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Original Research Article

The presence of a low lying pubic tubercle in patients with indirect inguinal hernia

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ABSTRACT

Background: Among all external abdominal hernias, inguinal hernia is one most commonly encountered. Factors like chronic cough, constipation, prostatic enlargement etc. contribute to its development. Various defensive mechanisms of the inguinal canal like shutter and slit valve mechanisms help prevent its formation. In this study, a comparison has been made between the anthropometric measurements of the pelvis in patients with and without indirect inguinal hernia to look for a statistically significant difference in the position of the pubic tubercle which in turn affects the various protective mechanisms. Other measurements such as Height, Weight and interspinal distance have been included to look for positive correlations between the disease and said measurements.
Methods: This study was conducted in the General Surgery Department of SRM Hospital, Medical College and Research Centre, Kattankulathur after ethics committee clearance. It is a case control study conducted on 140 consenting patients and meeting the inclusion criteria from March 2016 to August 2017, of which 70 each were patients of indirect inguinal hernia and patients without inguinal hernia.
Results: Results developed using SPSS Software show majority of the subjects with a low lying pubic tubercle were inguinal hernia patients. There was also a positive correlation between the ratios of weight and ST length as well as Height and ST length between cases and controls.
Conclusions: It can be concluded from this study that factors such as a low lying pubic tubercle and other related anthropometric variables predispose patients to develop indirect inguinal hernia.

Keywords: Anthropometric variables, Indirect inguinal hernia, Low pubic tubercle

INTRODUCTION

Among all spontaneous external abdominal hernias, inguinal hernia is the most commonly encountered type. The statistics show that the indirect inguinal hernia is the most common of all forms of the hernia, affecting the males seven times more than the females.

There are various defensive mechanisms of the inguinal canal to prevent the formation of hernia which are based on anatomical factors. Different structures and anatomic variations facilitating herniation have been assessed in the past.[1]

In the development of indirect inguinal hernia, the origin of the internal oblique muscle from the inguinal ligament far away from the pubic tubercle, and its lower fibers not covering the internal ring has been implicated. The various degrees of incompleteness of the internal oblique muscle in the inguinal region lead to the essential predisposition to direct inguinal hernia. Other factors include an increase in the size of Hessert's triangle.[1]

One important factor that determines the probability of an individual to suffer from an inguinal hernia is the location of the pubic tubercle. Many authors have concluded that persons with low lying pubic tubercle are at a higher risk and more prone to develop hernia.

The various anatomical characteristics of the inguinal region and the areas of weakness in the anterior abdominal wall and their relation to development of inguinal hernia have been studied. However, not much importance has been given regarding their relation to the anthropometric parameters of the pelvis.[2]

Harris and White (1937), Rebustelo (1938), Piana (1947) and, more recently, Radojevic (1958, 1961, 1962), having studied numerous human pelves, concluded that a definite correlation exists between pelvic measurements and the occurrence of inguinal hernia.

The French surgeon Henri Fruchaud, hypothesized that a change in the course of fibers of abdominal muscles due to a change in direction of the abdominal forces, which occurred as consequence of man adopting an upright position [3]. Though this change resulted in a favorable position for walking, it created a possible weak spot in the anterior abdominal wall i.e the Fruchard's area. This area is bounded by the rectus abdominus muscle, conjoint tendon and the inguinal ligament. The bipedal posture has also transformed the bony pelvic configuration such that the 'weak area' in the anterior abdominal wall has become broader than before to facilitate balancing.[3]

Various authors have studied the pelvis in cadavers and have found a positive correlation in the Fruchard's area and bony pelvis and have conclude that it plays a very significant role in the development of hernia.[2]

METHODS

A case control study type was adopted with a sample size of 140 patients, 70 belonging to case group and the other 70 belonging to the group of controls. Parameters for all participants were measured by two independent clinicians, who were blinded regarding the type of study/ with the average being taken as the final value. All measurements were made using the help of Standard measuring tape, weighing scale, Stadiometer over a uniformly flat surface with co-relation with Pelvic Xrays. Few cases were randomly chosen and Pelvic Xrays were repeated to exclude errors regarding the position of the patient during measurements.

In all selected cases, the parameters were found to be the same. The period of study was from March 2016 to August 2017. The patients to be included in the study were done so after explaining the study to them in detail in their local language and consenting patients meeting the inclusion criteria were included. The study was commenced after obtaining approval from the Ethics committee.

The inclusion criteria for cases were, males, greater than 18 years of age with indirect inguinal hernia and no pelvic bone abnormalities or prior fractures or obvious associated diseases causing inguinal hernia like urinary outflow obstruction. All patients underwent USG Abdomen/ Inguino Scrotal region and XRay Pelvis AP view. Urologist clearance was obtained in patients with urinary symptoms.

The various parameters measured were:

- SS Line: Distance between each anterior superior iliac spines
- ST Line: Vertical distance between the pubic tubercle of affected side and the SS Line
- SS/ST, Height/ST, Weight/ST.

RESULTS

The Normality tests Kolmogorov-Smirnov and Shapiro-Wilks tests results reveal that the variables follow Normal distribution. Therefore to analyse the data parametric methods are applied. To compare the mean values between case and control groups independent samples t-test is applied. To compare proportions between study and control groups Chi-Square test is applied, if any expected cell frequency is less than five then Fisher's exact test is used. ROC curve analysis is performed to find the best cut-off value to classify cases.

Simple and multiple logistic regression analysis is used to calculate the unadjusted and adjusted Odds Ratios respectively. To analyse the data SPSS (IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY: IBM Corp. Released 2013) is used. Significance level is fixed as 5% ($\alpha = 0.05$).

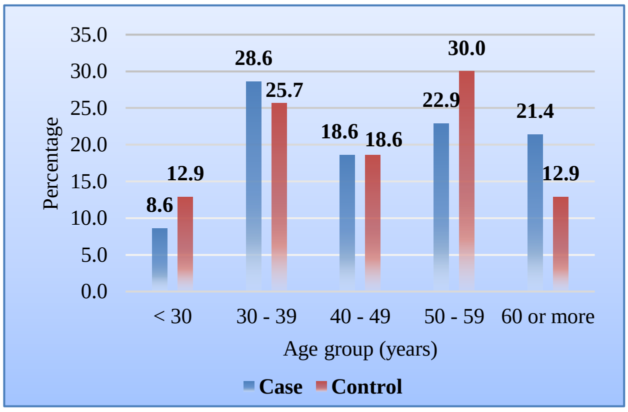

Figure 1: Age distribution of cases vs controls.

The age wise distribution of patients with inguinal hernia shows almost a uniform distribution above 30 years of age with peak incidence between 30-39 years and 50-59 years. Among 70 cases, 18 of them were between the age group 30-39 years and 21 cases belonged in the age group 50 59 years which shows that majority of the patients were either young adults or middle aged. The lowest incidence was seen in the age group less than 30 years.

The mean values of Age, Height (cm), Weight (kg), ST and SS (cm), ratio of SS/ST, Height/ST and Weight/ST were calculated. T-value was found to be highest for ST, SS/ST, Height/ST, and Weight/ST which showed a statistical significant difference between cases and controls.

Table 1: Independent samples T-test to compare mean values between cases and controls.

Variables	Group	N	Mean	Std. Dev	t-Value	P-Value
Age (years)	Case	70	47.44	14.598	1.330	0.186
	Control	70	44.36	12.802		
Height (cm)	Case	70	165.507	6.3540	0.590	0.556
	Control	70	166.136	6.2496		
Weight (kg)	Case	70	64.614	7.7456	2.617	0.010
	Control	70	68.179	8.3549		
ST (cm)	Case	70	7.607	.8160	6.603	<0.001
	Control	70	6.843	.5216		
SS (cm)	Case	70	24.507	1.5311	1.855	0.066
	Control	70	24.036	1.4752		
SS/ST	Case	70	3.25360	.363362	4.638	<0.001
	Control	70	3.53273	.348502		
Ht/ST	Case	70	21.9751	2.22655	6.696	<0.001
	Control	70	24.4200	2.09121		
Wt/ST	Case	70	8.57346	1.273076	6.177	<0.001
	Control	70	10.02731	1.502274		

By using Chi square test and a p value of <0.05 taken as standard, it was found that Weight, ST, SS/ST, Height/ST, Weight/ST all had a statistical significance with a p value <0.05 when comparing cases with controls with maximum significance seen in ST, SS/ST, Height/ST and Weight/ST.

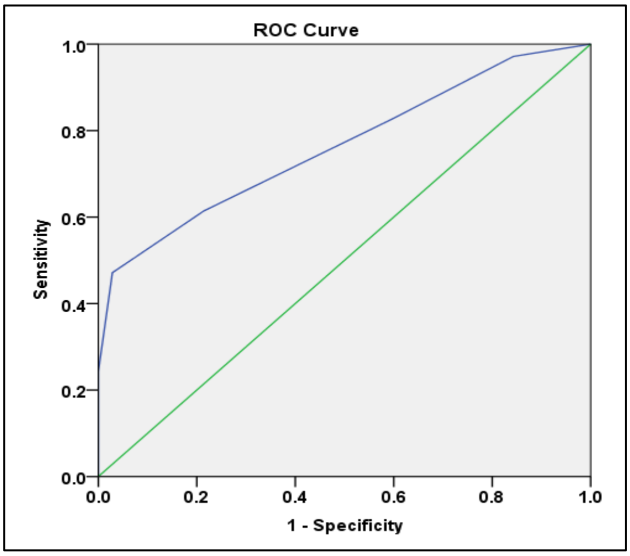

Figure 2: ROC Curve analysis for ST.

ROC Curve analysis is used to find the best cut-off values to classify Cases and Controls. Based on the cut-off values for each variables the Odds Ratio are calculated to find the risk.

Table 2: Area under the curve 1.

Test result variable (s): ST (cm)				
Area	Std. Error	P-Value	95% confidence interval	
			Lower bound	Upper bound
0.763	0.040	0.000	0.684	0.842

The test result variable(s): ST (cm) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

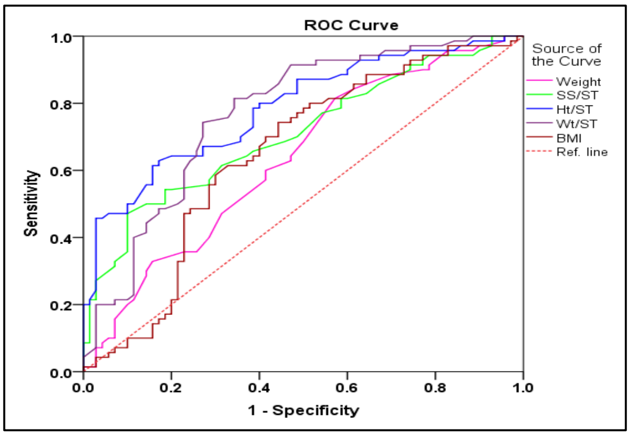

Figure 3: ROC curve analysis for other parameters.

The test result variable(s): SS/ST, Ht/ST, Wt/ST, has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

Table 3: Area under the curve 2.

Test result variable(s)	Area	Std. error	P-value	95% confidence interval	
				Lower bound	Upper bound
SS/ST	0.709	0.044	0.000	0.624	0.794
Ht/ST	0.786	0.038	0.000	0.711	0.860
Wt/ST	0.770	0.040	0.000	0.691	0.849

Using ROC curve analysis and Area under the curve, a value for each parameter was selected which would best distinguish the cases and controls.

Table 4: Chi-Square test to compare ST length between cases and controls.

ST cut-off	Group					
	Control		Case		Total	
	N	%	N	%	N	%
<7.75	68	64.8	37	35.2	105	100.0
≥7.75	2	5.7	33	94.3	35	100.0
Total	70	50.0	70	50.0	140	100.0

Pearson Chi-Square=36.610; p-value=<0.001

A cut off value of 7.75 cm was established for ST, and it was found that among the 140 candidates with an ST length of more than 7.75cm, 94.3% had an indirect inguinal hernia. 68 out of 70 of the controls had ST length of less than 7.75cm. This shows that majority of the sample size in our study with a low lying pubic tubercle, which is 33 out of 35 of the total sample size had an indirect inguinal hernia. Only 2 patients without an indirect inguinal hernia had a low lying pubic tubercle.

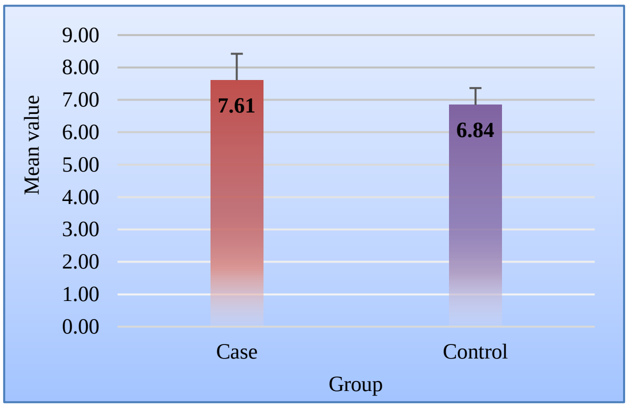

Figure 4: Mean ST length among patients and controls.

The mean ST lengths between cases and controls were also measured. It was found that the mean value of ST in the cases of indirect inguinal hernia were higher than those of the control group.

The ratio of SS/ST had a cut-off point of 3.18 as per the ROC curve analysis. 82.5% of patients who had a value less than 3.18 which showed that majority of the sample size with a low SS/ST value had an indirect inguinal hernia.

Table 5: Chi-Square test to compare SS/ST length between cases and controls.

SS/ST cut-off	Group					
	Control		Case		Total	
	N	%	N	%	N	%
> 3.18	63	63.0	37	37.0	100	100.0
≤ 3.18	7	17.5	33	82.5	40	100.0
Total	70	50.0	70	50.0	140	100.0

Pearson Chi-Square=23.660; p-value=<0.001

The ratio of SS/ST was calculated in order to see whether the interspinal length (SS) would cause any significant deviation in our calculations of ST length between the cases and controls. Even though the value isn't as significant as that of ST length difference between cases and controls, it correlates with our previous finding which shows that hernia patients had a larger ST length.

Table 6: Chi-Square test to compare height/ST length between cases and controls.

Ht/ST cut-off	Group					
	Control		Case		Total	
	N	%	N	%	N	%
>22.80	56	69.1	25	30.9	81	100.0
≤22.80	14	23.7	45	76.3	59	100.0
Total	70	50.0	70	50.0	140	100.0

Pearson Chi-Square=28.152; p-value=<0.001

Height/ST as a parameter was selected in order to minimise any bearing that the height of the patients might have on their ST length. A cut off value of 22.80 was established for the Height/ST ratio and it was found that 76.3% of those with a Height/ST value less than 22.80 belonged to the case group. It was also found that a majority of the cases, 45 out of the total 70, had a lower Height/ST value.

Table 7: Chi-Square test to compare weight/ST length between cases and controls.

Wt/ST cut-off	Group					
	Control		Case		Total	
	N	%	N	%	N	%
>9.26	51	73.9	18	26.1	69	100.0
≤9.26 (Case)	19	26.8	52	73.2	71	100.0
Total	70	50.0	70	50.0	140	100.0

Pearson Chi-Square=31.121; p-value=<0.001

Weight/ST as a parameter was selected in order to minimise any bearing that the Weight of the patients might have on their ST length. A cut off value of 9.26 was established for the Weight/ST ratio and it was found that 73.2% of those with a Weight/ST value less than 9.26 belonged to the case group. It was also found that a majority of the cases, 52 out of the total 70, had a lower Weight/ST value. The ratio of Height/ST and Weight/ST both show statistical significance when comparing cases with controls. Although weight and ST length both have a statistical significance as individual parameters unlike height (as seen in Table 1), it was found that the ratio of Height/ST has a p value <0.001 just as in the case of Weight/ST.

Table 8: Chi-square test parameter comparison cases and controls (Consolidated table).

		Group					
		Control		Case		Total	
		N	%	N	%	N	%
ST cut-off	<7.75	68	97.1	37	52.9	105	75.0
	≥7.75 (Case)	2	2.9	33	47.1	35	25.0
	Total	70	100.0	70	100.0	140	100.0
SS/ST cut-off	>3.18	63	90.0	37	52.9	100	71.4
	≤3.18 (Case)	7	10.0	33	47.1	40	28.6
	Total	70	100.0	70	100.0	140	100.0
Ht/ST cut-off	>22.80	56	80.0	25	35.7	81	57.9
	≤22.80 (Case)	14	20.0	45	64.3	59	42.1
	Total	70	100.0	70	100.0	140	100.0
Wt/ST cut-off	>9.26	51	72.9	18	25.7	69	49.3
	≤9.26 (Case)	19	27.1	52	74.3	71	50.7
	Total	70	100.0	70	100.0	140	100.0

Table 8 is a consolidated table showing the results of chi square test on the various parameters measured. The previous analysis of the measurements showed that majority of the sample size with a longer ST length and a lower SS/ST, height/ST and weight/ST had an indirect inguinal hernia.

Table 9: Logistic regression analysis: crude (unadjusted) odds ratios.

		Case		Odds Ratio	95% CI		P-Value
		N	%		LB	UB	
ST cut-off	<7.75	37	35.2	1.00			
	≥7.75	33	94.3	30.32	6.89	133.5	<0.001
SS/ST cut-off	>3.18	37	37.0	1.00			
	≤3.18	33	82.5	8.03	3.23	19.96	<0.001
Ht/ST cut-off	>22.80	25	30.9	1.00			
	≤22.80	45	76.3	7.20	3.36	15.44	<0.001
Wt/ST cut-off	>9.26	18	26.1	1.00			
	≤9.26	52	73.2	7.75	3.66	16.44	<0.001

Table 10: Logistic regression analysis: adjusted odds ratios.

		Case		Adj OR	95% CI		P-Value
		N	%		LB	UB	
ST cut-off	<7.75	37	35.2	1.00			
	≥7.75	33	94.3	25.31	3.62	176.8	0.001
SS/ST cut-off	>3.18	37	37.0	1.00			
	≤3.18	33	82.5	0.55	0.11	2.36	0.416
Ht/ST cut-off	>22.80	25	30.9	1.00			
	≤22.80	45	76.3	1.62	0.56	4.67	0.373
Wt/ST cut-off	>9.26	18	26.1	1.00			
	≤9.26	52	73.2	2.05	0.67	6.24	0.206

This consolidated table shows us that the control group of patients, i.e patients without indirect inguinal hernia showed the least representation in the categories mentioned earlier – long ST length, low SS/ST, height/ST and weight/ST ratio.

Using the cut off values obtained for the various parameters in question, Odds ratio was used to calculate the risk of developing hernia. In the unadjusted analysis, all 4 parameters i.e ST, SS/ST, Height/ST and Weight/ST all had an odds ratio > 1 which shows that exposure is associated with higher odds of outcome.

But on calculating the adjusted odds ratio which takes into account all the variables simultaneously, it was found that ST length, Height/ST, Weight/ST had an Odds ratio >1 but only ST length had a p value of 0.001 which is statistically significant.

DISCUSSION

The anatomy of the inguinal region and the anatomy of the pelvis by extension has always proved to be a major factor in the development of inguinal hernia. The muscles, ligaments and tendons and their various attachments provide defence mechanisms that prevent hernia formation. In this study, we focus on indirect inguinal hernias which passes through the deep inguinal ring, traverses the inguinal canal and exits out the superficial ring. The lateral abdominal wall muscles which include the transversus abdominis and the internal oblique muscle, form the conjoint tendon and offer reinforcement only in the medial half of the inguinal canal as it arches over the deep ring which makes it the weakest part of the posterior wall. A low lying pubic tubercle is associated with a narrow origin of the internal oblique muscle which further weakens the posterior wall at the deep ring, which in turn increases the risk of development of indirect inguinal hernia.

The age-distributed prevalence rates shows that inguinal hernia prevalence was peaking at adult age group of 30-39 years which constituted almost 29%, and 50-59 years which accounted for 23% of inguinal hernias in this study, whereas Indranil Basu et al study showed that the peak incidence of inguinal hernia was 42 to 57 years.[4] It is relatively less common in adolescent age groups. Some studies have shown that age distribution is bimodal peaking at early childhood and old age. This can be explained on the basis that most patients especially of the lower socioeconomic group do not present to the hospital during the initial presentation of the disease, instead opting for surgery only when the disease becomes a hindrance to their occupation or day to day activities.

In this study, it was found that, of all the patients who had an ST length of more than 7.75cm (both cases and controls), 94.3% had an indirect inguinal hernia. Only 2 people i.e 5.7% of the patients with an ST length greater than 7.75cm did not have an inguinal hernia.

Chand Sehgal et al (2000) in their study have classified the patients into groups as having 'High lying pubic tubercle' with ST length less than or equal to 7.5 cm and 'Low lying pubic tubercle' with ST length more than 7.5 cm. This observation was made in 73.6% of cases and it was found that only 16% of controls belonged to the second group and hence made the conclusion that low pubic tubercle was a contributing factor.[5]

The change in posture to upright during the course of evolution has decreased the efficiency of shutter mechanism of inguinal canal thus contributing to inguinal hernia formation. The erect posture of man and the horizontal course of the muscle fibers have various implications with regards to weakness of the groin. The lower edge of the conjoint tendon has variable distance from the inguinal ligament which causes a defect, the Fruchaud's area. The posterior inguinal wall is supported by the fascia transversalis. Thus, repeated increase in intra-abdominal pressure predisposes to hernia formation.[6-12]

Lopez-Cano et al in their study made additional findings regarding hernia patients with a low lying pubic tubercle, and concluded that patients with a low pubic tubercle had a longer inguinal ligament and also made a larger angle medially by the inguinal ligament and suprainguinal space (superior border). Morphological variations in the abdominal musculature of external oblique, internal oblique, transversus abdominus muscles are seen in patients with a low pubic tubercle.[1]

Radojevic calculated the angle created between the interspinal line and Malgaigne's line and concluded that a large angle increases the risk of development of inguinal hernia.[8] Radojevic and Ami independently studied the pubic height.[8,9] Both arrived at the same conclusion that greater the pubic height, more likely are the chances of developing hernia due to a larger Fruchaud's area, a theory that was postulated by Georges Chavannaz, a French professor.

Harris and White found an association between the length of inguinal ligament and a tendency to develop inguinal hernia and found that they are directly proportional.[13]

Ajmani and Ajmani studied the musculature of the lower abdominal wall muscles and noticed that in inguinal hernia patients, the internal oblique muscle origin from the inguinal ligament was away from the pubic tubercle and its lower fibers did not cover the deep inguinal ring. As a result the deep inguinal ring is left unprotected thus predisposing to hernia formation.[14]

The unusual origin and insertion of internal oblique and transverses abdominis muscle, results in an ineffective shutter mechanism of the inguinal canal. Agrawat M et al undertook a study of 135 cases of inguinal and came to similar conclusions.[15]

According to Stoppa, pelvimetry is a simple clinical examination which should be routinely considered.[16] These findings help us determine whether the functional significance of the inguinal region is modified by anatomic variations be it bony, muscular or ligamentous.

CONCLUSION

Configuration of bony pelvis seems to be a major contributing factor in determining the risk of development of inguinal hernia as evidenced by the variations in ST length.

Other parameters such as Weight/ST and Height/ST also showed statistically significant variations.

Early identification of said risk factors in early adulthood could help in the prevention of hernia.

Pelvimetry with radiograph correlation is a simple, and non-invasive method that could help in identification of the risk factors as well as adequately plan pre operatively the kind of hernia repair to be undertaken for individual patients.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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