

# Accuracy of the Distance between Suprasternal Notch and Superior Iliac Spine to Determine Umbilical Arterial Catheter Length

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**Objective:** The present study aimed to validate the SSSL in pre-determinating the insertional length between the sixth and tenth thoracic vertebrae (T6-T10) and examine repeatability property.

**Material and Method:** A prospective recruitment of 52 babies who were placed the umbilical arterial catheter in the NICU, Thammasat University Hospital was performed. Insertional length of the distance between suprasternal notch and superior iliac spine (SSSL) were performed. The catheter tips were verified against anatomical points on chest and abdominal radiograph. The SSSL was measured twice on each patient to indicate repeatability property.

**Results:** All babies (100 percent accuracy) were correctly placed the catheter tips at high placement (T6 to T10) at the first attempt. Repeatability coefficient for repeating measure of the SSSL was 0.7 centimeters.

**Conclusion:** The SSSL is repeatable, simple, and perfectly accurate for pre-determination of the umbilical arterial catheter length to position the catheter tip at T6 - T10.

**Keywords:** Umbilical arterial catheter, Simple, Accurate, Estimation, Length, High placement, Suprasternal notch, Superior iliac spine

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The insertion of a catheter into the umbilical artery of a newborn is an important procedure for drawing blood samples, measuring blood pressure, and administering fluid and medications<sup>(1,2)</sup>. Appropriate placement of the catheter tip is important to minimize vascular complications including hemorrhage and ischemic damage to organs<sup>(1-3)</sup>. The catheter is considered high placement if the tip is between the sixth and tenth thoracic vertebrae (T6-T10) on the radiograph<sup>(4)</sup>. A cochrane meta-analysis recommended use of initial high placement of umbilical arterial insertion to minimize occurrence of vascular complications, removal and other adverse sequelae<sup>(5)</sup>. A variety of methods to pre-determine umbilical arterial insertion was used differently from centers to centers<sup>(6-11)</sup>.

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Recently, the distance between suprasternal notch to superior iliac spine length (SSSL) was proposed by the author for rapid calculation of insertion by a single neonatal morphometric measure<sup>(12)</sup>. The present study, therefore, aimed to validate the SSSL in pre-determinating the insertional length at high placement and examine repeatability property.

## Material and Method

The present study was approved by the Thammasat University Human Ethics Committee. Entry criteria were babies, without gross anomaly, who had clinical need to umbilical arterial access in the neonatal intensive care unit (NICU), Thammasat University Hospital. Umbilical arterial radio-opaque catheter was used with aseptic technique for catheter insertion. Suprasternal notch to superior iliac spine length (SSSL) was measured and was added up with the umbilical stump length to obtain the insertional

length. Location of the catheter tip was determined by a radiograph of the chest and abdomen. Catheter position was adjusted by withdrawal or by re-insertion if the first insertional catheter tip was placed out of T6-T10 levels. The SSSL distance was repeatedly measured in all babies within 48 hours after the first measurement.

Proportion of catheters correctly positioned with the catheter tip at between T6-T10 on initial radiography was calculated for accuracy percent. Repeatability coefficient, defined as half the 95% reference range for differences between repeat measurements on the same subject, equaled  $2\sqrt{2}$  of standard error of the difference<sup>(13)</sup>.

## Results

There were 52 babies, 29 boys and 23 girls, with the mean birth weight of  $2,090 \text{ grams} \pm 936 \text{ grams}$  (range of 740 grams and 4,215 grams). The mean gestational age was  $34.1 \pm 4.2$  weeks (range of 26 and 42 weeks). Birth weights and gestational ages are detailed in Table 1. All babies (100 percent accuracy) the catheter tips correctly placed at high placement (T6 to T10) at the first attempt. Repeatability coefficient for repeating measure of the SSSL was 0.7 centimeters.

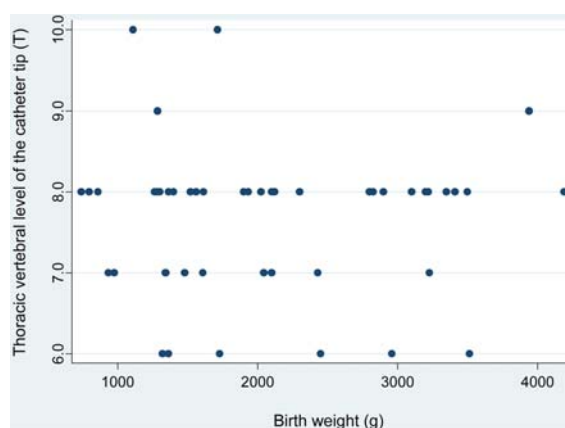
Concerning catheter tips at the more precise placement as between T7 and T9 on the radiograph, there were 43 cases (83%), 7 cases (13%), and 2 cases (4%) correctly inserted, overinserted, and underinserted respectively. The plot between birth weight against the level of vertebrae of the catheter on radiograph is showed in Fig. 1.

## Discussion

A variety formula has been used to pre-determine the insertional length for high placement<sup>(6-11)</sup>. Nomograms from Dunn's post-mortem study that was used to calculate the insertional length was published in 1966<sup>(6)</sup>. Deriving several formulas using morphometric measures to calculate the insertional length have been reported. Weaver and Algren developed a formula as heel to crown length  $\times 0.33$  while Rubin' et al proposed the distance of the baby's xyphoid process to his pubis adding up with the distance from the pubis to the mid-umbilicus<sup>(7,8)</sup>. Birth weight was also used to derive formula to calculate the insertional length. Shukla and Ferrara reported a formula of  $[3 \times \text{BW (kg)}] + 9$ , which has been used widely<sup>(9)</sup>. However, using the formula of Shukla and Ferrara has been claimed a consistent overestimation of catheter insertional length in the smallest infants<sup>(11)</sup>.

**Table 1.** Birth weights and gestational ages of the babies studied

	n = 52	Percent
Birth weight (g)		
740-999	5	9
1000-1499	14	27
1500-2500	18	35
2500-3999	13	25
4000-4215	2	4
Gestational age (weeks)		
26-27	3	6
28-36	32	61
37-39	16	31
42	1	2



**Fig. 1** Relationship between birth weight and vertebral level of the catheter tip on radiograph

The formula,  $[4 \times \text{BW (kg)}] + 7$ , proposed by Wright IM, et al has been recently reported to have good results but for only a special group of very low birth weight infants<sup>(11)</sup>.

Recently, the authors selected the SSSL among several morphometric measures as a new formula after comparing the accuracy and reliability in pre-determine the insertional length with those of previously used formulas<sup>(12)</sup>. Perfect accuracy result in the present study confirms using this SSSL in pre-determination of the insertional length at high placement, between T6-T10 levels. However, the catheter tips tend to place higher thoracic vertebral level than T8 (or T6-T7 levels) regardless of birth weight as seen in Fig. 1. This SSSL was well repeatable with low repeatability coefficient of only 0.7 centimeters. In practice, the SSSL distance has to add up with

the umbilical cord stump length to obtain the final insertion length.

In conclusion, the SSSL is perfectly accurate for pre-determination of the umbilical arterial catheter length to position the catheter tip at T6 and T10 regardless birth weight.

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**ความแม่นยำในการประมาณความยาวของสายสวนหลอดเลือดแดงสายสะดือของทารกแรกเกิด  
ด้วยระยะระหว่าง suprasternal notch และ superior iliac spine**

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**วัตถุประสงค์:** การศึกษานี้เพื่อศึกษาความแม่นยำของระยะระหว่าง suprasternal notch และ superior iliac spine ในการประมาณความยาวสายสวนหลอดเลือดแดงสายสะดือของทารก ให้ปลายสายสวนอยู่ในตำแหน่งระดับกระดูกสันหลังระดับอกที่ 6 และ 10

**วัสดุและวิธีการ:** เป็นการศึกษาไปข้างหน้าในทารกแรกเกิดในหออภิบาลผู้ป่วยทารกแรกเกิดวิกฤติ โรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติที่ต้องใส่ สายสวนหลอดเลือดแดงสายสะดือจำนวน 52 ราย โดยใช้สายสวนหลอดเลือดแดง สายสะดือด้วยความยาวเท่ากับระยะระหว่าง suprasternal notch และ superior iliac spine ประเมินปลายสายสวนหลอดเลือดแดงสายสะดือ เทียบกับตำแหน่งระดับกระดูกสันหลังระดับของทารกแต่ละคน โดยอ้างอิงกับภาพรังสีบริเวณช่องท้องและช่องอก และประเมินความน่าเชื่อถือของการวัดโดยวัดซ้ำ และเปรียบเทียบระยะระหว่าง suprasternal notch และ superior iliac spine 2 ครั้ง

**ผลการศึกษา:** การประมาณความยาวสายสวนหลอดเลือดแดงสายสะดือด้วยระยะระหว่าง suprasternal notch และ superior iliac spine มีความแม่นยำมาก พบว่าปลายสายสวนอยู่ในตำแหน่งระหว่างระดับกระดูกสันหลังระดับอกที่ 6 และ 10 อย่างถูกต้องทุกรายในการใส่สายสวนครั้งแรก (ร้อยละ 100) ค่า repeatability coefficient ซึ่งแสดงความแตกต่างในการวัดซ้ำของระยะระหว่าง suprasternal notch และ superior iliac spine เป็น 0.7 เซนติเมตร

**สรุป:** การประมาณความยาวสายสวนหลอดเลือดแดงสายสะดือ ให้ปลายสายสวนอยู่ในตำแหน่งระหว่างระดับกระดูกสันหลังระดับอกที่ 6 และ 10 ด้วยค่าความยาวระหว่าง suprasternal notch ถึง superior iliac spine นั้น มีความแม่นยำ น่าเชื่อถือ และง่ายต่อการวัด

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