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Prospective study on effect of polypropylene mesh prosthesis on testicular perfusion in patients undergoing surgical repair of inguinal hernia

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Abstract

Inguinal hernia repair involves a variety of approaches. Among the multitude of procedures available, the Gold Standard Procedure of Inguinal Hernia repair in recent times is the Lichtenstein's Tension free mesh hernia repair. When placed intra-operatively, the direct contact of the mesh and associated peri-mesh fibrosis to the vessels in the inguinal canal, there exists a possibility of impaired testicular blood flow and subsequent postoperative morbidity of testicular atrophy. Testicular perfusion, its relation to testicular atrophy is well documented.

Keywords: Lichtenstein, hernia, mesh repair, peri-mesh fibrosis, testicular perfusion, atrophy

Introduction

Lifetime occurrence of hernia in people is approximately around 10%. In comparison to females, incidence of hernias in males is higher by seven fold'. Abramson *et al.* reported that the overall current risk for a male to have an inguinal hernia is 18%, and the lifetime risk is 24% [1]. Inguinal hernias and the spermatic cord share a close relationship with reference to human anatomy. Mechanical pressure, intermittently on the vessels supplying the testis, increases the risk of decreased perfusion time testicular vessels [2, 3].

Vascular assessment of the testicular vessels prior to surgery on the involved side of hernia via a color Doppler ultrasound revealed an increased resistive index (R) in comparison with the unaffected side according to some reports [4].

In a study by Munoz Sanchez *et al.*, it was found that there were no changes in arterial supply of the affected side testis in a setting uncomplicated inguinal hernias [5]. The Technique of tension free repair where sac is also ligated high up (Lichtenstein repair) for inguinal hernia, is currently practiced routinely as surgical treatment of inguinal hernia [6, 7]. The complications of hernia repair on testicular perfusion are still under study despite the popularity of use of Open and Laparoscopic techniques for herniorrhaphy. According to literature, Reduction in size of the testis (testicular atrophy) and its subsequent dysfunction due to inadequate perfusion, although rare (incidence of 0-2% of patients after hernia repair [21, 8]) is among the most fearful complications of inguinal hernia repair. A Study by Yavetz *et al.*, analyzed 8500 patients with complaints of infertility presenting to fertility clinic and reported that about 6.65% (i.e) 565 men reported who underwent inguinal hernia repair with or without subsequent testicular atrophy [9]. The use of color Doppler Ultrasound (CDUS) preoperatively and postoperatively to evaluate Spermatic cord and structures, is well known particularly with respect to testicular pathologies and hernias [10, 11]. For the evaluation of extra testicular vascularization and perfusion of testes, CDUS is a handy tool in even the most basic of setups. CDUS when used appropriately can pick up low flow velocities such as PSV (peak systolic velocity) and end diastolic velocity (EDV). Intratesticular RI (i.e) Resistive index measurement forms an integral part of CDUS of scrotum and testes as shown by Lefort and colleagues. An increased RI is an indicator of ischemia [12]. The impact of mesh repair on testicular perfusion using a CDUS has, however not been well documented in research.

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Materials and Methods

Objectives

1. To study the effect of Polypropylene prosthesis on Testicular Perfusion in patients undergoing surgical treatment for inguinal hernia
2. To assess testicular perfusion using testicular volume and arterial flow on CDUS.

Table 1: Study particulars

Sl. No.	Study Characteristics	Description
1	Design	Prospective Observational study
2	Setting	Department of General Surgery, JSS Hospital, Mysuru
3	Duration	18 Months – October 2018 - April 2020
4	Population	Patients with uncomplicated unilateral inguinal hernia with no comorbidities
5	Conduct	Collection of Data and Analysis: October 2018- April 2020
6	Tool	Color Doppler Ultrasonography

Table 2: Patient selection criteria

Sl. No.	Inclusion Criteria	Exclusion Criteria
1	Males aged 18-60 years	1 Complicated Inguinal Hernias
2	Uncomplicated Inguinal Hernia	2 Previous history of surgeries on scrotum, testicles or prostate
3	Consenting to be a part of the study	3 Diseases of Testis (orchitis, tumors)
		4 Diabetes, Chronic Arterial or Venous disease

Sample Size: The Sample Size was estimated as 113 considering SD of Resistive Index before and after Surgery as 0.078 with 90 % power and 5% Alpha error.

Sampling Technique: Simple Random Sampling

Data Collection: Patients satisfying the inclusion criteria will undergo

- Pre-operative CDUS of Testis to assess perfusion
- Post-Operative (Day 3 and Day 90) Assessment of Testicular Perfusion with CDUS of Testis

Data Analysis: Statistical analysis using the following tests

- Repeated measure ANOVA
- Kruskal Wallis test.

Patients with Inguinal Hernia satisfying the inclusion criteria undergoing Surgical Repair using Polypropylene Prosthesis in open tension free Lichtenstein's mesh repair will be subjected to color Doppler Ultrasound Preoperatively to assess Testicular perfusion and postoperatively on Day 3 and 3rd month.

Results

Results were analyzed using SOC Calculator, Microsoft Excel and SPSS Version 24. This study aimed at analyzing 113 patients undergoing open inguinal repair using polypropylene prosthesis after satisfying inclusion criteria. Patient's demographic characteristics like, age, occupation, etiological factors such as smoking, COPD, constipation, post appendectomy, postoperative complications such as seroma, pain, SSI (surgical site infection). Mesh related complications such as the mesh getting infected were analyzed. CDUS (Color Doppler ultrasonography) parameters like peak systolic velocity (PSV), RI (Resistive index – an indicator of ischemia), EDV (End Diastolic velocity), testicular volume was studied prior to and post-surgery. The 4 parameters PSV, EDV, RI, testicular size was compared statistically.

Demographic Analysis

1. Age-Wise Distribution

The mean age of the study population was 43.34 years with youngest patient analyzed of 20 years of age and oldest patient of 59 years of age.

Table 3: Age Distribution

Age	Patient Load	Percentage
18 - 20	2	2
21 - 30	9	8
31 - 40	35	31
41 - 50	34	30
51 - 60	33	29

2. Professions

Table 4: Distribution of Occupation

Occupation	Frequency	Percentage
Auto Driver	22	19
Farmer	30	27
Manual Laborer	19	17
Office Worker	21	19
Retired	14	12
Student	7	6

3. Laterality of Inguinal Hernia

Table 5: Laterality of Hernia

Laterality	Frequency	Percentage
Right	79	70
Left	34	30

- 70% of patients analyzed were found to have right sided inguinal hernia preoperatively.

Type of Hernia

Table 6: Type of Hernia

Type of Hernia	Frequency	Percentage
Direct Inguinal Hernia	55	49
Indirect Inguinal Hernia	58	51

Table 7: Hernia Contingency Table

Hernia	Direct Hernia	Indirect Hernia
Right Inguinal Hernia	40	39
Left Inguinal Hernia	15	19

- Among the patients analyzed, there was a right sided predominance in the incidence of inguinal hernias.

- Around 35.4% and 34.5% patients had direct and indirect inguinal hernias of the right side.
- Here, among the study population, the number of patients

having direct and indirect hernias are almost the same even though generally indirect hernias are more common.

Predisposing Factors

Table 8: Predisposing Factors

Predisposing Factors	Frequency	Percentage
BPH	17	15
Bronchial Asthma	8	7
Constipation	18	16
Post Appendicectomy	14	12
Smoker	26	23
None	30	27

Table 9: Age Distribution of Predisposing Factors

Age	BPH	Bronchial Asthma	Constipation	Post Appendicectomy	Smoker	None
18 – 20	0	0	0	1	0	1
21 – 30	0	0	0	4	1	4
31 – 40	0	2	2	6	10	15
41 – 50	0	0	10	1	13	10
51 – 60	17	6	6	2	2	0

- Among the study population, the common etiologies of inguinal were analyzed.
- 27% of the study population were found to have no predisposing factor.
- 23% of the patients, i.e 26 patients were found to be smokers.
- In the age group of 51-60 years, the most common predisposing factor was benign prostatic hyperplasia followed by bronchial asthma and constipation.
- In the 5th decade, the most common etiology was smoking followed by constipation.
- In the 4th decade, smoking was the causative factor in 10 patients.

Complications of Surgery

Table 10: Surgical Complications

Complication	Frequency	Percentage
None	92	81.4
Seroma	9	8
Surgical site infection	7	6.2
Urinary Retention	5	4.4
Mesh infection	0	0

Comparison of pre-operative and post operative variables

In a particular group of 113 patients, CDUS assessment of patients prior to surgery, the velocities assessed, peak systolic and end diastolic velocities and resistive index along with the testicular volume were compared with early postoperative (POD3) and late postoperative periods and were expressed as

Mean +/- Standard deviation. Resistive index and Testicular volume were compared statistically and were found to be statistically not significant (p value less than 0.05) suggestive of non-affection of perfusion to testicular vessels in patients undergoing Lichtenstein hernia repair.

Table 11: Analysis of Preoperative and Postoperative variables of testicular perfusion and volume

Parameter s	N	Pre- Operative		Early Post-Operative		Late Post-Operative		p value
		Mean	SD	Mean	SD	Mean	SD	
PSV	113	14.15	3.02	14.11	3	14.07	3.01	0.9636
EDV	113	4.99	2.3	5.08	2.01	5.14	1.88	0.9989
RI	113	0.68	0.15	0.67	0.14	0.65	0.13	0.326
TV	113	14.58	4.3	14.65	4.17	14.73	4.06	0.9289

- The variables were expressed as mean and standard deviation. Analysis was done using Kruskal-Wallis Test.
- infection and post-operative urinary retention.
- Analysis was made comparing the sonological values of the 4 testicular perfusion parameters and the p-value was noted to be statistically not significant (p- value in all 4-parameter comparison was >0.05).
- Development of complications in the post-operative period had no statistically significant effect on testicular perfusion as measured by the sonological parameters.

Comparison of sonography variables in preoperative and post-operative periods in patients with complications

- 21 patients in the study population were noted to have developed complications post-surgery
- Complications being seroma formation, surgical site

- Variables were expressed as mean and Standard deviation and analysis was done using Kruskal-Wallis test to calculate test of significance.

Table 12: Analysis of Preoperative and Postoperative variables of testicular perfusion and volume in Patients with Complications

Parameters	N	Pre-Operative		Early Post- Operative		Late Post- Operative		p
		Mean	SD	Mean	SD	Mean	SD	
PSV	21	14.24	3.68	14.21	3.77	14.1	3.68	0.9772
EDV	21	4.9	2.75	5.04	2.43	5.13	2.27	0.9959
RI	21	0.69	0.19	0.68	0.15	0.67	0.16	0.8928
TV	21	16.33	4.98	16.33	4.72	16.3	4.49	0.9571

- Individual analysis of pre- and post-operative testicular perfusion parameters for each of the observed complications also showed no statistical significance that the onset of complication may have on post-operative testicular perfusion, with the p-value continuing to be >0.05.

Table 13: Individual Analysis of Preoperative and Postoperative variables of testicular perfusion and volume for each Complication

Complications	Parameters	N	Pre-Operative		Early Post- Operative		Late Post- Operative		p
			Mean	SD	Mean	SD	Mean	SD	
Seroma	PSV	9	15.41	4.29	15.4	4.39	15.16	4.3	0.8506
	EDV	9	5.29	2.59	5.46	2.1	5.52	2	0.9982
	RI	9	0.67	0.16	0.66	0.13	0.65	0.15	0.7983
	TV	9	15.96	4.34	15.98	4.13	15.99	3.87	0.993
Surgical Site infection	PSV	7	13.86	3.25	13.87	3.36	13.86	3.19	0.9663
	EDV	7	4.26	3.29	4.49	2.86	4.53	2.66	0.9807
	RI	7	0.74	0.19	0.73	0.15	0.72	0.16	0.8938
	TV	7	19.3	3.07	19.23	2.61	19.08	2.32	0.8913
Urinary Retention	PSV	5	12.66	2.93	12.54	2.98	12.54	3.13	0.9778
	EDV	5	5.12	2.66	5.06	2.73	5.28	2.47	0.9827
	RI	5	0.65	0.26	0.63	0.19	0.63	0.19	0.8981
	TV	5	12.82	6.42	12.89	6.11	12.96	5.93	0.9925

Discussion

Age-wise distribution of study population

When compared with the population analyzed by Ira M. Rutkow¹³ where majority of the subjects were among the 45-64 years age group, in our study, patients above the age of 60 years were excluded. 113 patients diagnosed with uncomplicated unilateral inguinal hernia undergoing surgical treatment of

inguinal hernia via open Lichtenstein repair were analyzed and when compared with other research scholars whose studies composed of sample size of 26-64. There were 64 subjects in Suculla I *et al.*, 39 patients in Edgar *et al.*, 32 in Neset *et al.*, 40 as in that carried out by Sinan Hatipoglu *et al.*, 26 in a study by Dilek *et al.* [9, 10-12, 14].

Mean age of presentation in this study population is 43.33 years.

Table 14: Comparative analysis of age incidence with standard literature

Age	Patient Load	Percentage	Ira M. Rutkow study population age distribution	Percentage of study population
18 – 20	2	2	<15	18
21 – 30	9	8	15-44	26
31 – 40	35	31	45-64	30
41 – 50	34	30	>65	26
51 – 60	33	29		

Highest incidence in this study was in the 4th decade whereas that of Ira M. Rutkow, it was in the age group 45-64 years (30 cases) followed by 26 cases in both 15- 44 years and >65 years age group.

Occupation

Table 15: Comparison of Occupations in Study Populations

M. Bay Nielson	Percent	Percent
Continuously strenuous work	14.1	47.2
Intermittently strenuous work	33.1	
Walking- no heavy lifting	28.3	28.3
Sedentary Work	22.0	22.0
Unspecified	2.5	2.5
Total	100.0	100.0

Profession

Table 16: Profession wise Analysis

Profession	Frequency	Percent
Auto Driver	22	19
Farmer	30	27
Manual Labourer	19	17
Office Worker	21	19
Retired	14	12
Student	7	6

Comparison of occupational status with standard literature

- Farmers comprise of the maximum number (30 patients) of study subjects followed by auto drivers (22 cases).

- Manual laborers comprise of 17% of the study population. 44% of the population (59 cases) comprise of farmers and manual labourers whereas constantly/ intermittently strenuous work group in the study by M. Bay Nielson, who constitute 47.2% which is comparable.
- 12% of the study population is retired patients compared to 22% of sedentary workers in the study group analyzed by M. Bay Nielson.

Predisposing Factors

Table 17: Predisposing factors

Predisposing Factors	Frequency	Percentage
BPH	17	15
Bronchial Asthma	8	7
Constipation	18	16
Post Appendectomy	14	12
Smoker	26	23
None	30	27

- Mike S. L Liem¹⁵ and others analyzed that strenuous activity, COPD and BPH were the major etiological factors (24%, 10% and 5% respectively).
- In our study, smoking (23%) was the most common predisposing factor apart from patients in whom no identifiable risk factor was made out suggesting the possibility of a congenital preformed sac.
- Causative factors for hernia are multifactorial and constitutes a tough task to single out a predisposing factor.
- Smokers constituting a sizeable proportion of patients indicates an abnormal biochemical, metabolic and connective tissue disorders as in literature and a reflection

Testicular Perfusion - Sonological parameters

Table 18: Testicular perfusion CDUS parameters

Parameters	N	Pre-Operative		Early Post-Operative		Late Post-Operative		P
		Mean	SD	Mean	SD	Mean	SD	
PSV	113	14.15	3.02	14.11	3	14.07	3.01	0.9636
EDV	113	4.99	2.3	5.08	2.01	5.14	1.88	0.9989
RI	113	0.68	0.15	0.67	0.14	0.65	0.13	0.326
TV	113	14.58	4.3	14.65	4.17	14.73	4.06	0.9289

Peak Systolic Velocity (PSV)

As p value 0.96 is > 0.05, implies that there is no statistical significance between pre-operative and post-operative PSV values.

End Diastolic Velocity (EDV)

As p value 0.99 is > 0.05, EDV when compared prior to and in the post-surgical repair periods was found to have no statistical significance.

Resistance Index (RI)

As p value 0.326 is > 0.05 validates that RI is not significantly altered due to the surgery indicating that there is no significant ischemic changes.

Testicular Size (TS)

As p value 0.9289 is > 0.05, there is no alteration in the testicular volume that when compared statistically, is significant. Hence testicular atrophy or variation in size of the testicle post-surgical repair of inguinal hernia using polypropylene prosthesis due to changes in perfusion is not statistically significant thereby

reinforcing the belief that the current method of hernia repair using mesh prosthesis is less morbid.

- High incidence in farmers and manual laborers correlates well with the idea that India is an agricultural country.

Diagnosis - Types of hernia

Table 16: Comparison of Types of Hernia

Hernia Type	Frequency	Percentage	Ira. M. Rutkow frequency
Right Direct Inguinal Hernia	40	35	15
Right Indirect Inguinal Hernia	39	35	36
Left Direct Inguinal Hernia	15	13	13
Left Indirect Inguinal Hernia	19	17	28

The occurrence of different types of hernia shown above reveal that indirect inguinal hernias of the right side are comparable to each other.

Complications of surgery

Table 17: Complications of surgery – Analysis

Complication	Frequency	Percentage
None	92	81.4
Seroma	9	8
Surgical site infection	7	6.2
Urinary Retention	5	4.4
Mesh infection	0	0

- In the study, majority of patients who underwent Lichtensteins hernia repair had uneventful post-operative period. Some patients faced complications such as seroma formation, surgical site infection and urinary retention.

reinforcing the belief that the current method of hernia repair using mesh prosthesis is less morbid.

Our study consisted of 113 patients diagnosed with uncomplicated unilateral inguinal hernia undergoing surgical treatment of inguinal hernia via open Lichtenstein repair in comparison with other research scholars whose studies composed of sample size of 26-64. There were 64 subjects in Suculla I *et al.*, 39 patients in Edgar *et al.*, 32 in Neset *et al.*, 40 as in that carried out by Sinan Hatipoglu *et al.*, 26 in a study by Dilek *et al.* ^[10, 12-15]. Ipsilateral testicular perfusion of every patient was assessed by color Doppler ultrasound (CDUS) prior to surgery and post-operative day 3 (early post-operative) and late postoperative - day 90.

Patients between the ages of 18-60 years were included with a mean age of 43.33 years. In the study by Edgar *et al.*, mean age of patients was 49.6 years whereas that by Dilek *et al.* was reported as 46.7 and 54.2 years in the TEP and LHR group^{10, 15} as compared to Neset *et al.* (54.2 years and 52.2 years (TEP group and LHR group) and 22 and 23 years (LG group and MPG group) in a study by Suculla I *et al.* ^[12, 14]. Incidence of inguinal hernia was the highest in the 4th decade (35 patients

(31%)) followed by 5th decade (30%) in our study.

CDUS – Color Doppler Ultrasonography Parameters

Systolic and diastolic velocity

Adequate testicular arterial flow is imperative for the maintenance of volume and function of the testes^[16] as the testicular artery is the chief provider of nutrition for testes and the diameter of which can increase upto 1.5mm^[17].

The diastolic velocity serves as an important tool for the diagnosis of severe arterial occlusive disease. When the diameter of the vessel reduces by >70% (Stenosis >70%), diastolic velocity goes up, however with complete occlusion the value reduces to zero^[18].

In our analysis, peak systolic velocities on an average, progressively reduced from 14.15 prior to surgery, to 14.11 on POD3 to 14.07 in the late postoperative period, results which are akin to the ones reported by Edgar *et al.* and Dilek *et al.* 3 months post- surgery (18.58 and 17.38)^[8, 14].

The result in our study was compared and analysed statistically and was found to be insignificant (p value of 0.9636).

Mean diastolic velocities in the early and late postoperative period when compared with the pre-operative values were marginally increased (4.99, 5.04 and 5.14 respectively). Though there was increase in diastolic velocities, they were not statistically significant (p-value of 0.9989). Dilek *et al.* reported an increased late postoperative value (5.71), however the study by Edgar *et al.* (3.28) showed a reduction in post-operative average velocity^[8, 14]. The results in these two studies were found to be not statistically significant.

RI - Resistance index

When resistance index is increased, it is a sign of ischemia and is representative for small-caliber vessels, since its calculation encompasses other values from the Doppler wave. In this setting, the average preoperative RI (Resistance index) was 0.68 with a (SD±0.15), 0.67 on POD 3 with a SD of ±0.14 and on POD 90 ± 0.13. When compared with other studies like the one by Eduardo *et al.* where pre-operative and postoperative RI values were increased, however they were insignificant statistically^[8, 10, 12, 14, 15, 19].

Volume of Testis (TV)

Atrophy of the testis is determined by its volume post-surgical repair on inguinal hernia patients^[20]. Patency of arterial circulation is quintessential in the preservation of volume and function of the testis. A statistically insignificant (p-value of 0.92) increase in testicular volume (14.58, 14.65, 14.73 mean values in the pre, early post-operative and late post-operative periods) in the current study.

Eduardo *et al.* and Edgar *et al.*, both reported a mild increase in average values on late post-operative period (day 60) (17.45) and (day 90) (11.96) respectively compared to average size prior to surgery (16.44 and 11.76)^[8, 19].

Testicular perfusion and volume in comparison with post-operative complications

In our current study 21 patients suffered from minor post-operative morbidity such as seroma, SSI, retention of urine. No statistically significant difference was found comparing pre- and post-operative Doppler parameters with post-operative complications in current study.

Conclusion

In the past, Hernia repair was done by closing the orifice with

suture material. Currently, the operative procedures focus on the use of mostly non absorbable meshes for the reinforcement of the posterior wall. The subsequent tissue reaction to the foreign body leads to mesh shrinkage or induration of the local tissue and affect nerves and other anatomically important structures like testicular vessels, its perfusion leading to testicular atrophy. The purpose of inguinal hernia repair is to achieve a recurrence free repair with minimal complications. In this study, there is evidence to say that Lichtenstein herniorrhaphy doesn't affect perfusion of testicular vessels and thence the testicular volume. There is ongoing research as to whether testicular perfusion is affected adversely as a complication of the use of polypropylene prosthesis in inguinal hernia repair. Here, it is concluded that impairment of testicular perfusion is spared due to the rich perfusion from the arteries and the support of the collateral vessels which are protective against ischemic injury to the testes. In Inguinal hernia repair by Lichtenstein technique, the above-mentioned complications can be minimized by protecting the anastomoses during repair using meticulous dissection, high index of suspicion, sound anatomical knowledge, good technique and preserving the vessels. Injury to spermatic cord and structures, occurrence of testicular atrophy can be avoided by restricting the dissection beyond the pubic tubercle, or when the distal part of indirect hernial sac is left attached to the cord and by utilizing posterior preperitoneal repair as is the case in recurrent hernias. Preservation of the cremasteric muscle fibers and fascial reconstruction are protective measures against inflammation surrounding the cord structures. Excessive dissection of indirect sacs distally, delivering the testis into the wound from the scrotal sac and simultaneous scrotal surgeries are best avoided. An attempt of preperitoneal repair in the case of recurrent hernias gives the added advantage of preventing subsequent recurrences and avoids complications related to the testes. Thus, it is very evident that meticulous surgical technique, appropriate reconstruction with utmost reverence to surgical anatomy, utilization of appropriate prosthetic material provides excellent outcome.

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