Hernia (2016) 20:429–434
DOI 10.1007/s10029-016-1479-5

ORIGINAL ARTICLE

Laparoscopic TEP repair of inguinal hernia does not alter testicular perfusion

P. Lal[1] · B. Bansal[1,3] · R. Sharma[1] · G. Pradhan[2]

Received: 18 September 2015 / Accepted: 17 February 2016 / Published online: 29 February 2016

Abstract
Purpose The effect of laparoscopic TEP repair on testicular perfusion is unclear. The procedure entails dissection of testicular blood vessels off the hernial sac and incorporation of a prosthetic mesh. This carries at minimum, a theoretical risk of compromise in testicular blood supply, which in turn may affect fertility. Our study aims to establish if any alteration in testicular perfusion occurs in very early (24 h), early (1 week) or late postoperative period (3 months) after laparoscopic TEP repair in the Indian population.
Methods In our prospective trial, 20 patients underwent unilateral and 8 underwent bilateral laparoscopic TEP hernia repairs using standard technique by experienced surgeons. Flow parameters of testicular, capsular and intratesticular artery were noted using color Doppler ultrasound preoperatively and postoperatively and the postoperative resistive indexes of operated side ($n = 36$) were compared with preoperative values. Additionally, for unilateral repairs, flow parameters on operated side were compared with the non-operated side.
Results No statistically significant difference was noticed in the resistive index of the arteries upon comparing these postoperative with preoperative values. For unilateral repairs, the flow parameters of the operated side were comparable with that of non-operated side (i.e. $p > 0.05$).
Conclusion Laparoscopic TEP performed by experienced surgeons does not alter testicular flow dynamics in early or late postoperative period.

Keywords Laparoscopic TEP · Total extraperitoneal repair · Inguinal hernia · Color Doppler ultrasound · Testicular perfusion · Polypropylene mesh

Introduction

Laparoscopic inguinal hernia repair is increasingly being adopted worldwide as a standard of care. For inguinal hernia surgery, testicular complications affecting sexual function is one of the rare but serious complications requiring meticulous care. This is because inguinal hernia repair is carried out anatomically in close relationship with the testicular blood vessels. According to Fong et al., primary ischemic orchitis occurs in 0.65 % of patients undergoing open hernia surgery. The rate of ischemic orchitis and testicular infarction increases in case of extensive dissection of the spermatic cord or delivery of the testis during surgery or in case of large hernias extending into scrotum or recurrent hernia [1]. Although the mesh used in open/laparoscopic tension-free inguinal herniorrhaphy is described as an inert material, its long-term effects are debatable. Experimentally all mesh cause an initial and chronic inflammatory response in the recipient after implantation. One of the potential effects of the inflammation induced by the mesh is ischemic orchitis and/or testicular atrophy in adult male patients [2].

Electronic supplementary material The online version of this article (doi:10.1007/s10029-016-1479-5) contains supplementary material, which is available to authorized users.

✉ B. Bansal
babulbansal@yahoo.com

[1] Department of General Surgery, Maulana Azad Medical College, New Delhi, India

[2] Department of Radio-diagnosis, Maulana Azad Medical College, New Delhi, India

[3] C-35, New Agra Colony, Agra, U.P. 282005, India

High resolution Color Doppler Ultrasound (CDUS) is capable of imaging small vessels in superficial organs and non-invasively measuring flow in them. It reliably shows the testicular arterial anatomy by imaging intra-arterial blood flow and a knowledge of the normal CDUS appearance and waveform characteristic of the testicular artery aids in detecting alteration in blood flow [3]. According to few studies undertaken to evaluate the influence of laparoscopic inguinal hernia surgery on testicular perfusion, blood flow normalizes after few months and is comparable to the preoperative values [4–7]. There is paucity of literature on the effect of laparoscopic hernia repair on testicular perfusion.

In this study, we attempt to evaluate the effects of laparoscopic total extraperitoneal (TEP) repair on testicular blood flow in Indian population in very early (24 h), early (1 week) or late postoperative period (3 months).

Materials and methods

Between August, 2011 and January, 2014, 28 patients who presented to the Department of Surgery, Maulana Azad Medical College and associated Lok Nayak Hospital, New Delhi and clinically diagnosed to have inguinal hernia were included in this prospective controlled study after a written informed consent. Male patients with age 18 years and above, fit to undergo general anesthesia and available for follow-up were included in the study while those with undescended testis, recurrent hernia, complicated hernia (irreducible/obstructed/strangulated hernia), complete inguinal hernia, co-existent varicocele, and history of lower abdomen/groin surgery were excluded.

Detailed history and examination was recorded for each patient. Routine preoperative workup was done and anesthesia clearance was obtained. Preoperative CDUS evaluation of testicular blood flow was done for each patient using an ultrasound unit (Philips HD11^{TM}, USA) with a 8 MHz linear array probe in the Department of Radio-diagnosis. Patients were scanned in supine position after 10 min of rest in a warm room and bilateral testicular, capsular and intratesticular arterial flow dynamics were assessed. Point spectral analysis was performed in the testicular artery (1 cm superior to the upper pole of testis), capsular artery and the intratesticular artery and the parameters evaluated for each artery were peak systolic velocity (PSV), end-diastolic velocity (EDV) and resistive index (RI).

Patients presenting with unilateral hernia were counseled regarding the risks and benefits of undergoing a bilateral repair [8]. Unilateral or bilateral repair for these cases was performed in accordance with decision of the patient. Bilateral repair was done for cases presenting with bilateral hernia. Laparoscopic TEP repair was done for each patient using standard technique by experienced surgeons performing laparoscopic TEP routinely (see Video: dissection of sac off the cord). A contoured (Bard 3DMax^{TM} Mesh) polypropylene mesh of appropriate size was used in each case. Routine postoperative care was provided to these patients. CDUS (as described above) was done at 24 h [very early (VE)], 1 week [early (E)] and 3 months [late (L)] postoperatively. All the results are expressed as mean ± standard deviation. Data were analyzed using the SPSS (SPSS, Chicago, IL, USA) software program. Comparison of the results between groups was performed using the paired *t* test. A *p* value less than 0.05 was considered significant. The postoperative (VE, E and L) resistive index (RI) of above mentioned arteries of operated side was compared to preoperative (*p*) values (paired *t* test) and the two sides of a bilateral repair were evaluated independently. For unilateral repairs, the resistive index of operated side was compared with non-operated side, both pre- and postoperatively (VE, E and L).

Results

A total of 36 sides were operated in 28 patients. The average age of these patients was 42.4 years (range 18–72 years). 24 of these patients were clinically diagnosed to have unilateral hernia (16 right sided and 8 left sided, 21 indirect and 3 direct hernias) and 4 to have bilateral hernia (2 direct and 2 indirect). Eventually 20 patients underwent a unilateral repair (14 right sided and 6 left sided) and 8 patients underwent bilateral repair. 1 patient was diabetic, 4 were hypertensive and 8 were smokers/tobacco chewers. None of them had any history of cardiac disease, pelvic trauma, orchitis or retractile testis. In cases of clinically diagnosed unilateral hernia ($n = 24$), the resistive index (testicular artery) of the hernia side preoperatively was 0.74 ± 0.13 and that of clinically normal side was 0.73 ± 0.11. No statistically significant difference was seen between the resistive indexes of the two sides ($p = 0.43$; paired *t* test).

The average operative time taken for a unilateral and a bilateral repair was 82.75 and 115.65 min, respectively. Of the 36 operated sides, large sized mesh was used in 22, medium sized contoured mesh was used in 13 and extra-large sized contoured mesh was used in 1 side. Peritoneal breach occurred in 7 cases and there was no instance of spermatic cord, vascular or visceral injury.

The average duration of stay in hospital was 1.5 days (range 1–3 days). Postoperatively, nine patients had pneumo-scrotum (which resolved within 48 h), three patients had seroma (which resolved within 4 weeks), one patient had urinary retention (required catheterization).

Table 1 Resistive index [mean ± SD] of testicular artery (TA), Capsular artery (CA) and ITA (ITA) preoperatively and postoperatively [very early (VE), early (E) and late (L)]

Timing of CDUS measurement	Resistive indexes [Mean ± SD]		
	Testicular artery (TA)	Capsular artery (CA)	Intratesticular artery (ITA)
Preoperative (P)	0.74 ± 0.11	0.66 ± 0.10	0.62 ± 0.13
Very early postoperative (VE)	0.78 ± 0.08	0.69 ± 0.09	0.64 ± 0.09
Early postoperative (E)	0.75 ± 0.08	0.66 ± 0.10	0.62 ± 0.10
Late postoperative (L)	0.72 ± 0.07	0.64 ± 0.09	0.61 ± 0.09

$n = 36$; *CDUS* color Doppler ultrasound, *SD* standard deviation

Table 2 Alteration in resistive index [Mean difference ± SD (p value)] of the arteries of operated side postoperatively

Time period of CDUS measurements compared	Alteration of RI in postoperative period [Mean difference ± SD (p value)]		
	Testicular artery	Capsular artery	Intratesticular artery
Preoperative (P) and very early postopertive (VE)	−0.04 ± 0.13 (0.116 ns)	−0.03 ± 0.12 (0.162 ns)	−0.01 ± 0.14 (0.548 ns)
Preoperative (P) and early postoperative (E)	−0.01 ± 0.12 (0.634 ns)	0.00 ± 0.13 (0.888 ns)	0.01 ± 0.14 (0.671 ns)
Preoperative (P) and late postoperative (L)	0.03 ± 0.10 (0.117 ns)	0.02 ± 0.11 (0.294 ns)	−0.02 ± 0.11 (0.360 ns)

Paired t test; $n = 36$

ns not significant, *P* Preoperative resistive index, *VE* very early postoperative resistive index, *E* early postoperative resistive index, *L* late postoperative resistive index, *CDUS* color Doppler ultrasound, *RI* resistive index, *SD* standard deviation

Table 3 Resistive index [Mean ± SD] of operated and non-operated side pre- and postoperatively in cases of unilateral hernia repair

Timing of CDUS measurement	Resistive indexes [Mean ± SD]					
	Testicular A.		Capsular A.		Intra-testicular A.	
	Operated	Non-operated	Operated	Non-operated	Operated	Non-operated
Preoperative (P)	0.73 ± 0.13	0.74 ± 0.11	0.66 ± 0.12	0.65 ± 0.10	0.64 ± 0.15	0.64 ± 0.13
	$p = 0.65$ ns		$p = 0.27$ ns		$p = 0.94$ ns	
Very early postoperative (VE)	0.79 ± 0.09	0.77 ± 0.08	0.70 ± 0.10	0.67 ± 0.09	0.64 ± 0.08	0.65 ± 0.09
	$p = 0.30$ ns		$p = 0.17$ ns		$p = 0.59$ ns	
Early postoperative (E)	0.76 ± 0.08	0.74 ± 0.08	0.67 ± 0.11	0.68 ± 0.08	0.62 ± 0.12	0.60 ± 0.11
	$p = 0.37$ ns		$p = 0.64$ ns		$p = 0.44$ ns	
Late postoperative (L)	0.72 ± 0.07	0.73 ± 0.08	0.65 ± 0.12	0.66 ± 0.12	0.61 ± 0.11	0.63 ± 0.08
	$p = 0.63$ ns		$p = 0.51$ ns		$p = 0.42$ ns	

Paired t test; $n = 20$

ns not significant, *P* Preoperative resistive index, *VE* very early postoperative resistive index, *E* early postoperative resistive index, *L* late postoperative resistive index, *CDUS* color Doppler ultrasound, *SD* standard deviation

The average RI (mean ± SD) of the operated side both preoperatively and postoperatively (VE, E and L) are described in Table 1. The resistive index of all the three arteries increased in VE and then decreased to the preoperative values by E. However, this trend did not achieve statistical significance using paired t test (Table 2).

In addition, in cases of unilateral repair ($n = 20$), see Table 3, the preoperative and postoperative resistive indexes of the three arteries of the operated side was compared with their corresponding values on the non-operated side using paired t test. The resistive indexes of testicular, capsular and intratesticular arteries of the operated and non-operated side were similar preoperatively and did not differ significantly at any time postoperatively (VE, E or L).

Discussion

Laparoscopic total extraperitoneal repair has established itself as a favored procedure with comparable results to open surgery and is set to become the future standard of

Table 4 Summary of clinical studies evaluating resistive index (RI) of testicular blood supply after mesh hernia repair

Study	*N*	Design	Groups	Result
Beddy [4]	37	PCS	Lichtenstein vs TEP	Significant decrease in RI after repair in both group to normal at median follow-up of 6.1 months
El-Awady [11]	40	PCS	Lichtenstein	Significant decrease in RI after repair to normal by 3 months (follow-up 9 months–normal)
Neto [12]	39	PCS	Lichtenstein	No significant difference at 3 and 6 months follow up
Ramadan [13]	48	PCS	Mesh repair (unspecified)	No significant difference at 2 months follow-up
Aydede [15]	60	RCT	Open posterior preperitoneal vs open anterior tension-free mesh repair	Significant difference between RI of preoperative and early postoperative period (higher RI) in both groups which normalizes by late postoperative period (6 months)
Stula [16]	43	PCS	TAPP vs open anterior tension-free mesh repair	Significant increase in RI of ITA in early postoperative period (day 2) in TAPP group which normalizes by late postoperative period (5 months)
Koksal [6]	32	RCT	Lichtenstein vs TEP	No significant difference in both groups at 3 days or 6 months postoperatively
Celik [7]	40	RCT	TEP (slit vs non-slit mesh)	No significant difference at day 5 Significant decrease in RI at 6 months in both groups
Ersin [5]	44	PCS	Open anterior tension-free mesh repair vs TEP	No significant difference in RI of TA in both groups Significant decrease in RI of CA and ITA at POD 1 in TEP group which normalized by POD 7
Dilek [18]	26	RCT	Lichtenstein vs TEP	No significant difference in either groups at 3 months follow-up
Brisinda [19]	24	PCS	Open anterior tension-free mesh repair	No significant difference at 1, 3 and 9 months follow-up
Skawran [20]	59	PCS	TEP	No significant difference in RI at 3 months or more
Sucullu [22]	64	RCT	Lichtenstein vs mesh plug repair	Significant increase in RI postoperatively at 3 months in both groups; no effect on spermiogenesis
Our study	36	PCS	TEP	No significant difference

RCT randomized controlled trial, *PCS* prospective controlled trial, *TEP* total extraperitoneal repair, *TAPP* transabdominal preperitoneal repair

care [9, 10]. Effect of the presence of hernia itself on testicular perfusion is debatable and not studied well in detail. Beddy et al. and El-Awady et al. found the resistive index on the side of unilateral hernia to be significantly higher than that on the normal side [4, 11]. However, Neto et al. and Ramadan et al. did not find any statistically significant elevation in resistive indexes which is also the finding in our study [12, 13]. Our finding reaffirms that the presence of hernia does not affect testicular blood supply.

We speculate that the early postoperative changes in testicular perfusion (i.e. at 24 h and 1 week postoperatively) may occur due to surgical insult or handling of the testicular vessels and late changes are reflective of interaction of the mesh with the spermatic cord structures due to fibrosis. Measurement of resistive index of testicular vessels by CDUS is an objective method to evaluate such changes [14]. The studies evaluating effect of mesh hernia repair on testicular perfusion are summarized in Table 4.

Ischemic orchitis has been reported in 0.65 % cases of primary inguinal hernia repairs and 2.25 % in recurrent repairs. By leaving intact all significant distal hernial sacs and not dissecting beyond the pubic tubercle the incidence rates were reduced to 0.03 and 0.97 %, respectively. These data help us to emphasize the importance of surgical insult on testicular perfusion [1]. Since laparoscopic total extraperitoneal repair is relatively a new procedure and entails dissection of the sac off the spermatic cord, the question of its effect on testicular perfusion is pertinent.

Aydede et al., in his patients undergoing open mesh hernioplasty, demonstrated a significant increase in resistive index of testicular vessels in early postoperative period. In addition, Stula et al. demonstrated a statistically significant increase in RI of ITA at day 2 postoperatively. In both cases the resistive index normalized by late postoperative period [15, 16]. A similar trend ($p > 0.05$) is apparent in our study where increase in resistive index of

testicular vessels occurs at day 1 and approaches preoperative values by day 7. Koksal et al. and Celik et al. in their studies demonstrated no significant change in RI in early postoperative period (day 3 and 5, respectively) after laparoscopic TEP repair [6, 7]. However, Ersin et al., on the other hand, in patients of TEP, did notice a significant decrease in RI of capsular and intratesticular artery at day 1 postoperatively, which normalized by postoperative day 7 [5]. These findings suggest that whatever initial changes occur in testicular perfusion at 24–48 h, they get reversed by postoperative day 7 and become comparable to the preoperative values.

The long-term effect of polypropylene mesh used in tension-free repair of hernia is under evaluation. Upon animal studies, in a dog model, Uzzo et al. found no difference in testicular arterial perfusion or testicular volumes after mesh or non-mesh repair [17]. Several studies have demonstrated that the resistive index of testicular vessels at varying intervals from 3 to 9 months do not differ significantly from preoperative values [6, 12, 13, 16, 18–20]. In studies of El-Awady et al. and Beddy et al. the raised preoperative RI of the hernial side normalized by late postoperative period (at 3 and 6.1 months, respectively) [4, 11].. In our study, the resistive indexes of testicular vessels in late postoperative period were comparable to the preoperative values. These findings suggest that in both laparoscopic and open mesh hernia repairs, interaction of mesh with testicular vessels in the cord structures does not affect testicular perfusion at 3, 6 or 9 months postoperatively.

On the other hand, Peiper et al. in a rabbit model observed a typical foreign body reaction, which appeared 1–12 weeks after surgery, typically at the interface between mesh and surrounding tissue. This inflammation was not detectable after non-mesh (Shouldice) repair. The mesh repair, in contrast to Shouldice repair, led to a decrease in testicular arterial perfusion [21]. Also, Sucullu et al. demonstrated in 64 patients undergoing open anterior mesh repair a statistically significant increase in RI at 3 months postoperatively. However, this increase in RI did not adversely affect spermiogenesis [22].

Although it would have been useful to our understanding of the subject, a thorough review of literature did not reveal any study evaluating the effect of different meshes (e.g. PTFE, Biological meshes) or non-mesh techniques (e.g. Shouldice repair) on testicular perfusion.

Though the sample size of our study ($n = 36$) is relatively small and does not have the power of statistics, the findings of our study are in concert with the majority of the world literature. The preoperative as well as postoperative resistive index of the testicular vessels (testicular artery, capsular artery and intratesticular artery) on the operated side were comparable to the non-operated side. Also, the preoperative and postoperative resistive index of the testicular vessels did not differ. Therefore, we can conclude that in Indian population laparoscopic TEP repair does not adversely affect testicular perfusion, when performed by experienced minimal access surgeons performing laparoscopic TEP procedures routinely.

Compliance with ethical standards

Conflict of interest All authors declare no conflict of interest.

References

1. Fong MD, Wantz GE (1992) Prevention of ischemic orchitis during inguinal hernioplasty. Surg Gynecol Obstet 174:399–402
2. Klinge U, Klosterhalfen B, Muller M, Schumpelick V (1999) Foreign body reaction to meshes used for the repair of abdominal wall hernias. Eur J Surg 165:665–673
3. Middleton WD, Thorne D, Melson GL (1989) Colour Doppler ultrasound of the normal testis. Am J Roentgenol 152:293–297
4. Beddy P, Ridgway PF, Geoghegan T, Peirce C, Govender P, Keane FBV, Torreggiani WC, Konlon KCP (2006) Inguinal hernia repair protects testicular function: a prospective study of open and laparoscopic herniorrhaphy. J Am Coll Surg 203:17–23
5. Ersin S, Aydin U, Makay O, Icoz G, Tamsel S, Sozbilen M, Killi R (2006) Is testicular perfusion influenced during laparoscopic inguinal hernia surgery? Surg Endosc 20:685–689
6. Koksal N, Altinli E, Sumer A, Celik A (2010) Impact of herniorrhaphy technique on testicular perfusion: results of a prospective study. Surg Laparosc Endosc Percutan Tech 20:186–189
7. Celik AS, Memmi N, Celebi F, Guzey D, Celik A, Kaplan R, Oncu M (2009) Impact of slit and nonslit mesh technique on testicular perfusion and volume in the early and late postoperative period of totally extraperitoneal preperitoneal technique in the patients with inguinal hernia. Am J Surg 198:287–291
8. Lal P, Philips P, Chander J, Ramteke VK (2010) Is unilateral laparoscopic TEP inguinal hernia repair a job half done? The case for bilateral repair. Surg Endosc 24:1737–1745
9. Zhu X, Cao H, Ma Y, Yuan A, Wu X, Miao Y, Guo S (2014) Totally extraperitoneal laparoscopic hernioplasty versus open extraperitoneal approach for inguinal hernia repair: a meta-analysis of outcomes of our current knowledge. Surgeon 12:94–105
10. Lal P, Kajla RK, Chander J, Shah R, Ramteke VK (2003) Randomized controlled study of laparoscopic total extraperitoneal versus open Lichtenstein inguinal hernia repair. Surg Endosc 17:850–856
11. El-Awady SE, Elkholy AA (2009) Beneficial effect of inguinal hernioplasty on testicular perfusion and sexual function. Hernia 13:251–258
12. Lima Neto EV, Goldenberg A, Jucá MJ (2007) Prospective study on the effects of a polypropylene prosthesis on testicular volume and arterial flow in patients undergoing surgical correction for inguinal hernia. Acta Cir Bras 22:266–271
13. Ramadan SU, Gokharman D, Tuncbilek I, Ozer H, Kosar P, Kacar M, Temel S, Kosar U (2009) Does the presence of mesh have an effect on the testicular blood flow after surgical repair of indirect inguinal hernia? J Clin Ultrasound 37:78–81
14. Dogra VS, Gottlieb RH, Oka M, Rubens D (2003) Sonography of the scrotum. Radiology 227:18–36
15. Aydede H, Erhan Y, Sakarya A, Kara E, Ilkgül O, Can M (2003) Effect of mesh and its localisation on testicular flow and

spermatogenesis in patients with groin hernia. Acta Chir Belg 103:607–610
16. Stula I, Druzijanic N, Srsen D, Capkun V, Perko Z, Sapunar A, Kraljevic D, Bosnjak N, Pogorelic Z (2012) Influence of inguinal hernia mesh repair on testicular flow and sperm autoimmunity. Hernia 16:417–424
17. Uzzo RG, Lemack GE, Morrissey KP, Goldstein M (1999) The effects of mesh bioprosthesis on the spermatic cord structures: a preliminary report in a canine model. J Urol 161:1344–1349
18. Dilek ON, Yucel A, Akbulut G, Degirmenci B (2005) Are there adverse effects of herniorrhaphy techniques on testicular perfusion? Evaluation by color Doppler ultrasonography. Urol Int 75:167–169
19. Brisinda G, Cina A, Nigro C, Cadeddu F, Brandara F, Marniga G, Vanella S, Bonomo L, Civello IM (2008) Duplex ultrasound evaluation of testicular perfusion after tension-free inguinal hernia repair: results of a prospective study. Hepatogastroenterology 55:974–978
20. Skawran S, Weyhe D, Schmitz B, Belyaev O, Bauer KH (2011) Bilateral endoscopic total extraperitoneal (TEP) inguinal hernia repair does not induce obstructive azoospermia: data of a retrospective and prospective trial. World J Surg 35:1643–1648
21. Peiper C, Junge K, Klinge U, Strehlau E, Krones C, Ottinger A, Schumpelick V (2005) The influence of inguinal mesh repair on the spermatic cord: a pilot study in the rabbit. J Invest Surg 18:273–278
22. Sucullu I, Filiz AI, Sen B, Ozdemir Y, Yucel E, Sinan H, Sen H, Dandin O, Kurt Y, Gulec B, Ozyurt M (2010) The effects of inguinal hernia repair on testicular function in young adults: a prospective randomized study. Hernia 14:165–169