีบริเวณช่องท้องและช่องอก และคำนวณค่า correlation coefficient (r) ระหว่างตัวแปรความยาวแต่ละส่วนของร่างกาย กับความยาวเส้นเลือดแดงสายสะดือถึงตำแหน่งระดับกระดูกสันหลังระดับอกที่ 8*

***ผลการศึกษา**: ผู้ศึกษาได้เลือกตัวแปรค่าความยาวระหว่าง suprasternal notch ถึง superior iliac spine เพื่อสร้างสมการประมาณความยาวสายสวนเส้นเลือดแดงสายสะดือ เนื่องจากมีค่า reliability coefficient สูงเป็น 0.964 และมีค่า correlation coefficient (r) เป็น 0.906 และเป็นตัวแปรที่ง่ายต่อการวัด สามารถใช้ค่าดังกล่าวนี้ในการประมาณความยาว สายสวนเส้นเลือดแดงสายสะดือได้โดยตรง ให้ปลายสายสวนอยู่ในตำแหน่งระดับกระดูกสันหลังระดับอกที่ 6-10 ได้อย่างถูกต้องถึงร้อยละ 90*

***สรุป**: การประมาณความยาวสายสวนเส้นเลือดแดงสายสะดือให้ปลายสายสวนอยู่ในตำแหน่งระดับกระดูกสันหลังระดับอกที่ 6-10 ด้วย ค่าความยาวระหว่าง suprasternal notch ถึง superior iliac spine นั้นมีความแม่นยำ และง่ายต่อการใช้ โดยสามารถใช้ทดแทนสูตรเดิมได้ในกรณีที่ไม่ทราบน้ำหนักแรกเกิด หรือ ความยาวของทารก*