International Journal of Innovative Research in Medical Science (IJIRMS)
Volume 07, Issue 02, February 2022,
https://doi.org/10.23958/ijirms/vol07-i02/1358

Original article

Ilioinguinal and Iliohypogastric Nerve Localization in Children: Our Initial Ultrasound Investigation

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Received 04 February 2022; Accepted 23 February 2021; Published 26 February 2022

Abstract

Objective: The purpose of our study is to examine the localization of the Ilioinguinal and Iliohypogastric (ILIH) nerves by using ultrasound and its relationship to age, BW in children.

Methods: Children between 1-16 years of age, ASA I-II class, admitted to the surgical department for inguinal hernia, orchidopexy, and hydrocele repair were included in this prospective, randomized study at the National Center for Maternal and Child Health of Mongolia. We divided these children into three age groups: 1-4 years, 5-8 years, and more than 9 years old. The transducer was placed longitudinally at the line drawing from the ASIS to the umbilicus and after identifying the ILIH nerves we measured the distances of the anatomical structures: depth or thickness of the abdominal anterior wall structures and distance of ILIH nerves from the ASIS. When we identified the ILIH nerves we saved the pictures in the US machine. Identification and visibility scores of nerves and muscles were made by using a Likert scale and Vienna score and showed in the median. We recalled the data and analyzed it with repeated measurements, followed by ANOVA for a single factor. The correlation was calculated using the Pearson's correlation coefficient. The tables show a mean ±SD and number (%) of subjects. A p-value<0.05 was considered statistically significant.

Results: A total of 55 pictures were analyzed. The current study showed that the distance and depth of some anatomical structures, such as the mean distance of skin-peritoneum was 1.43±0.37 cm (CI 95% 0.76-2.37, p=0.0023), the thickness of internal oblique muscle was 0.33±0.14 cm (CI 95% 0.11-0.75, p=0.0022), the target point of ILIH nerve which was equal to the skin to TAM distance 1.06±0.3 cm (CI 95% 0.56-1.82, p=0.0093) were increasing regarding the age. For other measurements of depth not seen age-related statistically significant differences.
According to the location of the ILIH nerves to the ASIS, in younger children they locate more close than in bigger children, however, only the distance of ASIS-IHN was statistically significant. The ILIH nerves localize more close to the iliac bone in the younger children and when age is increasing the nerve locates more medially and it correlates to the BW and ages.

Conclusion: ILIHN were visible by ultrasound in children. ILHN location correlates to age, BW, and BMI.

Keywords: ***Ilioinguinal nerve, Iliohypogastric nerve, ultrasound guidance, inguinal hernia, pediatric pain management***

Introduction

Ilioinguinal and iliohypogastric (ILIH) nerve block is the most common block of the abdominal wall block which is used for surgical procedures of inguinal area, especially inguinal hernia repair, orchidopexy in children [1-3], in addition to emergency procedures such as an obstructed hernia [4]. It is considered a safe, low-risk, effective block. There are many studies in adults of ILIH nerve block was used in the lower abdominal wall incisional surgery such as cesarean section, gynecological operation, and kidney recipient surgery [5-8]. ILIH nerve block may be performed with the anatomical landmark (conventional, blind technique) or with ultrasound-guided (USG) techniques. There are studies where the needle entry point is defined in the medial anterior superior iliac spine (ASIS) in the anatomical landmark (AL) technique [9-11]. Furthermore, there are also studies pointing out that lumbar nerve origins and progress of ILIH nerves in the anterior abdominal wall may vary [12-15]. The AL technique for ILIH block, without ultrasound guidance, has a reported failure rate of up to 45% [3]. It is associated with incorrect local anesthetic placement in 14% of cases, inadvertent femoral nerve block [11], and the rare but serious complication of small bowel puncture [16,17].

The purpose of our study is to examine the location of ILIH nerves by using an ultrasound machine and to compare the results with some studies which were performed in cadavers.

Materials and Methods

Study design: Children between 1-16 years of ages, ASA (American Society of Anesthesiologists) I-II class, admitted to the General Surgical and Urological departments for inguinal hernia, orchidopexy, and hydrocele repair were included in this prospective, randomized study at the National Center for Maternal and Child Health of Mongolia.

Data collection: A total of 60 children were involved in this study. Children with an allergy to local anesthetics, ASA III-IV class, skin infection at the injection site, and those who refused to participate in the study were excluded from the study. All patients were received general anesthesia. No premedication was done. General anesthesia for children 0-3 years of age was induced by inhalation of sevoflurane up to 8% with oxygen. After establishing venous access, 2mcg/kg of fentanyl (№280715,09052 Moscow, Russia) was given to all children. The children aged more than 4 years old who were established IV in the ward already, were given 5 mg/kg of Thiopental sodium (№ 4602565020385, Kurgan, Russia) and 2mcg/kg of fentanyl intravenously. Anesthesia was maintained with 1-1.5 MAC isoflurane in air/O2 (FiO2-0.4). The children breathed spontaneously via a laryngeal mask airway.

After induction, ilioinguinal and iliohypogastric nerves were examined by using an ultrasound machine (PHILIPS Sparq US machine) with a high-frequency linear array transducer 4-12 MZ. The transducer was placed longitudinally at the line drawing from the ASIS to the umbilicus. After identifying the ilioinguinal and iliohypogastric nerves we pictured and saved the pictures in the US machine. Identification and visibility scores of nerves and muscles were made by using a Likert scale and Vienna score and showed in the median [18,19].

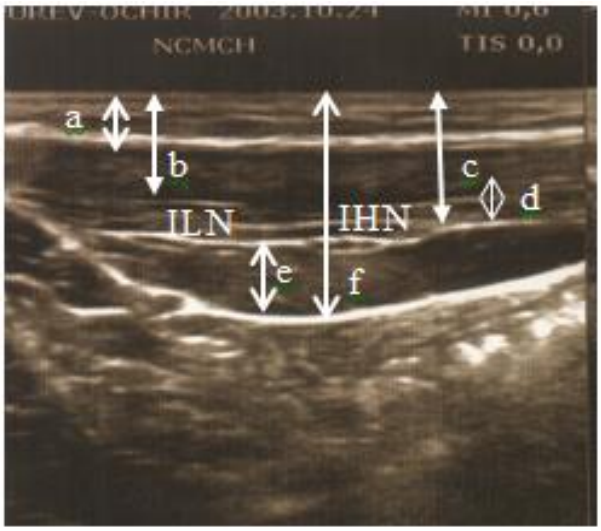

Figure 1: Abdominal anterior wall structures: US picture with high-frequency linear array transducer 4-12 MZ. a. S-EOM, b. S-IOM, c. S-TAM, d. t-IOM, e.t-TAM, f. S-peri; ILN-Ilioinguinal nerve, IHN-iliohypogastric nerve

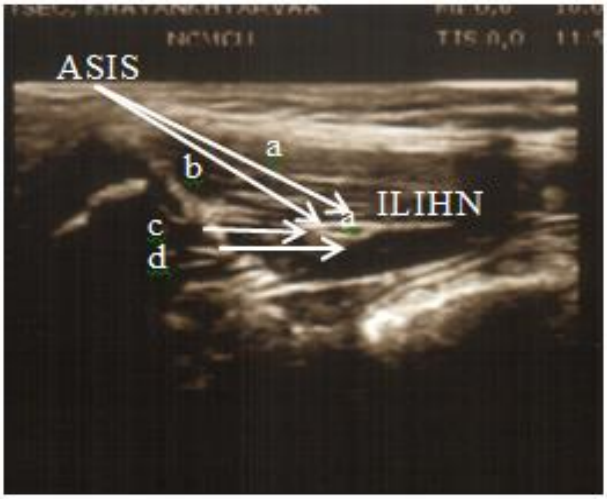

Figure 2: Nerve distance from ASIS and Iliac bone: US picture with high-frequency linear array transducer 4-12 MZ. a. ASIS-IHN, b. ASIS-ILN, c. Bone-ILN, d. Bone-IHN; ILIHN-Ilioinguinal and Iliohypogastric nerve.

The Likert scale consisted of a 5 point scale:

1. Anatomical structure's identification is very poor
2. Poor identification of structures around the nerve
3. Poor identification of the nerve
4. Good visibility of the nerve
5. Excellent visibility of the nerve with internal structure

Vienna scores consisted of a 4 point scale.

1. Internal structure of nerve seen
2. Nerve seen as a circular or oval-shaped bright halo
3. Nerve seen as reflections determined by the anatomical structures of surrounding tissue
4. Anatomical position of nerves shows no response to ultrasound beam (isoechoic behavior)

After the operation we measured the distances of anatomical structures at the line drawing from the anterior superior iliac spine (ASIS) to the umbilicus, including ASIS, as were the following:

1. Depth of anatomical structures of the abdominal anterior wall (from the skin to the external oblique muscle (S-EOM), internal oblique muscle (S-IOM), the thickness of IOM (t-IOM), skin-transversus abdominis muscle (S-TAM), the thickness of TAM (t-TAM), skin-peritoneum (S-Peri))
2. A distance of ILIH nerves from iliac bone: Bone-ilioinguinal nerve (B-IIN), Bone-iliohypogastric nerve (B-IHN), ASIS-IIN, ASIS-IHN

Statistical analyses: We did descriptive analyses with repeated measurements, followed by ANOVA for a multiple comparisons. The correlation was calculated using the Pearson correlation coefficient. The tables were shown a mean ±SD and number of subjects. A p-value<0.05 was considered statistically significant.

Results and Discussion

A total of 60 pictures were involved in this study. However, 5 pictures weren't saved or deleted and all 55 pictures were studied. ILIH nerves were visible by ultrasound in children. The demographical data is shown in Table 1.

Table 1: Demographical data*

	Units	Total	1-4 years	5-8 years	9 years<
		N=55	N=26	N=13	N=16
Age	months	73.2±49	30.2±12.4	79±13.5	138±23
CI 95%		14-192	14-48	60-96	108-192
Body weight	kg	21.9±10.8	14.4±3.4	19.5±3.6	35.8±8.9
CI 95%		10-56.2	10-25.3	14-26.2	24-56.2
Height	cm	107.5±22.7	90±9.9	107±11.3	137±12.4
CI 95%		75-165	75-110	92-130	117-165
Body mass index	Kg/m^2	18±2.2	17.8±2.5	17±1.2	19±2.2
CI 95%		13.7-24.8	13.7-24.8	15.3-20	16.2-23.6

**Data presented as mean ± SD.*

The depth of the anatomical structure of the abdominal wall is shown in Table 2. Thickness of IOM, skin to TAM and peritonium distance were increasing by age, which were statistically significant (p<0.00).

Table 2: The depth of the anatomical structure of the anterior abdominal wall (in cm)

	Total*	1-4 years*	5-8 years*	9 years<*	P value
	N=55	N=26	N=13	N=16	
S-EOM	0.47±0.17	0.46±0.13	0.44±0.18	0.51±0.2	0.5
CI 95%	0.24-1.0	0.26-0.8	0.24-0.89	0.3-1.0	
S-IOM	0.74±0.22	0.69±0.19	0.72±0.2	0.82±0.26	0.18
CI 95%	0.41-1.35	0.4-1.26	0.47-1.2	0.5-1.35	
t-IOM	0.33±0.14	0.27±0.09	0.35±0.12	0.42±0.17	0.0022**
CI 95%	0.11-0.75	0.12-0.46	0.18-0.54	0.11-0.75	
S-TAM	1.06±0.3	0.96±0.27	1.1±0.25	1.24±0.32	0.0093**
CI 95%	0.56-1.82	0.56-1.72	0.6-1.6	0.85-1.82	
t-TAM	0.35±0.12	0.32±0.1	0.37±0.11	0.39±0.14	0.13
CI 95%	0.12-0.65	0.15-0.56	0.1-0.56	0.17-0.65	
S-Per	1.43±0.37	1.27±0.34	1.47±0.3	1.66±0.35	0.0023**
CI 95%	0.76-2.37	0.76-2.2	0.9-1.64	1.09-2.37	

**Data presented as mean ± SD. **Data statistically significant with ANOVA multiple comparisons.*

Regarding to the distances from ASIS and Iliac bone to the ILIH nerves were increasing by age however not significant except IHN distance from the ASIS (Table 3).

Table 3: The distance of from ILIH nerve to the iliac bone and ASIS by age differences (in cm)

	Total	1-4 years	5-8 years	9 years<	P value
	N=55	N=26	N=13	N=16	
Bone-ILN	0.6±0.37	0.56±0.38	0.7±0.41	0.59±0.31	0.5
CI 95%	0.19-1.64	0.19-1.38	0.19-1.64	0.21-1.36	
ASIS-ILN	1.3±0.63	1.19±0.58	1.3±0.6	1.5±0.73	0.3
CI 95%	0.24-3.1	0.31-2.51	0.55-2.56	0.24-3.1	
Bone-IHN	1.0±0.5	0.98±0.53	1.14±0.55	0.89±0.35	0.4
CI 95%	0.24-2.4	0.24-2.4	0.29-1.97	0.49-1.56	
ASIS-IHN	1.66±0.5	1.5±0.42	1.73±0.45	1.87±0.56	0.04**
CI 95%	0.74-3.43	0.74-2.6	1.04-2.7	1.12-3.43	

**Data presented as mean ± SD. **Data statistically significant with ANOVA multiple comparisons.*

Abdominal anterior wall anatomical structures strong, positive relationship with BW and height in all children, however there were no relationship in children under 4 years (Table 4).

Table 4: Pearson's correlation: Abdominal anterior wall anatomical structures and anthropometric characteristics

	1-16 years (n=55)		1-4 years (n=26)		5-8 years (n=13)		9-16 years (n=16)	
	R	p-value	R	p-value	R	p-value	R	p-value
Bodyweight								
S-EOM	0.15	0.3	0.21	0.3	0.42	0.16	0.097	0.7
S-IOM	0.28	0.04*	0.17	0.4	0.62	0.023*	0.17	0.5
t-IOM	0.48	0.0002*	0.05	0.8	0.43	0.14	0.26	0.34
S-TAM	0.45	0.001*	0.06	0.8	0.71	0.006*	0.29	0.27
t-TAM	0.43	0.001*	0.1	0.6	0.37	0.22	0.66	0.005*
S-Per	0.52	0.9	0.002	1	0.75	0.003*	0.44	0.08

	Body mass index							
S-EOM	0.27	0.046*	0.12	0.6	0.06	0.85	0.5	0.049*
S-IOM	0.25	0.67	0.05	0.8	0.2	0.5	0.58	0.02*
t-IOM	0.13	0.34	0.11	0.6	0.64	0.02*	0.22	0.4
S-TAM	0.27	0.04*	0.12	0.5	0.49.	0.08	0.62	0.01*
t-TAM	0.17	0.2	0.18	0.4	0.45	0.12	0.32	0.23
S-Per	0.23	0.09	0.08	0.7	0.61	0.02*	0.64	0.008*
	Height							
S-EOM	0.08	0.6	0.29	0.16	0.31	0.3	0.1	0.7
S-IOM	0.23	0.09	0.19	0.36	0.57	0.04*	0.09	0.7
t-IOM	0.5	0.0001*	0.004	0.49	0.57	0.039*	0.24	0.36
S-TAM	0.41	0.002*	0.12	0.54	0.75	0.003*	0.07	0.8
t-TAM	0.39	0.003*	0.07	0.89	0.47	0.1	0.7	0.004*
S-Per	0.5	0.0001*	0.05	0.8	0.83	0.0004*	0.24	0.4

**Data statistically significant with Pearson's correlation.*

From ASIS to ILIH nerves distance were statistically significant, and strong positive correlation with BW, and height in children above 9 years old. Children under 9 years old there were no correlation between nerve distance and anthropometric characteristics except IHN and BMI in 1-4 years children (Table 5).

Table 5: Pearson's correlation: Nerve distance and anthropometric characteristics

	1-16 years (n=55)		**1-4 years (n=26)**		**5-8 years (n=13)**		**9-16 years (n=16)**	
	R	**P-value**	**R**	**P-value**	**R**	**P-value**	**R**	**P-value**
Bodyweight								
Bone-ILN	0.05	0.7	0.04	0.87	0.24	0.4	0.25	0.34
ASIS-ILN	0.4	0.003*	0.001	0.96	0.55	0.05*	0.7	0.026*
Bone-IHN	0.13	0.36	0.04	0.86	0.09	0.76	0.43	0.09
ASIS-IHN	0.4	0.002*	0.08	0.7	0.32	0.29	0.59	0.014*
	Body mass index							
Bone-ILN	0.34	0.01	0.71	0.9	0.1	0.7	0.09	0.7
ASIS-ILN	0.42	0.002*	0.51	0.01	0.14	0.6	0.29	0.03*
Bone-IHN	0.13	0.35	0.5	0.008*	0.16	0.59	0.19	0.17
ASIS-IHN	0.38	0.005*	0.54	0.004*	0.06	0.86	0.37	0.006*
	Height							
Bone-ILN	0.02	0.89	0.4	0.04	0.14	0.6	0.4	0.13
ASIS-ILN	0.29	0.03*	0.31	0.12	0.41	0.2	0.72	0.002*
Bone-IHN	0.19	0.17	0.36	0.07	0.07	0.8	0.33	0.22
ASIS-IHN	0.37	0.006*	0.26	0.2	0.25	0.4	0.6	0.02*

**Data statistically significant with Pearson's correlation.*

ILIH nerve block is a simple and effective technique for pain relief of the lower abdominal wall region, based on surface anatomy and visible skin landmarks, namely, the tubercle of the pubis, the inguinal ligament, and the anterior superior iliac spine of the ilium and umbilicus.

Accurate placement of the needle in the proximity to the nerve and accurate volume of local anaesthetic solutions are determining the success rate of nerve blockade. The direct sonographic visualization of the nerves improves the quality of the block [20,21], decreases the volume of local anaesthetic [22,2], and reduces the risk of complications. Also, there have been some case reports using US-guided new technique of ILIH nerve block in obese and high-risk patients [23,24]. However, the availability of the ultrasound machine itself could be a problem in some countries.

Therefore, a conventional AL technique is still used as part of multimodal analgesia for inguinal surgery and lower abdominal wall surgeries.

Overall failure rate is varied from 28-45% [25,3]. It may depend on the followings:

1. The anatomical variance of ILIH nerves
2. Piercing points of those nerves through muscle layers
3. Anaesthetists experience

Knowledge of the exact anatomical positions would enhance the success of this block, especially when using a "blind" technique.

The current study showed that depth from skin to peritoneum was 1.43±0.37 cm (CI 95% 0.76-2.37, p=0.0023), the thickness of IOM 0.33±0.14 cm (CI 95% 0.11-0.75, p=0.0022), the target point of ILIH nerve block which is equal to from skin to TAM distance was 1.06±0.3 cm (CI 95% 0.56-1.82, p=0.0093). For other measurements of depth not seen age-related statistically significant differences.

Regarding the anatomic pathway of the nerve that has been published in the literature, there was even evidence of the absence of IL nerve [13]. There are many cadaver studies of ILIH nerve topographic anatomy, mostly in adult specimens.

According to the location of the ILIH nerves to the ASIS, in younger children, it is close than in adults. Van Schoor et al. performed a study on a sample of 25 infant and neonatal cadavers. The results showed that the left and right IL nerves were close to the ASIS 1.9±0.9 mm and 2.0±0.7 mm, respectively. The mean distances of the left and right IH nerves to the ASIS were 3.3mm

and 3.9±1.0 mm, respectively. The authors suggested that an insertion point closer to the ASIS, approximately 2.5 mm from the ASIS on a line is drawn between the ASIS and the umbilicus [15].

Studies have shown that in adult cadaver study ILIH nerves were located more medially than in infants. The ILIH nerves arise from the lumbar plexus many different types as a described Klaassen et al in 100 cadaver study the IL nerve entered the abdominal wall 2.8±1.1 cm medial and 4 ± 1.2 cm inferior to the ASIS and the IH nerve entered the abdominal wall 2.8 ± 1.3 cm medial and 1.4 ± 1.2 cm inferior to the ASIS [26]. James L Whiteside et al studied the map of the course of the ILIH nerves from 11 fresh-frozen cadavers. Thirteen IH and sixteen IL nerves were identified and mapped. On average, the proximal end of the IL nerve entered the abdominal wall 3.1±1.5 cm (0.9-6.3 cm) medial and 3.7±1.5 cm (-0.5-5.9cm) inferior to the ASIS. The IH nerve entered abdominal wall 2.1±1.8 cm (-1.6-5 cm) medial and 0.9±2.8 cm (-5.4-5.5cm) inferior to the ASIS [27].

Secondly, there is no agreement, about where the needle should be placed: in between external and internal oblique muscles or between the internal oblique and the transversus muscle? Most studies suggest that the one-click method is less dangerous than double-click methods. In the present study, there were no complications observed. The proximal trunks of IL and IH nerves enter transversus muscle close and superior to the ASIS and both nerves are close to each other. The site where the nerve perforates the internal oblique muscle is subject to great anatomical variability. Jamieson et al. suggested that the anaesthetic blocking of the entire nerve–supply of the lower abdominal wall, the point selected should be within a restricted area where the nerves are closest together, that 3-4 cm above and medial to the ASIS and over the crest of the ilium. In the authors' opinion, a point 4-6 cm posterior tip of the ASIS, along the lateral aspect of the external lip of the ilium, where the ILIH nerves lie together as they perforate the transversus muscle, would be optimal [14]. Eichenberger et al studied in ten cadavers the accuracy of a selective ILIH nerve block by using ultrasound and confirmed by anatomical dissection and they suggested if using "blind" technique, a new injection point 5 cm cranial and 5 cm posterior of the ASIS may be advantageous and may reduce failure rates. In this area, the median distance of the IL nerve to the iliac bone was 6.0 mm and the distance between the two nerves was 10.4 mm [28].

In the current study the ILIH nerve distance from ASIS were statistically significant with age, BW, and height in all children, however under 9 years old the relationship between nerve distance and anthropometric value was insignificant, except above 9 years old ($p<0.05$) Table 4. Several descriptions of the conventional technique have been published, all of which are based on the subjective feeling of a "fascial click" when the needle pierces the muscle fascia [29].

In the clinical study, the block failure rate is various by determining intraoperative hemodynamic changes, postoperative pain intensity, rescue analgesic, and opioid requirements.

Conclusion

ILIH nerve block can be used safely and successfully as a part of multimodal analgesia in children. When using ILIH block by a conventional method, we recommend that the puncture site is at the junction lateral one fourth and the medial three fourths in a line from the ASIS to the umbilicus. This technique has a more dynamic character than other static points and it is very important in children who have an anatomic variance regarding their growing ages. Furthermore, we suggest if injecting at points medial and superior to the ASIS use double click and injection technique (under internal oblique aponeurosis) and if using medial and inferior point to the ASIS should inject in a plane under external and internal oblique aponeurosis, both.

Ethical statement

Ethical approval for this study was acquired from the Research Ethics Committee (Ethical Committee No 6/3/2015 06) of Mongolian National University of Medical Science. Parents of all children were informed verbally purpose and content of the study before the surgery and signed a written informed consent form.

List of abbreviations

ASIS-Anterior Superior Iliac Spine
BW-Body weight
BMI-Body mass index
ILIH-Ilioinguinal and Iliohypogastric
ILN-Ilioinguinal nerve
IHN-Iliohypogastric nerve
S-IOM-Skin to Internal oblique muscle
t-IOM –Thickness of Internal oblique muscle
S-EOM –Skin to External oblique muscle
t-TAM- Thickness of Transversus Abdominis Muscle
S-Peri- Skin to peritonium
US- Ultrasound

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Authors' contributions

Odgerel Boldbaatar performed the US guided examination of the ILIH nerves, and was a major contributor in writing the manuscript. Ganbold L and Sergelen O supervised of the performance of this study. All authors read and approved the final manuscript.

Acknowledgments

We thank Ariuntungalag M, who is a Head of Department of Anesthesia and Operation Block of Children's Hospital of National Center for Maternal and Child Health, for providing the research.

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