Evaluation of Resistive Index Following Unilateral Childhood Inguinal Herniotomy at Aminu Kano Teaching Hospital, Kano, Nigeria

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ABSTRACT

Background: Herniotomy is said to be the most commonly performed surgery in children; however, its effect on testicular vascularity remains unknown in our environment.

Aim: To determine the effect of surgery (herniotomy) on testicular resistive index in children with unilateral inguinal hernia.

Study Design: Prospective non-randomized hospital-based study.

Methodology: Consecutive children, 1 month to 12 years, who presented with unilateral inguinal hernia were recruited, and informed consent was obtained. Pre-operative testicular resistive index of the ipsilateral testis was measured using Doppler ultrasound a day before surgery. At 7 and 30 days post-operatively, repeat testicular Resistive Index (RI) measurements were taken to determine if there was any significant change in the RI of the testes. The resistive index was determined using the intra-testicular peak systolic velocity and end-diastolic velocity. Differences between the testicular resistive index before and after herniotomy were tested using a paired t-test. A p-value of < 0.05 was taken as significant at the 95% confidence interval.

Results: One hundred and twenty-five (125) boys with unilateral inguinal hernia were recruited into the study; however, 7 were lost to follow-up. Their ages ranged between 0.2 and 12 years, with a mean age of 3.78 years ± 3.12. Most of the children, 54 (45.8%), were within the age group of less than 3 years. The hernia was on the right side in 90 (76%) children and on the left in 28 (24%). The age-specific testicular volume before surgery was 0.28 ml for children less than 1 year, 0.60 ml for the age range of 1-1.99 years and 0.53 ml for children in the 6-6.99 years age range.

Preoperative mean testicular resistive index was 0.65 ± 0.13 with a range of 0.22 to 0.98. The postoperative mean testicular resistive index was 0.61 ± 0.10 and 0.63 ± 0.080 at 1week and 1 month, respectively. A

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statistically significant difference between the preoperative mean resistive index and the resistive index at 7 days postoperatively (p=0.0001) was noticed. However, there was no statistically significant difference when the preoperative mean resistive index was compared with the RI at 30 days postoperatively (p=0.235).

Conclusion: There was a transient statistically significant change in testicular resistive index on postoperative day 7 and returned toward baseline by 30 days. No postoperative alteration of testicular vascularity.

Keywords: Testis, Inguinal Hernia, Herniotomy, Resistive Index, Doppler Ultrasound

INTRODUCTION

Testis, structurally, is an oval-shaped organ with two structurally distinct compartments: the interstitial space and the seminiferous tubules, which contain germ and Sertoli cells. Typically, the testis contains around 400–600 seminiferous tubules responsible for sperm production.[1] It has a well-developed arterial supply and venous drainage.[2]

Hernia is an abnormal protrusion of a portion of an organ or tissue through a defect in the wall of the cavity containing it. Indirect inguinal hernias occur when the abdominal contents protrude through the deep inguinal ring lateral to the inferior epigastric vessels. The contents can also descend along with the inguinal sac to the scrotum through the superficial inguinal ring. It occurs due to the failure of embryonic closure of the processus vaginalis.[1,2]

The incidence of inguinal hernia ranges from 1 to 4.4% and is higher in infants, commensurate with the higher rate of patent processus vaginalis. Boys are six times more affected than girls.[3] Hernias can be life-threatening, resulting in the loss of a testis, an ovary or a portion of the bowel if incarceration, strangulation or operative complications occur.[3] No disease belonging to the province of surgeons needs accurate anatomical knowledge and good surgical skill more than hernia in all its varieties.[3]

Maintenance of testicular vascularity is vital in preserving both testicular volume and function. A good way of assessing whether the testicular volume or vascularity is affected following hernia surgery is by measuring the resistive index and testicular volume using Doppler ultrasound. RI = (Systolic peak velocity - End diastolic peak velocity)/systolic peak velocity.[4.] Intra-testicular arteries characteristically have a low resistive pattern; it ranges between 0.48 - 0.75 with a mean RI of 0.62.[5]

METHODS

This is a prospective non-randomized hospital-based study performed following approval by the Health Research Ethics Committee of Aminu Kano Teaching Hospital, with ref. no: NHREC/28/01/2020/AKTH/EC/3388. Parents of all the children consented.

Study Group: Analysis included boys, 12 years and below, with unilateral inguinal hernia. The study was performed between October 2022 and October 2023.

Sample Size

The minimum sample size was calculated using the formula for estimating a single mean

$$n = \frac{Z_{\alpha}^{2}\alpha^{2}}{d^{2}}$$

n = Minimum sample size

$Z\alpha$ = Standard normal deviate corresponding to 5% level of significance =1.96 (obtained from a normal distribution table)

σ = Standard deviation of the quantitative outcome of interest obtained from a previous study

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d = is the desired level of precision (usually at 5%)

A similar study by Basha et al[9]., reported a postoperative mean testicular volume at 1 week as 0.7406 cm^3 ± 0.22576. The standard deviation (0.22576) will be used to calculate the minimum sample size for this study.

$$n = \frac{1.96^2 \times 0.22576^2}{0.05^2}$$

$$n = \frac{3.8416 \times 0.0510}{0.0025} = 78.3686$$

To allow for attrition, a 10% non-response rate was added to the calculated sample size so that the minimum sample size was 85.8 ≈ 86. The sample size was, however, increased to 125 to increase the precision. Therefore, 125 boys with unilateral inguinal hernia met the inclusion criteria and were recruited into the study; however, 7 were lost to follow-up. The 7 patients lost to follow-up were excluded from the final analysis because they were lost at an early part of the research, and only the 118 patients with complete pre-operative, day 7 and day 30 measurements were included in the statistical comparisons.

Study Plan: Following diagnosis, patients had a testicular Doppler USS, and the testicular resistive index was measured preoperatively. All the patients had surgery; the Mitchell Banks herniotomy technique was used (inguinal canal was not opened) in 105 children (89.0%). The Gross and Ferguson technique (inguinal canal was opened) was used in 13 children (11.0%) among the older age group. Testicular resistive index was then reassessed by Doppler USS on post-operative days 7 and 30, respectively.

Radiological Evaluation: Testicular Doppler USS examinations were performed using a trans-scrotal approach with a high-frequency 9 - 16 MHz linear array probe (Nortek CS-50 system). All scans were performed by specialists in the radiology department with a special interest in paediatric radiology using the same equipment to reduce inter-ultrasound transducer variations. The examination was blinded to any clinical information, and the average of two measurements was taken to reduce intra-observer effects on the results. The Doppler ultrasound measurement of the ipsilateral testicular resistive index was recorded. No surgical procedure was done on the contralateral testes. Therefore, the contralateral testis could not serve as an intra-subject control for the effect of surgery, as any observed difference might still be due to individual physiological variation rather than the herniotomy itself. The study was therefore designed to compare pre-operative and post-operative values within the same (operated) testis.

Statistical Analysis: Data included demographic characteristics, presentation, operative findings and outcome. Statistical analysis was done with SPSS 29.0 software. Data were expressed as mean and standard deviation (SD) for quantitative variables, while numbers and percentages were used for descriptive variables. Paired t-test and chi-square statistics were used for quantitative and qualitative variables, respectively. The preoperative testicular resistive index (RI base) was compared with postoperative week one (7 days) and one month (30 days) RI, respectively. Differences between testicular RI before and after herniotomy were tested using a paired t-test. A p-value of < 0.05 was taken as significant at the 95% confidence interval.

RESULTS

Sociodemographic Characteristics of the Patients

One hundred and twenty-five (125) boys with unilateral inguinal hernia met the inclusion criteria and were recruited into the study; however, seven (7) were lost to follow-up. Their ages ranged between 0.2 and 12 years, with a mean age of 3.78 years ± 3.12.

Most of the children (45.8%) were within the age group of less than 3 years old (Figure 1).

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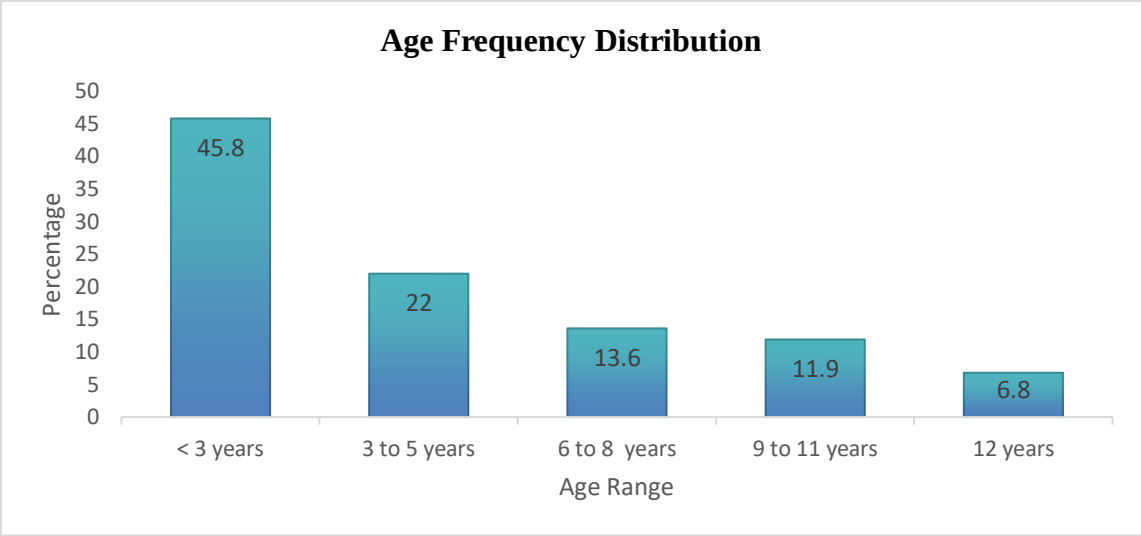

Figure 1: Age Frequency Distribution

Clinical Presentation of the Patients and Age-Specific Testicular Volume Distribution

Reducible groin/scrotal swelling was the presenting complaint in all the patients, with the duration of symptoms ranging from 1 to 7 months and a mean of 4 months ± 2.7. None of the parents reported a history of scrotal pain, discomfort or reduced testicular volume. The hernia was on the right side in 90 (76%) patients and on the left in 28 (24%). The age-specific testicular volume before surgery was 0.28 ml ± 0.08 for children less than 1 year, 0.60 ml ± 0.12 for the age range of 1-1.99 years and 0.53 ml ± 0.09 for children 6-6.99 years (Table I).

Table I: Age-Specific Testicular Volume

S/N	Age range	Frequency	Mean ± SD
1	0-0.99	20	0.28 ± 0.08
2	1-1.99	16	0.60 ± 0.12
3	2-2.99	18	0.54 ± 0.10
4	3-3.99	7	0.55 ± 0.17
5	4-4.99	16	0.89 ± 0.21
6	5-5.99	3	0.59 ± 0.16
7	6-6.99	10	0.53 ± 0.09
8	7-7.99	4	0.67 ± 0.20
9	8-8.99	2	0.63 ± 0.17
10	9-9.99	7	0.89 ± 0.20
11	10-10.99	0	0
12	11-11.99	7	0.84 ± 0.24
13	12-12.99	8	0.79 ± 0.22

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Preoperative and Postoperative Mean Testicular Resistive Index

Preoperative mean testicular resistive index was 0.65 ± 0.13 with a range of 0.22 to 0.98. The postoperative mean testicular resistive index is shown in Tables II and III below.

Table II: Preoperative and Postoperative Mean Testicular RI

Variable	N	Range	Minimum	Maximum	Mean	SD
RI before surgery	118	0.76	0.22	0.98	0.65	0.13
RI 1 weeks postop	118	0.62	0.28	0.90	0.61	0.10
RI 4 weeks postop	118	0.41	0.49	0.90	0.63	0.080

Table III: Comparison of the Preoperative Mean Testicular RI with the Postoperative Mean Testicular RI

Pair	Description	Mean	N	SD	SEM
1	Resistive index before surgery	0.65	118	0.13	0.012
	Resistive index 7-days post-op	0.61	118	0.10	0.0094
2	Resistive index 30-days post-op	0.63	118	0.08	0.0073

Comparison of the Preoperative Mean Testicular RI with the Postoperative Mean Testicular RI

A statistically significant difference between the mean preoperative resistive index and RI at 7 days postoperative (p=0.0001) was noticed. There was no statistically significant difference between the mean preoperative resistive index and RI at 30 days postoperative (p=0.235), as shown in Table IV below;

Table IIII: Paired t-test Comparison of the Preoperative Mean Testicular RI with the Postoperative Mean Testicular RI

Pair		Paired Differences					t	df	P-value
		Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
1	Resistive index before surgery - Resistive index 7days postop	0.040	0.10	0.0095	0.021	0.059	4.18	117	< 0.001
2	Resistive index before surgery - Resistive index 30days postop	0.016	0.14	0.013	-0.010	0.042	1.19	117	0.235

Postoperative Outcome

The postoperative outcomes were essentially good; however, 3 (2.5%) and 8 (6.8%) developed superficial surgical site infection and scrotal haematoma, respectively.

DISCUSSION

The mean age of 3.78 years ± 3.12 (0.2 - 12 years) reported in this study agreed with that found by Tuncer et al.[6] Also in keeping with the present study are the findings of a study done by Erdogan[7] where their mean age was 32 months ± 38. However, the mean age documented in this study is at variance with the findings by Emeka[8] in Nigeria, who reported a mean age of 22 months ±18.2, Basha et al.[9] reported a mean age of 9.46 ± 14.46 months (age range ¼ 2 months - 6 years); and Palabiyik et al.[10] reported a mean age of 6.33 years (range 2 - 14 years). Other contrasting results were reported by Schier et al.[11] and Çelebi et al.[12] The difference between the findings in the present study and those of Emeka might be because his study included other indications for herniotomy, like hydroceles, which usually present at a later age than in patients with inguinal hernia that have an increased risk of incarceration and early repair is advocated. Also, the mean duration of symptoms of 4 months reported in the present study may actually be longer than when it was first noticed by the parents.

In the present study, the hernia was on the right side in 90 (76%) patients and on the left in 28 (24%). A finding which is similar to the study by Khirallah et al.[13] Who reported that 53.5% of the hernias were on the right side, 37% on the left side and bilateral inguinal hernia in 9.5% of the children. On physical examination, Basha et al.[9] also reported that the hernias were unilateral in 57 boys (95%), on the right side in 39 boys (61.6%), on the left side in 18 boys (30%) and bilateral in 3 boys (5%). However, in this study, when compared to those of Khirallah et al.[13] and Basha et al.[9], bilateral cases were not present as they were excluded completely from the study. No study reported a higher incidence of left-sided inguinal hernia when compared with right inguinal hernia. The possible explanation for the higher incidence of right-sided inguinal hernia may be due to the delayed embryonic descent of the right testis when compared to the left.

The age-specific testicular volume of the children did not show an increase in testicular volume with increasing age, as the preoperative mean testicular volume of some older children was less than that of the younger ones. Our finding is in contrast to the report by Helen et al.[14] where a progressive increase in testicular volume with increasing age was noticed. We were unable to offer a direct reason for the observation within the limits of this study, but it could be due to variations in serum levels of androgenic hormones and androgen receptor sensitivity, which is independent of age.

The preoperative intra-testicular resistive index ranges between 0.22 and 0.98, with a mean of 0.65 ± 0.13. When compared with the postoperative resistive index at 1 week, a statistically significant difference was seen. This difference is, however, not clinically relevant as the mean postoperative resistive index at 1 week is still within the normal range of resistive index (0.48 - 0.75).[5] There was no statistically significant difference when preoperative resistive index was compared to postoperative resistive index at 1 month, which is in keeping with the study by Tuncer et al.[6], where they reported that the testicular blood flow was not statistically different when compared with the contralateral testes during the first month evaluation. This outcome is also similar to that of Palabiyik et al.[10], who found that PSV and RI significantly increased one week after surgery but recovered to preoperative levels one month later. Similarly, after surgery, Verinderjit et al.[15] discovered a brief rise in testicular blood flow on the affected side. The return to baseline RI at 1 month could be due to a reduction in tissue tension of the testes following improvement in lymphatic flow. It may also denote the unlikelihood of a long-term adverse compromise of the testicular vascularity, giving little or no risk of testicular ischemia/atrophy.

CONCLUSION

There was a transient statistically significant reduction in testicular resistive index on postoperative day 7, which returned toward baseline by 30 days. No persistent postoperative alteration of testicular vascularity was demonstrated.

RECOMMENDATIONS

- Health education to the community on the need for early presentation of uncomplicated hernia with better postoperative outcomes.
- Continuous use of this method of repair by the hospital.

- Train other secondary health institutions on this method of repair.

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