Original Article	
	
Pediatric surgery in tropics Jan-2026	
ISSN 3049-3404 (online)	**DOI : 10.70947/PST2026.35**
Title	**Morphometric Description of the Umbilicus in Infants Aged 1 to 24 Months: A Prospective Study**
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Keywords

Pediatric umbilicus, Umbilical anatomy, Children, Umbilical hernia

Abbreviatios

RXO/XP: Xypho-Umbilical to Xypho-Pubic Distance Ratio

Abstract

Background: The umbilicus is a central anatomical landmark with significant cultural, aesthetic, and surgical relevance. Its morphology and position vary according to genetic and environmental factors, yet data on pediatric populations of African descent remain scarce. This study aims to describe the anatomical characteristics of the umbilicus in infants under two years of age from a sub-Saharan African population and explore their implications for pediatric surgical practice.

Methods: We conducted a prospective, descriptive study between March and September 2023 in two pediatric surgery departments. All children aged 1 to 24 months who presented during the study period were consecutively included, regardless of the reason for consultation. For each patient, anthropometric data (height, weight, and abdominal circumference), umbilical measurements (transverse and vertical diameters), and umbilical position (xypho-umbilical, xypho-pubic, and umbilico-pubic distances) were recorded. Umbilical shape and appearance were classified, and the presence of an umbilical hernia was clinically assessed.

Results : The average transverse diameter of the umbilicus was 19.1 mm (6.2 mm to 58.6 mm), and the average vertical diameter was 15 mm (4 mm to 50 mm). The umbilicus was oval in 95 patients (76%) and prominent in 59.2% of patients. Umbilical hernia was present in 50.4% of cases. The average ratio of xypho-umbilical to

xypho-pubic distance was 0.6 (0.4 to 0.7). The analysis of the xypho-umbilical to xypho-pubic distance ratio in relation to age, sex, weight, and height yielded $p > 0.05$.

Conclusion: The umbilicus is positioned near the junction of the upper three-fifths and lower two-fifths of the abdomen, independent of sex, height, or weight variations. In this population, the umbilicus predominantly exhibited an invaginated and oval shape, with a horizontal major axis. Umbilical size decreased over time, potentially due to the spontaneous closure of umbilical hernias, which are frequently observed in this setting.

Introduction

Far more than merely the first scar present from birth, the umbilicus is a unique and fundamental feature that characterizes the abdomen [1].

It holds profound symbolic and medical importance, as it is a testament to the earliest moments of life. This initial scar is the remnant of our intrauterine life, during which the umbilical cord plays a crucial role in nourishing and oxygenating the fetus, thereby establishing an indispensable connection between the mother and the future newborn [1].

The umbilicus is widely represented in various forms of art and civilization over time [2]. In African art, the umbilicus is depicted prominently, as it represents the seat of life and knowledge and is revered as such [1].

The absence of the umbilicus due to congenital or acquired pathology is not always well received by affected individuals. Reconstructing the umbilicus can help restore not only the aesthetic aspect of the abdomen but also a sense of restored lineage [1].

However, the umbilicus, with its unique shape and position, remains largely unexplored in its anatomical diversity, particularly within specific populations. The differences in human anatomy due to genetic, environmental, and cultural factors are often overlooked, especially for children of African descent. This lack of knowledge limits our ability to personalize medical care and education to adequately meet the specific needs of this population [3,4].

While several studies have described umbilical morphology and position in Caucasian and Asian populations, morphometric data on children of African descent, particularly during infancy, are scarce. This study contributes novel anatomical data from a sub-Saharan pediatric cohort, helping to enrich global anatomical knowledge and supporting context-specific practices in pediatric surgery.

Our study aims to describe the anatomical characteristics of the umbilicus in a sub-Saharan African population of children aged between 1 month and 24 months.

Material and methods

1. Study Design and Setting

This was a prospective, descriptive, and analytical study conducted between March and September 2023 in two pediatric surgery departments: one in the capital city and the other in a rural region of a sub-Saharan African country.

2. Sample

A total of 125 children aged between 1 and 24 months were consecutively included in the study, regardless of the reason for consultation. All patients presenting during the study period and meeting the age criteria were evaluated during routine pediatric surgery outpatient visits. The reason for consultation was not used as a selection criterion. Most participants were seen for common conditions such as inguinal pathologies, minor abdominal wall concerns, or routine follow-up, and not specifically for umbilical abnormalities.

The minimum age of inclusion was one month, which corresponds to the typical period of umbilical healing, thereby minimizing potential interference from postnatal scarring or complications. Children with a history of umbilical catheterization, visible umbilical polyps, granulomas, or anomalies such as a patent vitelline duct were excluded from the study. No such cases were encountered during the inclusion process.

Additional exclusion criteria included visible abdominal wall defects, prior abdominal surgery, major congenital anomalies, syndromic presentations, or incomplete data collection.

3. Data Collection

Demographic information (name, first name, age, date of birth) was collected from participants and their parents, ensuring the confidentiality of the data.

Anthropometric measurements such as height (cm), weight (kg), age (months), abdominal circumference (cm), as well as the xypho-umbilical, xypho-pubic, and umbilico-pubic distances (mm), were taken according to standard measurement protocols.

The transverse and vertical diameters of the umbilicus were measured in millimeters.

The shape and appearance of the umbilicus were recorded.

The presence of an umbilical hernia was clinically evaluated and noted.

4. Measurement Methods

Anthropometric measurements were carried out by pediatric surgeons following standardized protocols to minimize measurement errors.

Weight was measured using a baby scale, height with a stadiometer, and abdominal circumference with a flexible measuring tape.

The xypho-umbilical, xypho-pubic, and umbilico-pubic distances, as well as the diameters of the umbilicus, were measured using a calibrated digital caliper to ensure precision

Results

1. Age Distribution

The age distribution of the participants is shown in table I.

Table I: Age distribution of the patients

Age Range	Quantity	Percentage (%)
1 month – 6 months	68	54.4
7 months – 12 months	24	19.2
13 months – 18 months	17	13.6
19 months – 24 months	16	12.8
Total	125	100

2. General Anthropometric Data

The average height was 68.2 cm, ranging from 48 cm to 90.5 cm.

The average weight was 7 kg, ranging from 2.5 kg to 13 kg.

The average abdominal circumference was 40.4 cm, ranging from 29.5 cm to 70.4 cm.

3. Umbilical Dimensions

The average transverse diameter of the umbilicus was 19.1 mm, ranging from 6.2 mm to 58.6 mm (Figure 1 and Figure 2).

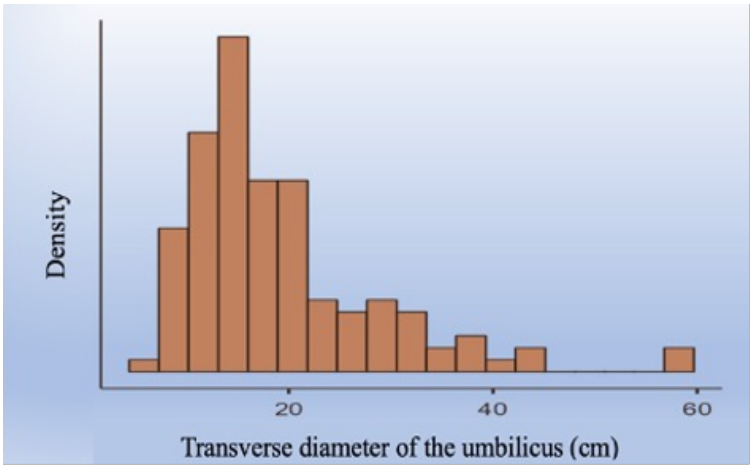

Figure 1: Distribution of patients according to the transverse diameter of the umbilicus.

The average vertical diameter of the umbilicus was 15 mm, ranging from 4 mm to 50 mm (Figure 2).

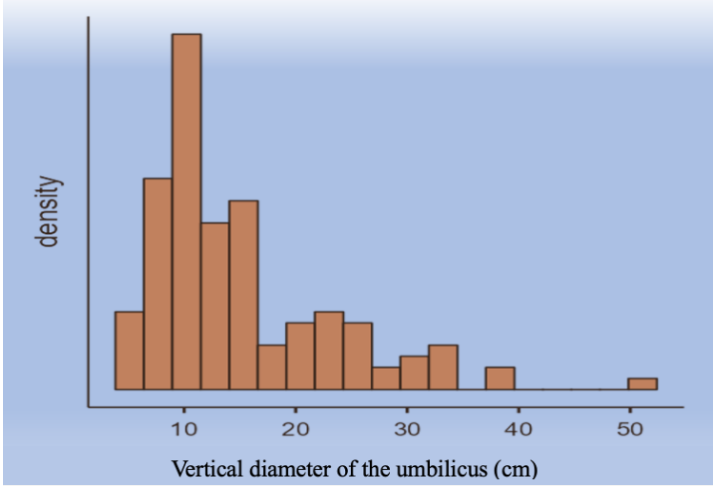

Figure 2: Distribution of patients according to the vertical diameter of the umbilicus.

4. Umbilical Shape

The umbilicus was oval in 95 patients (76%) and round in 30 patients (24%) (Figures 3 and 4). The distribution of umbilical shape by age group is shown in Table II.

Figure 3: Oval umbilicus

Photo taken in Ziguinchor by Dr. Cheikh Tidiane Mbaye

Figure 4: Round umbilicus on umbilical hernia

Photo taken in Ziguinchor by Dr. Cheikh Tidiane Mbaye

Table II: Distribution of patients according to the shape of the umbilicus

Age Range	Oval Umbilicus	Round Umbilicus
1 to 6 months	51 (75%)	17 (25%)
7 to 12 months	21 (87.5%)	3 (12.5%)
13 to 18 months	12 (70.6%)	5 (29.4%)
19 to 24 months	11 (68.8%)	5 (31.2%)
Total	95 (76%)	30 (24%)

5. Umbilical Appearance

The umbilicus was invaginated in 51 patients. The distribution of patients according to umbilical appearance is shown in Table III and by age group in Table IV. Various appearances of the umbilicus are depicted in Figures 5 to 8. An umbilical hernia was present in 63 patients (50.4%).

Figure 5: Invaginated oval umbilicus

Photo taken in Ziguinchor by Dr. Cheikh Tidiane Mbaye"

Figure 6: Prominent umbilicus: protruding

Photo taken in Dakar by Dr. Lissoune Cissé

Figure 7: Prominent umbilicus: cucumber-shaped

Photo taken in Ziguinchor by Dr. Cheikh Tidiane Mbaye

Figure 8: Prominent umbilicus: elephant trunk-shaped

Photo taken in Ziguinchor by Dr. Cheikh Tidiane Mbaye

Table III: Distribution of patients according to the appearance of the navel

Umbilical Appearance		Number	Percentage (%)
Invaginated		51	40.8
Prominent	Protruding	48	38.4
	Cucumber-shaped	16	12.8
	Elephant trunk-shaped	10	8
	Total	125	100

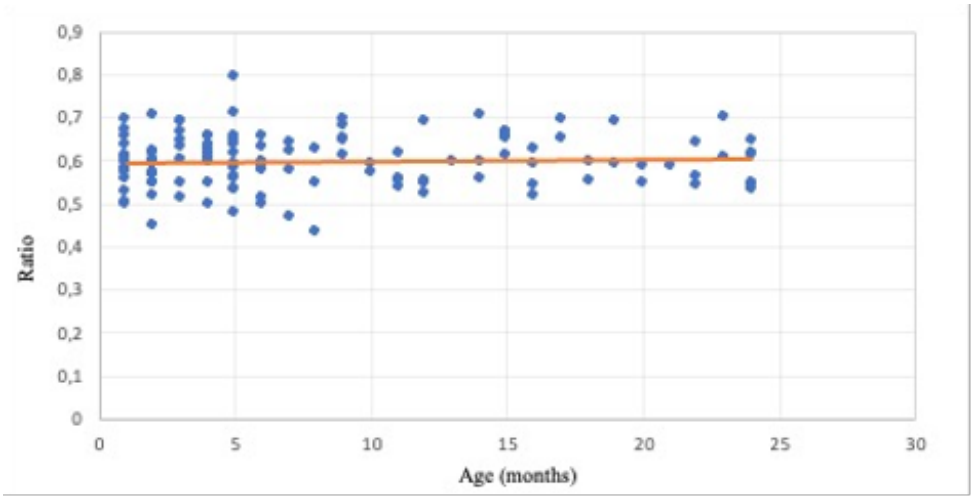

Figure 9: Evolution of the xypho-umbilical to xypho-pubic distance ratio with age.

Table IV: Distribution of navel appearance according to age group

Age Range	Invaginated	Protruding	Cucumbers haped	Elephant trunk shaped	Total
1 to 6 months	20	33	8	7	68
7 to 12 months	13	6	5	0	24
13 to 18 months	10	4	2	1	17
19 to 24 months	8	5	1	2	16
Total	51	48	16	10	125

6. Umbilical Position

The average xypho-pubic distance was 125.7 mm, ranging from 72.5 mm to 177.4 mm.

The average xypho-umbilical distance was 79.7 mm, ranging from 36.2 mm to 112 mm

The average umbilico-pubic distance was 53.3 mm, ranging from 22.8 mm to 99.4 mm

The average ratio of xypho-umbilical to xypho-pubic distance was 0.6, ranging from 0.4 to 0.7. The distribution of patients by this ratio is shown in Table V and its evolution with age is shown in Figure 9. Table VI provides a comparison of different parameters by age group.

Table V: Distribution of patients according to the xypho-umbilical to xypho-pubic distance ratio.

Ratio	Quantity	Percentage (%)
<0.5	17	13
0.5	2	2
>0.5	106	85
Total	125	100

Table VI: Comparison of different parameters by age group.

Parameter	1 to 6 months	7 to 12 months	13 to 18 months	19 to 24 months
Abdominal Circumference	38.3 cm	42.9 cm	41.7 cm	43.9 cm
Xypho-Pubic Distance	115.7 mm	129.4 mm	132.9 mm	142.8 mm
Xypho-Umbilical Distance	73.5 mm	85.4 mm	83 mm	93.5 mm
Umbilico-Pubic Distance	48.5 mm	58 mm	57.5 mm	59.2 mm
Ratio (XO/XP)	0.6	0.6	0.6	0.6
Transverse Diameter	19.7 mm	18.2 mm	19.6 mm	17.5 mm
Vertical Diameter	15.8 mm	14.8 mm	14.6 mm	11.9 mm
Umbilical Hernia	40	10	5	8

RXO/XP: Xypho-Umbilical to Xypho-Pubic Distance Ratio

7. Bivariate Analysis

Table VII shows no correlation between the Xypho-Umbilical to Xypho-Pubic Distance Ratio and age, sex, weight and height.

Table VII: Correlation between Xypho-Umbilical to Xypho-Pubic Distance Ratio and Different Factors.

Factor	Categories	< 0.5	≥ 0.5	Total	p-value
Age (months)	0-6	15	54	69	0.5326
	7-12	5	18	23	
	13-18	4	13	17	
	19-24	1	15	16	
Sex	Male	16	64	80	1
	Female	9	36	45	
Weight (kg)	2.5 to 5	4	34	38	0.1478
	5.1 to 7.5	12	23	35	
	7.6 to 10	9	29	38	
	10.1 to 13	0	13	13	
Height (cm)	0-50	0	3	3	0.1286
	51-60	2	33	35	
	61-80	21	48	69	
	81-100	2	16	18	

Discussion

This study adopts a prospective approach to collect real-time data, thereby reducing recall bias. It includes a sample of over 100 patients for statistical analyses. The recruitment of participants during pediatric surgery consultations helps minimize potential selection bias, ensuring the representativeness of the target population. Conducting the study in two pediatric surgery departments located in different regions enhances the diversity of the studied population's characteristics.

However, our study has certain limitations, such as the absence of consideration for environmental factors and socio-economic data. Additionally, despite a total sample size of 125 children, specific subcategories might have smaller sample sizes, which could limit the ability to draw robust conclusions for these particular groups. Nevertheless, it is essential to note that this is a preliminary study, laying the groundwork for more comprehensive future research.

The first study site, located in the capital city, reflects the ethnic and socio-economic diversity typical of major urban centers. In contrast, the second site is situated in a rural region characterized by dispersed communities and more limited access to healthcare services. These two settings offer distinct environments in terms of lifestyle, living conditions, and healthcare infrastructure.

Starting the study from the age of one month is strategic as it approximately corresponds to the umbilical healing period in infants [2]. This decision aims to ensure that the anatomical characteristics studied are not influenced by factors such as umbilical healing. On average, patients were 8.5 months old, with an age range from 1 to 24 months, reflecting a wide range of infant developmental stages. Moreover, significant variations were observed in the anthropometric measures highlighting the sample's diversity in terms of physical development. The decision to focus on the first two years of life was based on the objective of documenting external anatomical characteristics during a critical period of abdominal wall maturation. We acknowledge that this period includes important developmental events, such as spontaneous closure of umbilical hernias, which may affect the interpretation of certain findings. However, our aim was not to assess long-term hernia persistence but to describe the visible anatomical features observed in real-life clinical settings.

The dimensions of the umbilicus show variation influenced by the patients' age, as evidenced by the transverse and vertical diameter measurements across different age groups. This trend towards a decrease in umbilical dimensions can be attributed to physiological processes such as tissue retraction or spontaneous closure of umbilical hernias, which are very common in our context [2,4,5]. Indeed, it is noteworthy that more than half of our patients presented with an umbilical hernia, emphasizing the importance of considering this condition when evaluating umbilical dimensions. The distribution of umbilical hernias by age group shows a similar trend of decreasing prevalence with age, suggesting a possible spontaneous resolution or reduction

in umbilical hernia size with age, correlating with the progressive strengthening of the abdominal wall muscles [2].

However, one limitation of our study is the absence of direct assessment of the fascial defect size in children with umbilical hernia. As this was a surface anatomical study, no imaging or surgical exploration was performed to measure the actual size of the hernia orifice, which could have clinical relevance in surgical decision-making.

In cases of prominent or redundant umbilical skin—such as in the cucumber-shaped or elephant trunk-shaped variants—measurements were taken at the base of the umbilicus where it attaches to the abdominal wall, to ensure consistency across patients with different morphologies.

Despite the trend towards spontaneous closure of hernias and a decrease in umbilical dimensions, one characteristic persists: the transverse diameter of the umbilicus is generally larger than the vertical diameter, and this trait seems to accentuate with age. This observation raises interesting questions about the underlying mechanisms of this asymmetry.

The literature describes a wide variety of umbilical shapes, listing six distinct forms: T-shaped, round, deformed, protruding, vertical, and horizontal [1,2]. Unlike some studies in adults that favor the vertical oval and round shapes as ideal, pediatric studies have shown that these are not the most frequent shapes before the age of five [1,2]. In our study, the horizontal oval shape was predominant across all age groups, confirming that pediatric umbilical morphology follows a distinct pattern from that of adults.

The high prevalence of hernias contributes to the observation that the umbilicus is frequently prominent during the early years of life [2,6]. This trend was confirmed in our study, where over two-thirds of the patients exhibited a prominent umbilicus during the first six months of life, with this trend reversing after the first year. After the first year, the invaginated aspect becomes predominant.

A common belief is that the umbilicus is located in the middle of the abdomen. However, numerous studies have shown that it is not situated at the midpoint between the xiphoid process and the pubis [1,7]. Our study demonstrates that the umbilicus is almost always located at the junction of the upper three-fifths and the lower two-fifths of the xipho-pubic line. Moreover, no significant age-related variation in umbilical position was observed across the different age groups in our cohort ($p = 0.53$), suggesting that in children aged 1 to 24 months, the position of the umbilicus remains stable. This supports the notion that major positional shifts described in the literature tend to occur after early childhood [1,8].

Studies in older children have shown that the umbilical position tends to move with growth. Initially located above the midpoint of the xipho-pubic line, the umbilicus often shifts downward after the age of five, to a position between the midpoint and the junction of the upper two-thirds and lower third of the xipho-pubic line [1,8]. Other authors have reported that

the umbilical position remains relatively stable from birth to adulthood, consistently located at the junction of the upper two-thirds and the lower third of the xipho-pubic line, although slightly lower in individuals under 18 years compared to adults [2]. Our findings are consistent with this, showing no variation in position with age within our studied age range.

Regarding sex-based differences, our study, like others [1], found no significant variation in umbilical position between males and females, although some studies have reported a slightly lower umbilicus in males.

In adults, umbilical position has been shown to vary with body mass index (BMI), with increased BMI being associated with a more caudal (lower) position of the umbilicus [1,9]. In contrast, our study found that umbilical position in infants remained remarkably constant, regardless of height or weight, indicating a harmonious abdominal growth pattern during early childhood.

These results can guide medical practices by providing guidelines for umbilical reconstruction. They suggest positioning the umbilicus at the junction of the upper three-fifths and the lower two-fifths of the xipho-pubic line. It would be preferable to create horizontally oval umbilici in newborns and young children [2]. Additionally, this information on the low position of the umbilicus in children can guide surgeons during procedures such as laparoscopy. Although transumbilical access is commonly used in pediatric laparoscopy due to thinner abdominal walls, the low position of the umbilicus in infants may require adaptation of trocar placement. It may be suggested to place the umbilical trocar in a supra-umbilical position for pelvic surgeries [10].

Conclusion

Our study highlights the consistent position of the umbilicus in children aged 1 to 24 months, irrespective of sex, height, or weight, with a location near the junction of the upper three-fifths and the lower two-fifths of the xipho-pubic line. We observed that the transverse diameter remains larger than the vertical diameter across age groups, and that the umbilicus most frequently presents as oval, invaginated, and oriented along a horizontal axis.

These findings provide useful anatomical references for clinical practice, particularly in pediatric surgery and umbilical reconstruction.

Future studies should include longitudinal analyses to better understand the evolution of umbilical morphology over time, and explore specific subpopulations such as preterm infants or those with congenital malformations.

Finally, the high prevalence of umbilical hernias observed in this early age group supports further research into their anatomical basis and clinical implications.

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Received on 23rd May 2025	Published on 1st Jan 2026
Acknowledtements: Not applicable.	Conflicts of interest: The authors declare that they have no conflicts of interest related to this study.
Source of funds: No specific funding was received for this study.	Ethical clearance
Citation V3 I1	https://doi.org 10.70947/PST2026.35
Orcid if applicable	