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Iatrogenic Vas Deferens Injury Due to Inguinal Hernia Repair

Review Article

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Abstract

Aim-Background: One of the most common operations performed by general and paediatric surgeons is that of inguinal hernia repair. A rare complication of this surgery is injury to the vas deferens (vas), regardless of the surgical technique used. The aim of this article is to review current data regarding the consequences following vas injury and to provide surgeons, who operate in the inguinal canal, with all the current knowledge regarding appropriate treatment of the injured vas.

Methods: A systematic search was conducted through Pubmed, Embase, OVID, Medline, Cinahl and Google search engines to identify relevant reports.

Results: Vas injury can be the result of intraoperative manipulations or can be related to the mesh used for hernioplasty. A 0.1 - 0.53 % incidence of vas injury is reported in open inguinal hernia repairs. The most common consequences are spermatic granuloma formation, vas and epididymal epithelium dysfunction and testicular atrophy, unilateral or bilateral. The mechanism of bilateral testicular damage is mediated through the formation of sperm autoantibodies and sympathetic orchiopathia. The optical loupe-assisted modified one-layer anastomosis technique yields overall similar patency rates when compared with microsurgical techniques, and also has positive outcomes in terms of shorter operative time, less infrastructure and lower cost.

Conclusions: Immediate management of the injured vas requires a broad understanding of the consequences, advanced surgical skills, and liaison with specialists in this field. A therapeutic algorithm is proposed by the authors of this article.

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Key words:
Vas deferens injury, Inguinal hernia repair, Polypropylene mesh, Obstructive azoospermia and/or combinations with the words consequences and treatment

Introduction

Inguinal hernia repair, one of the most frequent operations performed worldwide by general and paediatric surgeons, is performed by using the open, laparoscopic or preperitoneal approach [1]. Regardless of surgical technique, an estimated 80% of these hernia operations include placement of a knitted polypropylene monofilament mesh prosthesis [2]. There are many and various complications of groin hernia repair; injury to the vas deferens is one of them. Intraoperative manipulations or mesh-related fibrosis can lead to perforation or obstruction (mechanical or functional) of the injured vas. The consequences include formation of a spermatic granuloma, or testicular, epididymal and vas damage, which can ultimately result in male infertility [3]. Although vas transection may be apparent intraoperatively, accidental operative crush or mesh-related injury is unlikely to be detected, or is identified only in adulthood, during an investigation for obstructive azoospermia. Consequently, it is imperative that the surgeon who operates in the inguinal region or the scrotum, especially in children, is careful to avoid vas injury and is fully aware of all the current methods for damage repair.

Methods

A systematic search of Pubmed, Embase, OVID, Medline, Cinahl and Google search engines was conducted from the inception of the databases until October 2010. Updated searches were also performed in July 2011 to add any new relevant articles. Searches were conducted without language restriction. The search terms were: vas deferens injuries, inguinal hernia repair, obstructive azoospermia, polypropylene mesh and/or combinations with the words consequences and treatment. Retrieved studies had a sample size exceeding 10 subjects with intraoperative vas injury or mesh-related vas injury due to inguinal hernia repair; age or animal-based studies did not

constitute a restriction. Studies of other forms of vas injury or injury due to other regional operations were excluded. Comparative studies allowing estimates of association between surgical technique and outcome of vasectomy reversal were also included.

A total of 3126 citations were identified from the electronic searches. After screening of the titles and abstracts, a total of 296 full-text citations were retrieved for detailed evaluation. Following critical appraisal of the 296 studies identified in the literature search, a total of 135 studies formed the evidence base for this review, based on the defined inclusion criteria. The quality of the available evidence was rated as poor [4]. The frequently small sample size and number of animal-based studies limited the validity of findings of this review. The results of future additional studies are needed before definite conclusions can be drawn.

Incidence

Patric et al found only a 0.13% incidence of vas injury in an analysis of 1494 hernia sacs submitted for histopathology after open inguinal hernia repair [5]. Steigman et al, in an analysis of 7314 sacs, reported that 0.23% of cases contained vas and 0.53% of the sacs contained either vas or epididymis [6]. Siddigui et al. argued that the incidence of vas found in a hernia sac is so low that routine histological examination is not indicated [7]. Vogels et al, in a retrospective study of 3128 herniotomies in children, identified injury to the vas in 0.1% of the cases [8]. The incidence of vas injury during laparoscopic inguinal hernia repair depends on the surgeon's and institute's experience [9]. Hassan et al reported a 7% incidence of vas injury [10], whereas Endo et al reported no injury to the reproductive system in 1257 laparoscopic inguinal hernia repairs [11]. Regardless of surgical technique, little clinical information concerning the long-term effects of the propylene mesh on the vas was available [12]; hence, the incidence of inguinal vassal obstruction due to mesh prosthesis has not yet been clearly delineated [13].

Aetiology

Transection or ligation related injury accounts for about 25% of iatrogenic vassal injuries [14]. This form of vas injury can be recognized intraoperatively, allowing for its immediate reconstruction. However, an accidental operative crush injury is unlikely to be detected during surgery, especially in the case of a congenital vas anomaly [15]. Duplication is the most common vas congenital anomaly for which the overall incidence in the general population is estimated to be less than 0.05% [16]. In cases of a duplicated vas, the anatomic variant may not be identified, increasing the chances of intraoperative injury. Although the duplicated vas may be smaller or incomplete, the consequences associated with its injury are the same [17].

Several studies document the results of simple operative manipulations to the vas. Grasping with toothed and non-toothed forceps, clamping with mosquito haemostats, and electrocoagulation, can lead to vas histological alterations [18], including intra- and transmural inflammatory reaction, mural disruption, muscle wall disruption and luminal obliteration [19]. Abasiyanik et al suggested that the type rather than the duration of injury is important, and concluded that the damage from these manipulations is appreciable and long term [20]. Janik et al reported that finger or vascular clamp grasping of the vas can cause a temporary mild transmural inflammation [21]. All the above studies suggest that vas manipulations should be minimized to digital manoeuvres. Moreover, during herniorrhaphy, care should be taken to prevent thermal damage to the vas, and only bipolar cautery or ophthalmic cautery should be used to stop adventitial bleeding [22].

Regardless of surgical technique, clinical information referring to the long-term effects of the polypropylene mesh (PM) on the vas is limited. Mesh-related vas injury can be the result of extrinsic compression or delayed fibrosis. Firstly, tight placement of mesh arms around the cord affects more than one cord structure and can cause cord swelling due to ischaemic orchitis, chronic pain and mechanical vas obstruction caused by extrinsic compression, or spermatic granuloma formation resulting from vas erosion [23]. Secondly, there are many animal and human studies conducted to clarify the effect of PM-related fibrosis on the vas. Maciel et al studied the effects of PM in 40 Wister rats, in which the vas was dissected, and a PM was placed underneath and fixed with interrupted non-absorbable sutures. Histopathologic study after 90 days showed a reduction in wall thickness due to smooth muscle substitution by scar tissue and loss of mucosal folds in the vas segment exposed directly to PM [24]. Uzzo et al examined the local effects of PM on the spermatic cord in a small animal-based study by performing a comparative histologic and clinical study of standard inguinal herniorrhaphy versus mesh inguinal hernioplasty. Histologic examination showed a significant decrease in vassal luminal diameter when compared with controls [25]. Shin et al studied 14 cases of human patients with azoospermia secondary to inguinal vassal obstruction related to previous PM hernioplasty. Surgical exploration revealed a dense fibroblastic response with either trapped or obliterated vas in all patients [26]. There is no doubt that

mesh material has an impact on the integrity of the spermatic cord [27]. If mesh material is needed in inguinal hernia repair, especially in young patients, the use of modern low-weight, large porous, self-gripping hernia mesh has a beneficial effect on the integrity of the vas [28-29].

Furthermore, other mechanisms of vas injury include stretching of the spermatic cord and vas devascularization. Temporary stretching of the spermatic cord is a frequently performed manipulation during open inguinal hernia repair. Ceylan et al, in an experimental study of 40 male rats, investigated the effects of temporary horizontal stretching of various amounts to the spermatic cord. The authors concluded that stretching to the vas and vessels can result in significant thinning of the vas smooth muscle layer and testicular atrophy [30]. Vas devascularization can occur during overzealous dissection of the hernia sac from the cord structures [31]. Moreover, postoperative cord swelling can compress vas blood supply, and delayed inflammatory mesh-related response can compromise perivassal vessels [32].

Consequences

Spermatic granuloma is a chronic inflammatory lesion which surrounds extravasated spermatozoa [33]. The mechanism of granuloma formation is traumatic injury inducing extravasation of germ cells. The lesion is formed in the interstitial spaces of the vas and the epididymis but not in the interstitial space of the testis. Itoh et al suggested that the microenvironment of testicular intersitium is the main factor in determining the limited formation of spermatic granuloma in the testis [34]. Silich et al presented a case of sperm granuloma formation following tension-free hernia repair. The mechanism implicated was believed to be erosion of the vas by the cut edges of the slit used to recreate the internal inguinal ring [35]. Spermatic granuloma should be included in the differential diagnosis of posthernioplasty pain and mass, though it does not have a significant impact on spermatogenesis [36].

Unilateral vas obstruction can cause bilateral testis damage [37]. A decrease in the epithelial depth and an increase in the basement membrane thickness and interstitial space surface are common histological findings [38]. At first, changes are slight and restricted but gradually become more severe and extensive. Finally, deficiency in both Leydig and Sertoli cell secretory function results in impaired spermatogenesis and sperm maturation [39]. Whyte et al proposed that increased intraluminal pressure is a basic factor that provokes ipsilateral testicular atrophy [40]. Vas obstruction increases pressure within the distal structures leading to a decrease in testicular blood flow and, subsequently, testis hypoxia and atrophy. The mechanisms that provoke bilateral testicular damage in cases of unilateral vas injury are mediated through the formation of antisperm autoantibodies (ASA) and currently through sympathetic vasospasm. Firstly, obstruction to the spermatozoa outflow results in ASA formation, because of spermatozoa absorption via the lymphatics and their ultimate destruction in the abdominal lymph nodes [41]. Many studies demonstrated the relationship between alterations in testicular histology (which are described above) and ASA [42]. ASA may need a few weeks to develop after vas injury, preceding histologic testicular damage [43]. Moreover, ASA may decrease sperm motility and fertilizing capacity through either agglutination or immobilization, thus limiting sperm progression through the female genital tract. ASA may also impair sperm capacitation and acrosome reaction, thereby affecting sperm-oocyte interaction [44]. Prepubertal vas injury can induce ASA formation after puberty [45]. Pedersen et al suggested that it is possible to prevent ASA formation in adulthood by performing vas repair before puberty [46]. Chehval et al concluded that monitoring of ASA levels could possibly predict testicular damage prior to its development and, hence, avoid it [47]. Secondly, a current theory of contralateral testicular injury proposes a reflexive decrease in contralateral testicular blood flow mediated through sympathetic vasospasm. The vasospasm in the contralateral testis is suggested to arise when a neurovascular pathway, triggered by an ipsilateral sympathetic reflex arc, results in decreased blood flow [48]. Sympathetic orchiopathia leads to testicular tissue hypoxia, as indicated by the increase in biochemical levels of lactic acid and hypoxanthine. Chemical sympathectomy in animal studies reduced the effects of tissue hypoxia and preserved testicular histology and fertility [49]. These studies suggested that the sympathetic nervous system plays a role in testicular degeneration, when associated with injury-related vas obstruction [50].

Vas and epididymal epithelial dysfunction have been best described after vasectomy, resulting from real iatrogenic vas injury [51-52]. Lavers et al demonstrated that acute vasectomy effects comprise acute inflammation at the site of ligation, with a major increase in transferrin and osteopontin expression by the vas and epididymal epithelium [53]. Turner et al reported a significant decrease in a number of proteins (which are required for the sperm maturation) at later postvasectomy times [54]. Moreover, Turner showed that the alterations in the epithelium can persist after an apparently successful vasectomy reversal [55].

Finally, the greatest consequence of unilateral and bilateral vas injury is male infertility. Among subfertile patients, the incidence of vassal obstruction was found to be as high as 26.7% when a history of childhood inguinal hernia repair is reported [56]. Yavetz et al recorded a 6.65% incidence of inguinal herniorrhaphy in a large series of 8500 patients attending for investigation of obstructive azoospermia, with or without subsequent testicular atrophy [57].

Treatment

The surgical techniques used for repair of the injured vas are identical to those employed in vasovasostomy procedures. The outcome of vas repair is influenced by several factors, as presented in table 1 [58]. Furthermore, the human and infrastructure resources of the involved hospital can influence the decision-making of treatment. By the term "suitable hospital", we define a hospital with specialized urologists and/or operating microscope. By the term "non-suitable hospital", we define a hospital without specialized urologists and operating microscope. In the case of accidental, immediately recognized, short segment vas injury, a general or paediatric surgeon has to evaluate the proposed following options, as shown in fig. 1.

In suitable hospitals, reconstruction of the injured vas should be performed by urologists experienced in both vasectomy and vasovasostomy (VV), being ready to deal with long vas segment with the aim of magnification [59]. Annually, urologists perform significantly more VVs than general surgeons. They are also more likely to use double-layer closure and micro-

Table 1 Factors predicting the outcome of vas repair [58]

Factors		Influence
Surgical technique	• Leakproof mucosal approximation • Tension-free anastomosis • Good blood supply • Atraumatic technique	Positive
Duration of obstruction interval		Negative
Follow up of a-1-4 glucosidase semen levels*	Decreased levels	Negative
Sperm quality in proximal vas	• Sperm granuloma • Intravasal azoospermia and thick vassal fluid	Positive Negative

*a-1-4 glucosidase is a normal constituent of human semen, produced mainly in the epididymis and is significantly correlated with sperm count and sperm motility percentage. Its activity is low in cases of vas and epididymal obstruction

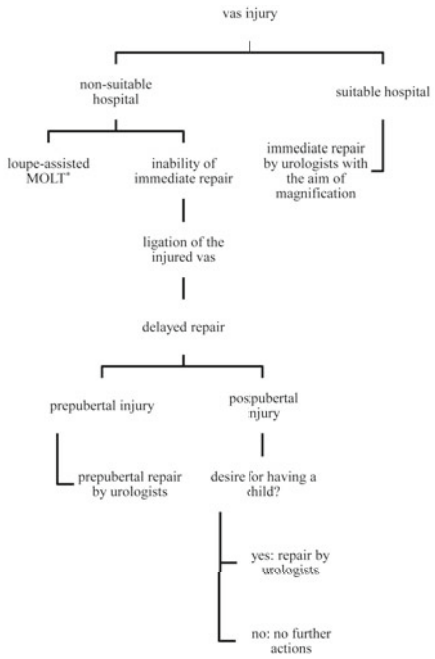

Fig.1 Proposed therapeutic algorithm for vas injury repair. *Modified One-Layer Technique

surgical techniques. Urologists reported significantly greater patency rates compared with those recorded by general surgeons, at 76% and 52% respectively [60]. Goldstein's original technique of using multiple sutures in three layers produced some of the best reported results for this surgery [61]. However, the prospect of placing eight sutures in each of the three layers is a daunting task, even for accomplished microsurgeons. This is the reason why a large number of publications describe the type of sutures used and the techniques performed, each one claiming to be easier than the other. Currently, only absorbable sutures are being used for vas injury repair, as they provide better patency rates compared to non-absorbable sutures [62]. The two main methods of microsurgical reversal are the two-layer anastomosis (TLA) and the modified one-layer anastomosis (MOLT), carrying similar results in terms of patency and pregnancy rates [63]. Both methods include placement of interrupted sutures using an operating microscope [64]. A few studies in the literature have tried to answer the question of whether or not the microscope is really necessary [65]. The authors advocate that macrosurgical loupe-assisted MOLT gives an outcome comparable with microsurgical techniques, as illustrated in table 2 [66]. Moreover, the loupe-assisted procedure combines the advantages of less skill requirements, less training, reduced operative time, less instrument requirements and consequently lower cost [67].

In non-suitable hospitals, considering the vast number of inguinal hernia repairs performed per year, a

general surgeon should have deep knowledge of all the current treatment approaches in order to repair an accidental iatrogenic vas injury [68]. Immediate repair of the injured vas can be performed by macrosurgical (with or without optical loupes) one-layer technique (OLT) or loupe-assisted MOLT. Some surgeons prefer to perform a macrosurgical OLT, which demands placement of full-thickness 6-0, 7-0 or 8-0 sutures [69]. Glick and Boulanger proposed an immediate macrosurgical OLT repair of the injured vas using two to three simple monofilament

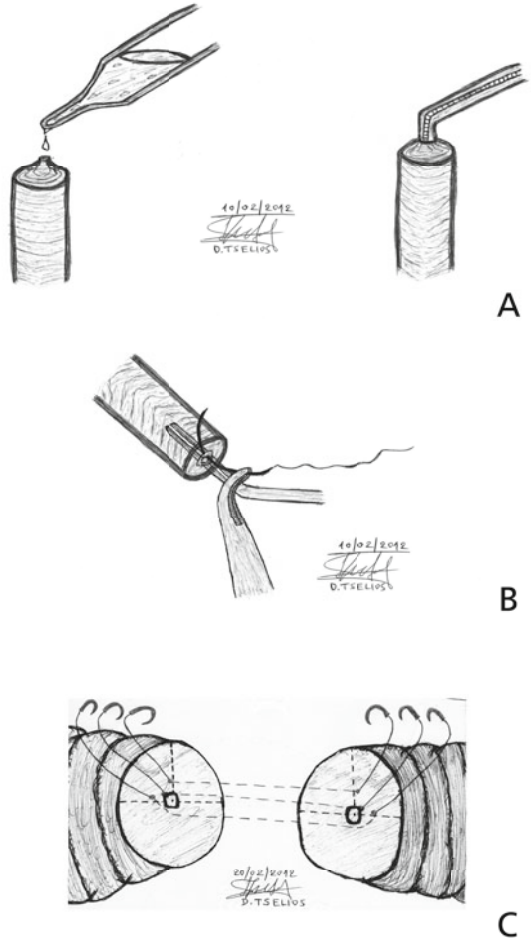

Fig.2 Loupe-assisted modified one-layer technique.

A. 1-3 ml of papaverine is dripped onto the cut ends and the lumen is gently dilated with jeweller's forceps.

B. Both cut ends are irrigated with a 25-G needle to verify patency. The blunt tip is inserted into the lumen and acts as a needle guide.

C. A first 9-0 nylon suture is passed through the entire vas wall. A second and a third 8-0 nylon seromuscular sutures are placed on each side of the 9-0 suture. This pattern is repeated for each quadrant of the anastomosis, leading to a total of 4 luminal sutures and 8 seromuscular sutures.

Table 2 The outcomes (%) of microsurgical repair and macrosurgical (with or without optical loupes) modified one -layer technique (MOLT)

REFERENCE	Microsurgical repair Patency[1] %	Macrosurgical MOLT Patency[1] %
Friedrich [73]	86 (n=141)	87 (n=64)
Hsieh [67]	91 (n=42)	89 (n=32)
Jee [68]	96[2] (n=25)	72[2] (n=25)
Portillo [74]	73 (n=22)	70 (n=25)

[1]Differences not statistically significant ($p>0.05$), [2]Differences statistically significant ($p<0.05$)

Table 3 Number of sutures needed for macrosurgical one-layer technique based on vas luminal diameter [71]

Vas luminal diameter (mm)	Number of sutures
1	4-5
1,25	5-6
1,5	6-7
1,75	7-8
2	8-9

8-0 absorbable sutures [70]. However, the number of sutures required for a watertight closure depends on the luminal diameter, in order to avoid a "dog-eared deformity" with subsequent potential leakage, as shown in table 3 [71]. The MOLT requires optical loupe for magnification. A first 9-0 nylon suture is passed through the entire vas wall. A second and a third 8-0 nylon seromuscular sutures are placed on each side of the 9-0 suture. This pattern is repeated for each quadrant of the anastomosis, leading to a total of 4 luminal sutures and 8 seromuscular sutures [72]. The MOLT is illustrated in fig. 2.

Conclusion

In the context of this paper, it is important to emphasize the three points concerning iatrogenic vas injury during inguinal hernia repair. Firstly, a vas injury identified intraoperatively in a non-suitable hospital can be immediately repaired by the specialized general surgeon. The loupe-assisted modified one-layer technique is the preferable option. Secondly, a similar injury noted intraoperatively in a suitable hospital, demands immediate repair by urologists experienced in both vasectomy and vasovasostomy, with the aim of magnification. Thirdly, a non-recognized unilateral vas injury may have bilateral effects on the male genital tract system leading to infertility. In this case, liaison with urologists is recommended because delayed detection of iatrogenic vas injuries is associ-

ated with longer defects, impaired blood supply, and longer obstructive intervals, frequently causing secondary epididymal obstruction.

Conflict of interest

The authors declare that they have no conflict of interest.

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Ιατρογενής Κάκωση του Σπερματικού Πόρου στην Αποκατάσταση της Βουβωνοκήλης

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Περίληψη

Μία από τις συχνά εκτελούμενες χειρουργικές επεμβάσεις στην ειδικότητα της γενικής χειρουργικής και της παιδοχειρουργικής είναι η χειρουργική αποκατάσταση της βουβωνοκήλης. Ανεξαρτήτως της χειρουργικής τεχνικής, μία σπάνια επιπλοκή είναι ο τραυματισμός του σπερματικού πόρου. Μια συστηματική έρευνα διεξήχθη στις παρακάτω μηχανές αναζήτησης: Pubmed, Embase, OVID, Medline, Cinahl and Google με σκοπό την ανεύρεση σχετικών άρθρων. Σκοπός του παρόντος άρθρου είναι να εφοδιάσει τους χειρουργούς που χειρουργούν στην βουβωνική χώρα, με όλες τις τρέχουσες γνώσεις σχετικά με τις συνέπειες του τραυματισμού του σπερματικού πόρου και την κατάλληλη χειρουργική αντιμετώπιση του τραυματισμένου σπερματικού πόρου. Με βάση τα αποτελέσματα της έρευνας, ο τραυματισμός του σπερματικού πόρου είναι το αποτέλεσμα διεγχειρητικών χειρισμών ή έχει σχέση με το πλέγμα που χρησιμοποιείται στην χειρουργική αποκατάσταση βουβωνοκήλης χωρίς τάση. Η συχνότητα τραυματισμού του σπερματικού πόρου κατά την αποκατάσταση βουβωνοκήλης με την ανοικτή μέθοδο αναφέρεται σε ποσοστό 0,1 - 0,53%. Οι πιο συχνές συνέπειες είναι ο σχηματισμός σπερματικού κοκκιώματος, η δυσλειτουργία του επιθηλίου της επιδιδυμίδας και του σπερματικού πόρου και η ατροφία των όρχεων. Ο μηχανισμός της αμφοτερόπλευρης ορχικής βλάβης σε περίπτωση ετερόπλευρου τραυματισμού του σπερματικού πόρου είναι το αποτέλεσμα του σχηματισμού αντισωμάτων κατά των σπερματοζωαρίων και του μηχανισμού της συμπαθητικής ορχιοπάθιας. Η υποβοηθούμενη με μεγεθυντικά γυαλιά τροποποιημένη σε ένα στρώμα αναστόμωση του τραυματισμένου σπερματικού πόρου έχει παρόμοια ποσοστά βατότητας σε σύγκριση με μικροχειρουργικές τεχνικές και επίσης συνδυάζει τα πλεονεκτήματα του μειωμένου χειρουργικού χρόνου, τις λιγότερες ανάγκες σε τεχνικό εξοπλισμό και κατά συνέπεια του μειωμένου κόστους. Συμπερασματικά η άμεση αντιμετώπιση του τραυματισμένου σπερματικού πόρου απαιτεί άριστη γνώση των συνεπειών, άριστη γνώση των νεότερων χειρουργικών τεχνικών και συνεργασία με εξειδικευμένους σε αυτόν τον τομέα ουρολόγους. Ένας αλγόριθμος θεραπευτικής αντιμετώπισης προτείνεται από τους συγγραφείς του παρόντος άρθρου.

Λέξεις κλειδιά

Τραυματισμός του σπερματικού πόρου, Χειρουργική αποκατάσταση βουβωνοκήλης, Πλέγμα από πολυπροπυλένιο, Αποφρακτική αζωοσπερμία και/ή συνδυασμός με τις λέξεις συνέπειες και θεραπεία

- Χειρουργική Κλινική, Ουρολογική Κλινική, Γενικό Νοσοκομείο Δράμας