Analysis of volume change of the testis after inguinal hernia repair using the PIRS method – a prospective pilot study

Analiza zmian objętości jąder po zabiegu chirurgicznym przepukliny pachwinowej metodą PIRS – prospektywne badanie pilotażowe

Przemysław K. Wolak[1,2], Aneta Piotrowska[1,2], Agnieszka Strzelecka[1], Piotr Cierniak[3], Piotr P. Wolak[4], Łukasz Władyszewski[1,2], Joanna Wróbel[1], Grażyna Nowak-Starz[1], Stanisław Głuszek[1]

[1]*Collegium Medicum*, Jan Kochanowski University, Kielce, Poland
Head of the Collegium: Prof. Marianna Janion MD, PhD
[2]Department of Paediatric Surgery, Urology, and Traumatology, Provincial Hospital, Kielce, Poland
Head of the Department: Przemysław Wolak MD, PhD
[3]Department of Paediatric Radiology, Provincial Hospital, Kielce, Poland
Head of the Department: Piotr Cierniak MD, PhD
[4]Department of Internal Disease, City Hospital of Zabrze, Zabrze, Poland
Head of the Department: Włodzimierz Pokrzywnicki MD, PhD

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Key words: inguinal hernia, PIRS, laparoscopy, ultrasonography, testicular volume.

Słowa kluczowe: przepuklina pachwinowa, PIRS, laparoskopia, ultrasonografia, objętość jądra.

Abstract

Introduction: Laparoscopic surgery of inguinal hernias in children using the PIRS method is a recognized method of treatment that has been used for several years.
Aim of the research: To assess the effects of inguinal hernia repair performed with the percutaneous inguinal ring suturing (PIRS) method on the volume of the testicles.
Material and methods: It was a prospective study conducted between January 2016 and December 2019 in the Department of Paediatric Surgery. Twenty-nine male patients aged 0–8 years were included in the study. Ultrasound evaluation of both testicles, comparing the volume before and after inguinal hernia repair, was performed.
Results and conclusions: The ultrasound measurements of the testicular volume after the surgical procedure showed no inhibition of growth with the preoperative sonographic examination and concerning the testis of the opposite, non-operated side. The increase in the median of the volume of both testis' was observed in cases before and after the elective surgeries, although there was no statistically significant difference. Emergency operation due to the incarcerated hernia on either side did not statistically significantly affect testicular volume in the tested group of patients. None of the laparoscopically operated patients showed atrophy of the testis. Laparoscopic surgery using the PIRS method in the case of inguinal hernia does not result in testicular atrophy or a decrease of the volume of the testis on the operated side.

Streszczenie

Wprowadzenie: Operacja laparoskopowa przepukliny pachwinowej u dzieci sposobem PIRS jest uznaną metodą leczenia stosowaną od kilkunastu lat.
Cel pracy: Wpływ leczenia operacyjnego przepukliny pachwinowej metodą PIRS na zmianę objętości jądra.
Materiał i metody: Pomiędzy styczniem 2016 a grudniem 2019 roku przeprowadzono badanie prospektywne w Uniwersyteckiej Klinice Chirurgii Dziecięcej. Do badania włączono 29 chłopców w wieku 0–8 lat. Analizie poddano zmianę objętości jądra w ultrasonografii przed zabiegiem chirurgicznym i po zabiegu. Badano zmianę objętości jądra strony operowanej w stosunku do jądra, które nie było poddane zabiegowi. Porównano zmianę objętości jądra operowanego przed zabiegiem i po zabiegu oraz jądra strony przeciwnej, które nie było poddane procedurze PIRS.
Wyniki i wnioski: Ultrasonograficzne pomiary objętości jąder po zabiegu chirurgicznym nie wykazały zahamowania wzrostu w przedoperacyjnym badaniu ultrasonograficznym jądra strony przeciwnej, nieoperowanej. Zaobserwowano wzrost mediany objętości obu jąder w przypadkach przed planowanymi operacjami chirurgicznymi i po nich, chociaż nie stwierdzono różnicy istotnej statystycznie. Operacja nagła z powodu uwięźniętej przepukliny po obu stronach nie wpłynęła statystycznie istotnie na objętość jąder w badanej grupie pacjentów. U żadnego z operowanych laparoskopowo pacjentów nie wystąpił zanik jąder. Operacja laparoskopowa metodą PIRS w przypadku przepukliny pachwinowej nie powoduje zaniku jąder ani zmniejszenia objętości jądra po stronie operowanej.

Introduction

The laparoscopic approach is a widely accepted method of treatment for inguinal hernias in the paediatric population [1–5]. One of the techniques is a minimally invasive, video-assisted, percutaneous inguinal ring suturing (PIRS) introduced by Patkowski [6–8]. This method consists of percutaneous closure of the internal inguinal ring with a non-absorbent suture under laparoscopically guided vision.

Whatever the operative method used, one of the potential postoperative complications in boys is testicular atrophy. Iatrogenic injury to the spermatic cord leading to testicular atrophy occurs in 0.1–1.2% of cases [9–11]. The risk of atrophy is higher in cases of incarcerated hernias [9, 11, 12].

Aim of the research

The aim of our study was to evaluate the effect of the inguinal hernia repair using the PIRS method on the testicular volume of the affected and contralateral side.

Material and methods

A prospective study evaluating the changes in the volume of the testicles after unilateral inguinal hernia repair using the PIRS method was conducted in the Department of Paediatric Surgery, Urology, and Traumatology in the Regional Hospital in Kielce between 1 January 2016 and 20 May 2019. Inclusion criteria for the study were as follows: age 0–18 years, male gender, presence of unilateral inguinal hernia confirmed intraoperatively (closed contralateral processus vaginalis). Patients were excluded from the study if the hernia was bilateral, had undescended testes, hydrocele, or other anomalies of the testicles, and if there was a history of past procedures on the testicles or history of orchitis and/or epididymitis.

Study design

The study protocol included the preoperative and postoperative ultrasonographic evaluation of both testicles. Ultrasound exam was completed one day before or on the day of the surgery. Both testicles were measured in 3 dimensions, and volumes were calculated. The follow-up exam was done not earlier than 2 months after surgery. The team of radiologists performing the ultrasound was highly experienced in evaluating paediatric patients with urological conditions. The same high-resolution ultrasound machine and the same diagnostic protocol of scanning was used for all exams. All surgeries were performed by one surgeon who was highly experienced in the PIRS method. Surgeries were either scheduled as elective or performed as an emergency operation if the hernia was incarcerated.

Informed consent for the ultrasound scan and surgical procedure was obtained from the guardian of the patient in all cases. The study was approved by the institutional research committee (Jan Kochanowski University Research Ethics Board, no. 12/2016) and was performed according to the guidelines of the Declaration of Helsinki.

Statistical analysis

Statistical analyses were performed using Statistical Package Statistica software (version for Windows 13.1 TIBCO Software Inc. – StatSoft, Poland). The results were presented in the form of the distribution, frequency, and median. The interquartile range of the studied variables was presented. The normality of the distribution of the studied variables was tested using the Shapiro-Wilk test. Differences between the groups under study were verified using the nonparametric Wilcoxon test and the Kruskal-Wallis test. Spearman's rank correlation coefficient was used to establish the relationship between age and volume before and after the procedure. The significance level was set at $\alpha = 0.05$.

Results

Twenty-nine patients qualified for the study. The median follow-up was 28 months (IQR = 17 months). The age distribution, location of the hernia (left or right), and the type of surgery in the study population are presented in Table 1. There were 9 (31.03%) patients less than one year old, 12 (41.38%) between the

Table 1. Age at the time of surgery, side of the operation, and type of surgery (before)

Side of the operation and type of the surgery	< 1 year *n* (%)	1–4 years *n* (%)	4–8 years *n* (%)	Total *n* (%)
Right side	8 (27.59)	10 (34.48)	5 (17.24)	23 (79.31)
Elective surgery	5 (17.24)	9 (31.03)	5 (17.24)	19 (65.52)
Emergency surgery due to incarcerated hernia	3 (10.34)	1 (3.45)	0 (0.00)	4 (13.78)
Left side	1 (3.45)	2 (6.90)	3 (10.34)	6 (20.69)
Elective surgery	0 (0.00)	1 (3.45)	3 (10.34)	4 (13.79)
Emergency surgery due to incarcerated hernia	1 (3.45)	1 (3.45)	0 (0.00)	2 (6.90)

Table 2. Side of the hernia and the testicular volume before and after surgery

The testicular volume	Min.–max. [ml]	Me (IQR) [ml]	*P*-value
Right testicular volume, before [ml]	0.34–1.20	0.60 (0.25)	0.404*
Right testicular volume, after [ml]	0.39–1.50	0.60 (0.23)	
Left testicular volume, before [ml]	0.34–1.10	0.60 (0.34)	0.353*
Left testicular volume, after [ml]	0.39–1.50	0.60 (0.23)	
Total testicular volume, before [ml]	0.34–1.20	0.60 (0.29)	0.095*
Total testicular volume, after [ml]	0.39–1.50	0.62(0.23)	

**Wilcoxon test, p > 0.05.*

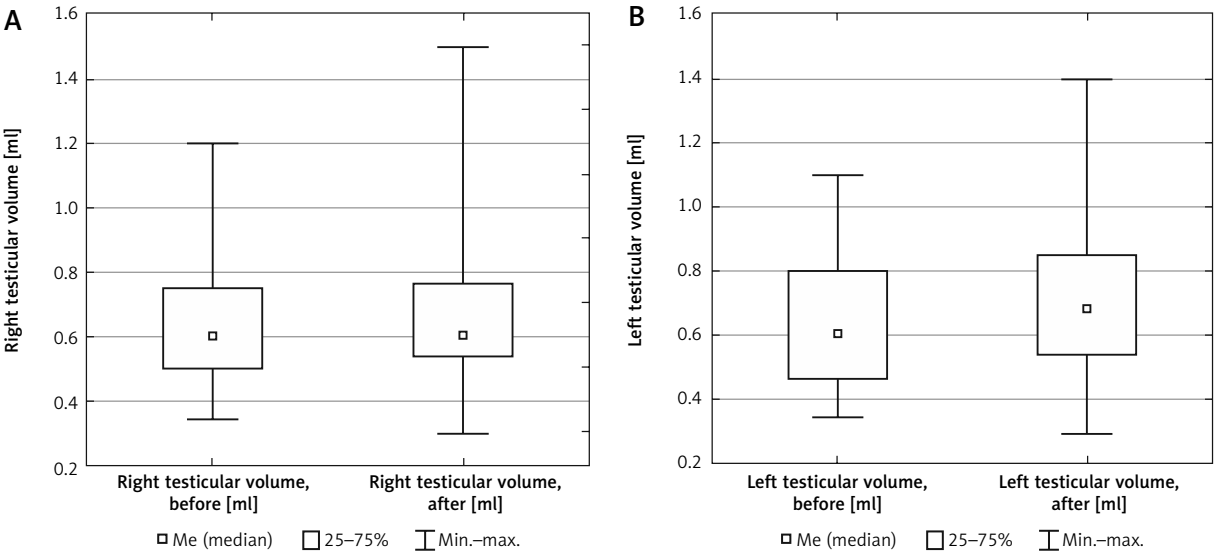

Figure 1. Side of the hernia and the testicular volume before and after the surgery

ages one and 4 years old, and 8 (27.59%) in the range of 4 to 8 years of age. In the studied group there were no patients over 8 years of age. There were 6 cases of left inguinal hernia repair (LIHR) and 23 cases of right inguinal hernia repair (RIHR). In 4 cases, 3 in a right- and one in a left-sided hernia, surgery was performed as an emergency procedure because of incarceration.

There was no statistically significant difference between the volume of the right testicle before and after surgery ($p = 0.404$). For the left testicle the results were similar, i.e. the difference in volume before and after surgery was not statistically significant. Total testicular volumes before and after surgery were also not statistically significantly different (Table 2, Figure 1).

Volume of the testicle contralateral to the operated side was also analysed. For both LIHR and RIHR the difference between the volume of the testicle before and after surgery was not statistically significant, with $p = 0.978$ for LIHR and $p = 0.726$ for RIHR (Table 3, Figures 2, 3).

Table 3. Testicular volume before and after surgery for contralateral side

The testicular volume	Min.–max. [ml]	Me (IQR) [ml]	*P*-value
Right testicular volume, before [ml]	0.34–1.20	0.55 (0.40)	0.978*
Right testicular volume, after [ml]	0.39–1.50	0.57 (0.70)	
Left testicular volume, before [ml]	0.40–1.00	0.60 (0.34)	0.726*
Left testicular volume, after [ml]	0.30–1.20	0.70 (0.31)	
Total testicular volume, before [ml]	0.34–1.20	0.60 (0.30)	0.076*
Total testicular volume, after [ml]	0.39–1.50	0.68(0.31)	

**Wilcoxon test, p > 0.05.*

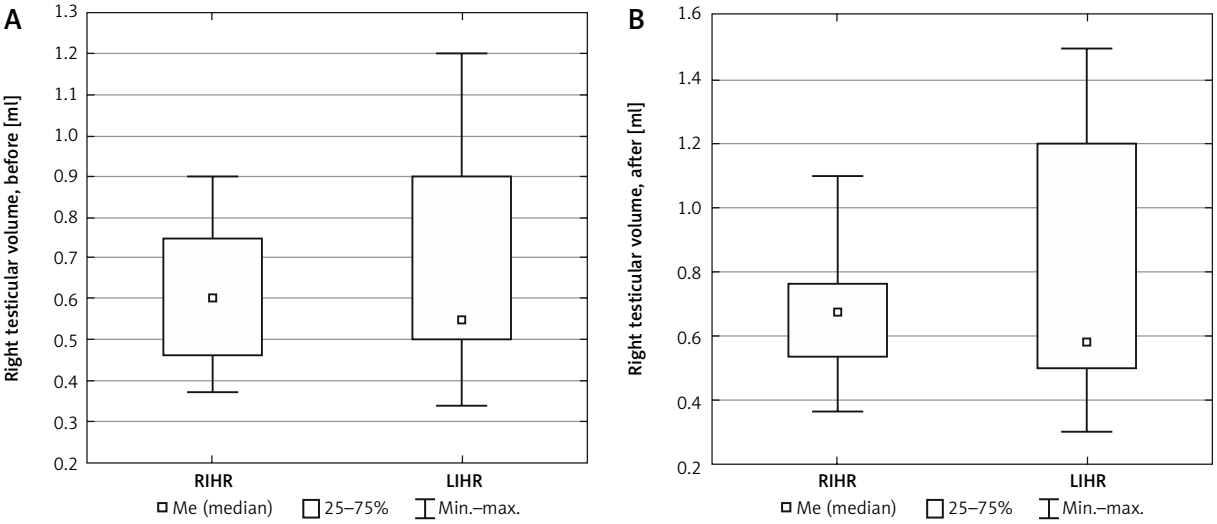

Figure 2. Right testicular volume before and after surgery for contralateral side

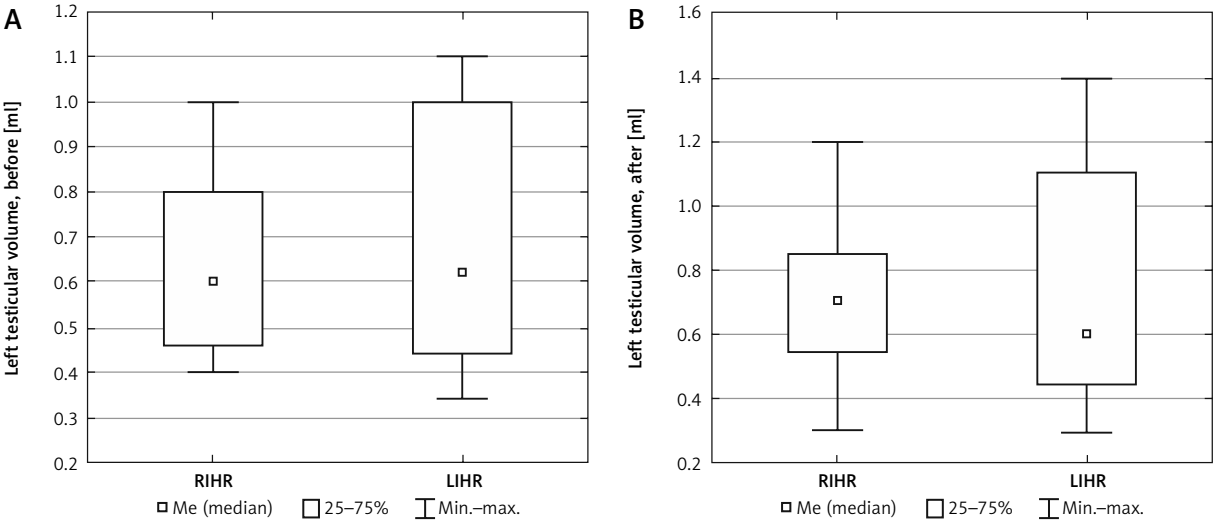

Figure 3. Left testicular volume before and after surgery for contralateral side

Table 4. Emergency operation due to the incarcerated hernia

The testicular volume	Min.–max. [ml]	Me (IQR) [ml]	*P*-value
Right testicular volume, before [ml]	0.40–0.90	0.62 (0.37)	0,273*
Right testicular volume, after [ml]	0.50–0.76	0.55 (0.15)	
Left testicular volume, before [ml]	0.34–0.44	0.39 (0.10)	0.715*
Left testicular volume, after [ml]	0.29–0.44	0.36 (0.15)	
Total testicular volume, before [ml]	0.34–0.90	0.47 (0.34)	0.273*
Total testicular volume, after [ml]	0.29–0.76	0.51 (0.14)	

**Wilcoxon test, p > 0.05.*

Emergency operation due to the incarcerated hernia on either side did not statistically significantly affect the testicular volume in the tested group of patients (Table 4).

Nonetheless, a decrease in the right testicular volume after the operation was observed. The median testicular volume decreased by 0.07 ml, which was not statistically significant (p = 0.273). The median

Table 5. Testicular volume for ipsilateral and contralateral side, for cases operated urgently due to incarcerated hernia

Emergency surgery due to incarcerated hernia	Min.–max. [ml]	Me (IQR) [ml]	*P*-value
Testicular volume, before [ml] operated side	0.34–0.90	0.47 (0.34)	0.9464*
Testicular volume, after [ml] operated side	0.29–0.76	0.51 (0.14)	
Testicular volume, before [ml] contralateral side	0.34–0.90	0.47 (0.34)	
Testicular volume, after [ml] contralateral side	0.30–0.89	0.54 (0.24)	

**Kruskal-Wallis test, p > 0.05.*

Table 6. Elective surgery

Elective surgery	Min.–max. [ml]	Me (IQR) [ml]	*P*-value
Testicular volume, before [ml] operated side	0.37–1.10	0.64 (0.30)	0.619*
Testicular volume, after [ml] operated side	0.36–1.40	0.67 (0.31)	
Testicular volume, before [ml] contralateral side	0.40–1.20	0.60 (0.34)	
Testicular volume, after [ml] contralateral side	0.30–1.50	0.70 (0.35)	

**Kruskal-Wallis test, p > 0.05.*

left testicular volume after emergency surgery due to the incarcerated hernia decreased after surgery by 0.03 ml. This difference was not statistically significant ($p = 0.715$) (Table 4).

Analysis of the data for the group of patients in which surgery was performed as an emergency procedure because of incarceration showed that for the operated side the testicular volume increased slightly after surgery, but the difference was not statistically significant. For the contralateral side the median testicular volume also increased slightly after surgery, but again the difference was not statistically significant (Table 5).

For the group of patients operated electively the results were similar. The median testicular volume increased slightly after surgery for both the ipsilateral and contralateral side, but the difference did not reach statistical significance (Table 6).

There is a significant statistical relationship between age and testicular volume, after surgery [ml] ($p = 0.029$, $r = 0.407$). However, no statistically significant correlation was found between age and age and left testicular volume, after surgery [ml] ($p = 0.056$, $r = 0.353$).

There were no reported complications in the study group after surgery and no recurrences.

Discussion

According to literature reports, inguinal hernia and hydrocele testis with open processus vaginalis are associated with worse testis development on the affected side. However, one of the known complications of inguinal hernia repair is testicular atrophy. Testicular ischaemia also might result from an incarcerated inguinal hernia.

Dandapat *et al.* provided similar results [13]. Patients with big unilateral hydrocele of the tunica vaginalis testis have been studied for the effect on the testis' structure and function, taking the contralateral side as a control. In 70% of cases, there was no pressure effect from the hydrocele on the structure of the testis, although there was a flattening of testis in 22% and testicular atrophy in 8% of cases. Also, it was detected that in 10%, there was partial and in 8% of cases there was total arrest of spermatogenesis. The remaining 82% showed normal spermatogenesis [13]. In the study of Gurbulak, patients with unilateral inguinal hernia were operated on with the TEP method (64 cases) and the Lichtenstein procedure (70 patients). Both groups had no detected differences in vascular flow or testicular volume before and after the surgery [14].

A study of the influence of unilateral hydrocele testis on the volume of affected testis and resistive and pulsatility index of intratesticular arteries of both sides was presented by Mihmanli *et al.* [15]. The authors showed significant differences in the testicular volumes before and after surgery on the operative and contralateral sides. After hydrocelectomy, there was a 21% mean decrease in the affected testis volume. There were also statistically significant differences in intratesticular arteries' resistive and pulsatility index on the operated side [15].

The analysis of 44 surgeries on adult patients compared Doppler flow parameters for the preoperative period, day one, and the early postoperative (day 7) period. There were 29 patients operated by open approach and 15 by laparoscopic approach. The study did not show any statistically significant differences between the 2 groups. The authors also compared Doppler flow parameters of the testicular artery in which statistically significant differences were found between preoperative and very early postoperative

values. The flow parameters of the testicular, capsular, and intratesticular arteries of the laparoscopic group showed statistically significant differences between preoperative and very early postoperative values [16].

In Parelkar's study, laparoscopic inguinal hernia repairs were performed using 3 ports in males. There were 100 cases, 75 of whom had a unilateral hernia. The analysis showed that there were no significant differences between preoperative and late postoperative volumes of testis on the operated side [17].

Another study on paediatric patients with unilateral inguinal hernia compared the testicular volume of the affected and healthy sides. The analysis was performed on 173 boys aged 0–179 months operated with an open approach. There was 1 case with a 50% drop in the testicular volume. However, no significant difference in testicular volume was found [18].

A similar study was done by Adaletli *et al.* in children [19]. This study showed a decrease in testicular volume in 15% of patients after unilateral communicating hydrocelectomy compared to the contralateral side. However, there was no significant difference in the testicular volume of the side without hydrocele [19].

It was observed that surgical manipulations during inguinal hernia repair in children cause transient changes in vascularization of the testes in the early postoperative period; however, late postoperatively it returns to normal [20].

A study by Schier included 65 boys (52 with unilateral inguinal hernia) operated with a laparoscopic approach. During the analysis, 4 parameters were measured 10 times each. First, oxygen saturation at the venous end of the capillaries was checked, where values of less than 10% indicated hypoxia. Second, the amount of haemoglobin within microvessels was measured. Values less than 20 patients indicated reduced perfusion. Third, the blood flow within microcirculation was controlled, and values of less than 5 patients were considered critically low. Last, the velocity of the blood in microcirculation was calculated. The authors, after meticulous calculations, concluded that laparoscopic inguinal hernia repair using suture closure of the internal ring does not impair testicular perfusion [21].

An analysis similar to our study was presented by Tuncer *et al.* on 23 cases. The authors presented results in which preoperative testicular blood flow in the right testicle was significantly reduced in patients with right-sided pathologies compared to the left testicle. In contrast, there was no statistically significant difference in postoperative early and late testicular blood flow for right and left testicle comparison. In our study, the blood flow was not measured quantitatively, only volumes. However, the testicle volume is derived from the blood flow within the testicle.

When preoperative, early postoperative, and late postoperative testicular volumes and blood flow of the testes with a pathological condition were compared using the Friedman test, there was no statistically significant difference in testicular blood flow ($p > 0.05$ in all groups). A slight increase in testicular blood flow in the pathological testes during the early postoperative period returned to normal during subsequent postoperative measurements; however, this difference was not statistically significant [22].

In the literature, many studies show testicular ischaemia after incarcerated inguinal hernias. In the study by Ozdamar *et al.* [23] there were 738 male patients treated for inguinal hernia, and 44 of them had incarcerated hernias. Emergency surgery was required for 16 patients due to irreducible hernias. Consequently, in 9 cases, testicular ischaemia and haemorrhagic necrosis were observed. Testicular ischaemia was found more in younger children with a longer duration of incarceration. Among patients with incarcerated hernias, 20% of testicular ischaemia was noted, and children with irreducible hernias raised the proportion to 56% of patients. In 2 patients postoperative testicular atrophy occurred [23].

A recent study was conducted on 2184 children who underwent inguinal hernia repair. There were 24 cases noted with irreducible incarcerated hernias. There was 1 case of sonographic-identified testicular atrophy in this group 6 years after the surgery [24].

Turgut *et al.* [25] presented a study on the incidence of acute testicular ischaemia in 147 patients with incarcerated inguinal hernias. The authors reported that 6.8% of cases had a decrease or absence of testicular blood flow. Testicular ischaemia incidence was high in children younger than 6 months (20% of cases). Testicular size did not significantly differ between the ipsilateral and contralateral sides for patients without disrupted testicular blood flow. Unlike in cases with testicular ischaemia, testicular size increase was noted for the testicle ipsilateral to the inguinal hernia ($p = 0.012$) [25].

Inguinoscrotal hernias are associated with testicular infarction and might cause male infertility [26]. Sonderman *et al.* analysed the TRICARE database in a large retrospective study, including more than 3 million children. Of 69,682 patients who underwent inguinal hernia, 8897 met the inclusion criteria for the study. There were 18 patients with testicular atrophy, and consequently orchiectomy was performed in 11 cases. Authors reported that all patients who developed testicular atrophy were aged 5 years or less, while 72% were under 13 months old. It was noted that an undescended testis was a significant factor in developing testicular atrophy [9].

The study of Mishra *et al.* [27] showed similar results in which, after incarcerated inguinal hernia, testicular atrophy occurred in 1 patient after laparoscopic reduction (3.7% of patients) and 1 after open surgery (2.2% of patients).

However, Esposito *et al.* [11], in 46 patients operated due to incarcerated inguinal hernia, did not report testicular atrophy. Similarly, Gokcora *et al.* [28] did not observe any testicular atrophies during 6 years of follow-up after surgical treatment of inguinoscrotal pathologies.

In another study, Chen *et al.* [29] emphasized the significant correlation between prolonged waiting time of patients with incarcerated inguinal hernias and a higher rate of complications.

The findings of this study must be considered in light of some limitations. First, this is a small single-centre study; therefore, the composition of the catchment population potentially limits the generalisability of our results. Because we based our predictions on a dataset, we should take into account that past performance is no guarantee of future results. Second, sonographic examination and, consequently, testicular volume measurements are operator-dependent, even though in our study the examinations were performed by radiologists specializing in children's care following the same protocol.

Conclusions

Regardless of laparoscopic inguinal hernia repair on the left or right side, the testicular volume did not decrease on the ipsilateral or on the contralateral side. Testicular volume change was not affected by the type of surgery: elective or emergency. Testicular volume change was not affected by the age of patients at the time of surgery.

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Conflict of interest

The authors declare no conflict of interest.

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Address for correspondence:

Przemysław K. Wolak MD, PhD
Collegium Medicum
Jan Kochanowski University
Department of Paediatric Surgery,
Urology, and Traumatology
Provincial Hospital
45 Grunwaldzka St
25-736 Kielce, Poland
Phone: +48 501 525 549
E-mail: przemyslaw.wolak@ujk.edu.pl