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A review of main controversial aspects of acute testicular torsion

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ABSTRACT

Testicular torsion (TT) is a severe acute urological emergency caused by twisting of the spermatic cord. It requires prompt diagnosis and treatment. Unfortunately, its importance is still underestimated in everyday life: early-detected TT can be cured in almost every case, whereas late identification may lead to loss of the testicles. We present a comprehensive review of TT, including the aetiology, risk factors, diagnosis, treatment and outcome, based on recently published articles. The novel and the major controversial aspects of this topic are highlighted. The PubMed and ScienceDirect databases were searched with the following keywords: TT, torsion of the spermatic cord and acute scrotum, particular stress being placed on articles published in the last 5 years. The genetic aspects of TT are discussed, together with the diagnostic possibilities, such as sonography, radionuclide and fluorescent imaging techniques. The effective surgical techniques and potential drugs for reducing molecular injuries were surveyed. Finally, the major controversial aspects of TT are considered. The new concepts of TT demonstrate that certain features remain unclear. New, more accurate diagnostic tools and prompt management may contribute to a better prognosis and prevent the loss of the testicles.

1. Introduction

Testicular torsion (TT) is a urological emergency caused by twisting of the spermatic cord resulting in an interrupted blood supply and testicular ischaemia. The annual incidence of TT has been reported to be 1 among 4000 men under the age of 25[1], though recent studies found an annual incidence of 3.8–4.5 among 100000 males[1–3]. There are two peaks by age: perinatally and in pubertal life[2,4,5]. Even so, TT is not excluded in adults or elderly patients[6].

TT requires immediate recognition and therapy. It is generally agreed that irreversible changes will begin after 6 h or after only 4 h in the event of an extremely twisted spermatic cord[5,7]. Thus, time is the most critical factor in the emergency care of TT, the salvage rate and late outcome mostly depending on this[3,8–10]. The success of surgery within 4–8 h from the onset of the symptoms is around 90%–100%, but at 12 h it is 50% and after 1 day only 10%[9]. Delay can be fatal and may lead to impaired fertility and loss of the testicles.

Although the medical care of TT demands well-defined evidence because of the limited time available, there are a number of disputed questions which may prolong the management. The present review evaluates the recent results and controversial aspects of TT as concerns the aetiology, diagnosis and therapy.

The databases of PudMed and ScienceDirect were searched with the keywords: TT, torsion of the spermatic cord and acute scrotum. Particular emphasis was placed on papers published in the last 5 years.

2. Aetiology

TT is subdivided into extravaginal and intravaginal types. The aetiological factors and the age at onset differ in these subgroups.

In perinatal life, TT has few potential aetiological factors. At this age, the testicles are still descending or have descended to the scrotum, but the tunica vaginalis is not appropriately fixed to the inner scrotal layers. In this case, the spermatic cord can twist proximally to the tunica vaginalis, a situation referred to as extravaginal torsion. A long mesorchium with cryptorchism has been described in some studies as a condition which may be associated with an enhanced frequency of TT. Cases have been reported when the undescended testis was torsed and the clinical findings were presented as an incarcerated inguinal hernia[11,12].

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In pubertal or adolescent life, the TTs are known as intravaginal torsion; the most common cause is bell clapper deformity. The posterior parts of the testicles and the epididymis are normally fixed to the tunica vaginalis. In intravaginal torsion, this fixation is situated more proximally to the spermatic cord, allowing the hanging testicle to twist within the tunica vaginalis. Although the bell clapper deformity has been found to be present in 12% of the male population, the incidence of the deformity related to the torsion is much lower[13]. Bell clapper deformity has frequently been observed in the contralateral testicle. A recent study of 27 pubertal TT cases indicated that the contralateral testis was affected in 78% of the boys. In contrast, only 1 partial bell clapper deformity was found among 50 perinatal cases[14]. Another predisposing factor is the rapid increase in the testicular tissue volume, which is normal in puberty up to the age of adolescence and may occur in diseases such as malignancy[3,10].

The aetiology of TT is still not completely clear. Physical activity may lead to torsion. The most frequently reported such activity is cycling. The suspected mechanism of TT during cycling: the testicles may rotate around their axis more easily between the moving legs and the cremasteric reflex could also be activated by the physical effort or by the cold airflow[15].

Traumatic events can cause an acute scrotum with TT. This is not an infrequent condition as it affects 4%–8% of the patients. The identification of the trauma caused by TT is quite difficult, because a wounded scrotum or haematoma could mislead the examiner. The survival rate of traumatic TT is around 40%. The most important factor is time as in other torsions[16].

The possible inheritance of TT remains unclear, though there are suspected elements of a genetic origin, such as the insulin-like 3 hormone and its receptor, Rxlf2. In humans, the exact role of these factors is still unknown, though cryptorchism and intraabdominal TT have been described in insulin-like 3 knockout mice[3,17]. Numerous cases of familial torsion have been described and the urologist should therefore always consider a potential familial origin[3,18]. A study of 70 boys with TT revealed a positive paternal history of TT in 11.4% of the cases. One family presented a positive history through 3 generations[19]. It is suggested that the family history should be examined and the patient or his parents should be informed about the possibility of further torsion in the family. A close follow-up is also recommended in these cases[19,20].

The interesting theory has been put forward that the weather conditions may influence the incidence of TT. Some authors have described a significantly higher number of TT cases during the colder months. It is hypothesized that at low temperature the cremasteric muscle fibres contract asymmetrically[21–23]. In contrast, certain authors observed no significant difference in the seasonal incidence of TT[3,24].

3. Pathophysiology

During TT, the spermatic cord and the testicle twist around its axis, leading to blockade of the blood supply, followed by ischaemia and necrosis.

Sessions *et al.* conducted retrospective examinations of 186 boys with TT who underwent surgical exploration[25]. About 52% left and 48% right-sided torsions were found. About 162 torsions were evaluated in terms of the direction and the degree of the torsions. Historically inward torsions were generally accepted, but the study revealed outward torsion in 33% of the cases. The torsion range was between 180 and 1 080°, with a median of 540° in the orchiectomy cases (38%) and 360° in the patients with salvaged testes (62%)[25].

Intermittent and permanent TT can be distinguished. In intermittent TT, the spermatic cord twists around its axis to cause symptoms, but later reverts spontaneously to the original position, ensuring the normal blood flow. Repeated intermittent episodes may cause chronic ischaemic injury, which leads to the impairment of testicular functions such as spermatogenesis and hormone production. Hayn *et al.* concluded that intermittent TT with elective bilateral testicular fixation can preserve the testicles and may prevent the risk of acute testicular infarction[26].

4. Diagnosis and differential diagnosis

4.1. Medical history and physical examination

Depending on the time that has passed from the onset of the symptoms, acute (0–24 h), subacute (1–10 days) and chronic (more than 10 days) TT are distinguished[27].

Patients with acute TT usually present with sudden asymmetric scrotal symptoms, such as a painful, erythematous, swollen scrotum, and systemic signs of fever, nausea and vomiting. The condition may also be associated with urinary or abdominal complaints[5,9].

On physical examination, the common suspicious findings are a positive Prehn's sign (when elevation does not decrease the pain in the affected testicle), a high-riding and horizontally positioned testis (Brunzel's sign) or retraction of the scrotal skin (Ger's sign)[9,27,28]. The latter is usually present in the bell clapper deformity. The absence of a cremasteric reflex is an almost certain sensitive sign of TT[29]. The specificity is only 66%, because this sign can occur in many other diseases[30]. However, in a few cases TT appears with a preserved cremasteric reflex[31,32].

The suspected diagnosis of torsion should be based on the history of the present illness, the symptoms and the physical examination. There are many diseases which can mimic the symptoms. TT is found in 10%–54% of the cases that present with an acute scrotum. The range is wide, because it mostly depends on the way in which the patients are selected[4,5,7,9,32,33]. The other two most common diagnoses are torsion of the appendix testis (TAT) (14%–67%) and epididymo-orchitis (EO) (5%–62%)[4,7,32,33]. Although the complaints and symptoms are usually similar, there are also differences. In the event of a twisting appendix, the necrotic appendix can be observed through the scrotum; this is called the blue dot sign. It is often present at an earlier age than in the case of TT[4,8,9]. In EO, the main complaint is tenderness, due to the inflammation. Most cases present after puberty, when the patients are sexually active, though it can be caused at an earlier age by anatomical disorders of the genitourinary tract[5,9].

In general, since the symptoms may be similar, the differential diagnosis is not possible only the basis of the medical history alone. However, there are certain conditions which present more common in the possible underlying disease. Fever usually occurs in EO, a history of trauma is more common in TAT and nausea is more characteristic of TT. The symptoms appear significantly earlier in TT than in EO or TAT[4,5,9].

Physical examination may facilitate the differential diagnosis, despite the fact that every underlying disease presents as an acute scrotum. The blue dot sign and isolated tenderness of the

upper pole are usually detected in TAT. An abnormal testicular lie, tenderness and absence of the cremasteric reflex are characteristic of TT. In EO, scrotal oedema and epididymal tenderness are more common[4,9,33].

The literature offers many other potential diagnoses as concerns acute scrotum, *e.g.* hydrocele, haematocele, varicocele, scrotal hernia, tumours and trauma[8–10]. Otherwise, TT can be considered in cases of systemic symptoms such as lower abdominal pain and nausea or vomiting[34]. Naturally, there are a few rare, but interesting cases in the literature which led to acute scrotum, such as filariasis, Henoch-Schönlein purpura, idiopathic scrotal oedema or even appendicitis[35–38]. In view of the many other possible causes of acute scrotum, physical examination and the medical history are not sufficient to establish a certain diagnosis[39].

4.2. Urine analysis

The urine test with a stick is a fast and easy method to exclude potential infectious diseases during the differential diagnosis. EO could give a positive result, which is normal in TT. A urine culture could also be positive in EO, but this takes more time and is therefore not recommended as a routine diagnostic approach[4,7].

4.3. Imaging techniques

In spite of the normal grey scale ultrasonography does not safely identify TT in the early phase as the echogenicity could be normal; there are many possible signs of TT, such as an abnormal testicular or epididymal position, enlargement of the testicle, scrotal wall thickening or additional hydrocele[27,40]. In the late period, an inhomogeneous testicular echotexture may be detected, which always means the necessity of orchiectomy, because of the testicular infarction[41].

The most widely used diagnostic method for TT in current clinical practice is colour Doppler ultrasound (CDUS) imaging, which has 63%–99% sensitivity and 97%–100% specificity[4,9,42,43]. The blood flow in the spermatic cord or the microcirculation of the testis may be visualized by CDUS. Especially in a twisted spermatic cord, the whirlpool sign may be seen[44]. The pitfalls of CDUS are that the findings can depend on the experience of the technician and there are a number of circumstances which may mislead the diagnostician. A false CDUS signal can be present in the prepubertal testis, where the normal vascularity has not yet developed or there could be an elevated volume of paratesticular blood flow from the communicating vessels. During the first stage of TT, hyperaemia and venous dilatation may also be seen. In the event of suspected TT, the CDUS findings on the ipsilateral testis must be compared with the contralateral picture[42].

Kalfa *et al.* published a multicentre assessment involving 919 patients with acute scrotum[45]. In all cases, CDUS and high-resolution ultrasonography (HRUS) were performed. Loss of the intratesticular blood flow was found in only 158 (76%) of 208 surgically verified TT cases. In contrast, a twisted spermatic cord was detected by HRUS in 199 (96%) of the 208 TT cases, while the remaining 711 cases yielded a normal finding with a specificity of 99%[45].

Contrast-enhanced ultrasonography provides better visualization than that with normal CDUS, especially in the cases with smaller testicles, such as neonates. It can also be highly sensitive in initial testicular infarction[42,46].

Dynamic contrast-enhancement magnetic resonance imaging (MRI) has high resolution and is more sensitive for the diagnosis of TT, with the ability to differentiate it from other acute scrotal diseases. Its disadvantages are that it is dye-dependent, not widely available and expensive. In most cases, there is no time for delay by performing MRI and evaluating the results. Thus, MRI is not one of the first-line diagnostic options[47].

Scrotal scintigraphy, another way to detect TT, makes use of an intravenous ^{99m}Tc-pertechnetate radionuclide dye to depict the blood supply abnormalities. The absence of testicular microcirculation is visualized as cold spots. Scintigraphy is more sensitive in the early phase of TT than in the late period, because the late hyperperfusion can give a false-positive signal. The disadvantages are the higher costs, the longer management and the potentially harmful radiation[7,48].

Near-infrared spectroscopy (NIRS) is a comparatively novel diagnostic tool, with which the level of tissue oxygenation and the blood flow condition can be measured. Calculations are performed with the concentrations of oxygenated and deoxygenated haemoglobin and the total amount of haemoglobin. Its advantage is that it is non-invasive, but NIRS is not yet readily accessible and is still more expensive than CDUS[49]. The near-infrared fluorescence technique visualizes the blood flow with the intravenous green dye indocyanine. It proved successful in localizing the strangulation in a rat model and provided high sensitivity in the detection of TT. Hopefully, in the future these methods will become widespread and cost-effective in order to improve the efficiency in the diagnosis of TT[50].

Bajory *et al.* described the diagnostic use of orthogonal polarization spectral (OPS) imaging for evaluation of the microcirculation after TT in a rat model[51]. This makes the use of biologically inert polarized light to assess the testicular microcirculation. There was no significant difference in efficiency as compared with fluorescence intravital video microscopy. The major advantages of OPS are the compact size and fluorescent dye-free imaging. OPS is an optimum diagnostic tool at the bedside, in emergency care or even in the theatre[51] (Figure 1).

The main controversy relates to the choice between acute surgical exploration and sonography. Although surgical exploration provides a certain diagnosis of TT and allows rapid

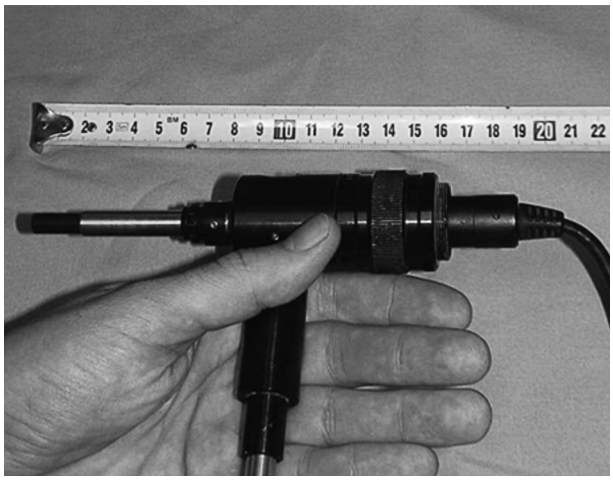

Figure 1. The handheld head of the OPS imaging instrument (Cytoscan A/R).

intervention, in non-TT cases it may lead to numerous unnecessary operations. Some authors suggest that in cases presenting with acute scrotum, a prompt diagnosis should be made by physical examination and history-taking and this should be followed by urgent surgical exploration, hesitancy possibly leading to testicular loss[32,52]. In comparison, others recommended that besides the history-taking and physical examination, an imaging procedure, such as CDUS or HRUS, is essential[45,53,54]. Unfortunately, a false-negative CDUS finding does not exclude TT; thus, when the history-taking and physical examination are suggestive of TT, rapid surgical exploration should be undertaken without delay[54,55].

5. Treatment

5.1. Perinatal cases

The treatment of perinatal TT still is a controversial area of urology. Prenatal TT still appears to be unsalvageable, because of the poor recognition, the absence of symptoms and the limited options for treatment[7,56]. Nonetheless, neonatal TT is salvageable, with a success rate of 21.7% or even up to 50% whereas others have reported poor success rates, particularly in the experience of Kaplan and Silber[56–58]. Synchronous bilateral TT is a rare finding, but requires urgent exploration[3,56]. The main controversy is the timing of the surgery in cases of unilateral or synchronous bilateral perinatal TT. Some authors have suggested postponed surgical exploration, because of the danger of anaesthetics in neonates[59,60]. Regardless of the potential complications such as hydrocele or infections[59], some authors suggest early surgery[56,57,61]. There are many surgical options such as bilateral orchiopexy or ipsilateral orchiectomy, but the most common procedure is ipsilateral orchiectomy combined with contralateral orchiopexy. This prevents later TT and atrophy of the contralateral testis[3,7,56,57,59,61]. Unfortunately, in many cases testicular salvage is not possible, due to the delayed recognition. The responsibility of the parents is extremely important, because an early diagnosis and immediate exploration can possibly save the testis[11].

5.2. Pubertal and adolescent cases

In puberty or adolescence, TT is probably curable if detected early and with prompt management. Manual detorsion is recommended by some authors as a fast, easy and non-invasive solution[7,62]. It may be performed with or without anaesthesia or analgesics. Use of these materials before manual detorsion is unfavourable, because the sign of success is an immediate asymptomatic, painless scrotum. Anaesthetics or analgesia may mislead the doctor while the testis remains in a twisted position. When there are other disorders in the background (*e.g.* TAT or EO), the symptoms will continue[62]. However, analgesics or anaesthetics are suggested by some authors, from the aspects of improved compliance and an enhancement of the efficiency of detorsion through relaxation of the cremasteric muscle[9].

In most cases of TT, the testicles twist inwards and detorsion should therefore be performed outwards, like opening a book. In one-third of TT case, the testicles twist in a lateral direction[25]. If manual detorsion can be performed successfully, the affected testis goes down within the scrotum[8].

The danger of manual detorsion is the residual TT due to incomplete untwisting of the testicle. This is possible because the range of torsion varies extensively, from 180 up to 1 080°. Sessions *et al.* described a residual TT of 32% after a manual manoeuvre[25].

The choice of the more appropriate solution between manual and surgical detorsion remains controversial. Some authors suggest urgent exploration and some prefer the non-invasive techniques and elective surgery. Naturally, many choices depend on the severity of the symptoms and the time factor, though the experience of the doctor with manual detorsion is the most important point. If manual detorsion cannot be performed, urgent exploration must be undertaken to avoid the loss of testicle. Nevertheless, manual detorsion can in no way replace orchiopexy. After successful manual detorsion, elective bilateral orchiopexy is very important to prevent further TT[7,9,62].

5.3. Orchiopexy

Orchiopexy, fixation of the testicle to the inner scrotal wall, can prevent further TT. Contralateral orchiopexy is suggested by most authors, because the bell clapper deformity is usually present in the contralateral testicle. The literature offers various options for orchiopexy[7–9,14,63].

One group of surgical methods involve the tunica albuginea. During some procedures, sutures are made through the tunica albuginea to create a fixation point to the median septum or the lateral or inferior scrotal wall[64,65]. In another procedure, the tunica vaginalis layer is fenestrated to produce a strong adhesion between the tunica albuginea and the inner scrotal wall[66]. Antao *et al.* recently described an axial fixation technique[65]. They considered that the retorsion after earlier orchiopexy is caused by suture insufficiency. They therefore performed a circular continuous suture with non-absorbable thread longitudinally in the tunica albuginea of both testicles and the upper and lower parts of the median septum. Hence, four fixation points are created, in contrast with other procedures[65].

Some authors consider that suturing through the tunica albuginea can lead to a greater incidence of spermatogenesis disorder[67]. Higher levels of anti-sperm antibodies were detected in animal studies where the blood-testis barrier was wounded[68,69].

In another group, the surgical techniques are performed without suturing of the tunica albuginea. By means of a subcutaneous dartos pouch, the testicles are fixed in an extravaginal position[70,71]. In the course of the Jaboulay repair, the tunica vaginalis is everted, which leads to adhesion between the testicular integuments[72]. Mazaris *et al.* recently described a novel technique for the fixation of the testicles to the dartos fascia[68]. The everted parietal layer of the tunica vaginalis is sutured continuously with absorbable thread and the testicle is fixed to the dartos fascia through this everted part by three non-absorbable sutures. The three-point fixation gives a better long-lasting connection[68].

An interesting case discussion was published about a patient with a single testis and a 720-degree TT for 9 h after the onset of the symptoms. In spite of the fact that the testicle subjectively appeared dead, orchiopexy was carried out. Normal levels of testosterone and a normal intratesticular blood flow were detected at 4 and 12 weeks. A cryopreserved semen specimen (50 h after surgery) subsequently was proved normal. The main conclusion is that there is a chance for salvage even if the testicle subjectively appears dead[73].

Kutikov *et al.* described reperfusion after detorsion necessitated by a localized compartment syndrome[74]. Hypoxia or a great volume of blood flow caused oedema in the testicle. The tunica albuginea did not allow enlargement of the testicular tissue and the oedema was therefore associated with an elevated intracompartmental pressure and a decreased microcirculation. In the testicular compartment syndrome, the decreasing viability of the testicle correlates with the elapsed time. In this study, a window was made through the tunica albuginea (a process known as testicular fasciotomy) after detorsion. The intracompartmental pressure decreased dramatically and the colour of the testicle became normal. This window was later closed and the pressure and the colour of the testicle then returned to those under the previous conditions. This demonstrated that both the ischaemic and the hyperaemic effects can lead to the compartment syndrome. With testicular fasciotomy, all of the reported testicles (n = 3) were preserved after a duration of ischaemia for 6 h[74].

Figueroa *et al.* described that the rate of testicular salvage following surgical detorsion was better after fasciotomy combined with tunica vaginalis flap coverage[75]. Among 59 patients, the rate of orchiectomy was 35.9% before and 15% after this procedure. Fasciotomy and flap coverage were suggested by the authors in cases of clinically marginal TT[75].

5.4. Orchiectomy

An unsalvageable and necrotic testis must be removed surgically. Orchiectomy is the final option in the management of TT, but it is then a real exigency. Unfortunately, many patients are observed with late symptoms, presumably with little or no possibility of therapy[5,9]. In recent studies, orchiectomy was performed in 31.9%–41.9% of the cases of surgically treated TT[2,24]. The decision to perform orchiectomy must always be based on the actual condition of the testicle and detorsion should first be performed to be sure that the testicle is unsalvageable[73].

After orchiectomy, the urologist must consider the patient's self-image. For most men, it is hard to live without a testicle and this may cause psychological problems. Testicular prosthesis implantation may help to restore the impaired self-esteem. In general, there are many indications of a testicular prosthesis replacement. About 25% of the procedures are performed because of previous orchiectomy after TT. After replacement, 68%–91% of the patients were satisfied with their prosthesis and their body image[76].

The most important factor is time, but the right choice between orchiopexy and orchiectomy must always be based on the individual personal condition of the patient. When there is a chance to salvage the affected testis, an attempt should be made to preserve it.

5.5. Drugs and other attempts

During TT and following detorsion, the testes may suffer ischaemic/reperfusion injury. These conditions are mostly dependent on the balance between reactive oxygen species (ROS) and anti-oxidant defence mechanisms. Naturally, many other components may be involved in this complex process, *e.g.* the leukocytes, the complement system and the increased vascular permeability. ROS are produced during hypoxia and may damage the tissues by oxidation of the cell membrane lipids, proteins and even the DNA. Under normal conditions, the human body can eliminate ROS through anti-oxidant defence mechanisms. During TT, the balance between ROS and defending mechanism is disrupted, which may influence the cell viability, hormone production and spermatogenesis. The main harmful effect of reperfusion is the acceleration of apoptosis[77,78]. The interesting paradox has been described that TT-related ischaemia harms the contralateral testis too in a rat model[79].

Many potential drugs and chemicals have been successfully tested in animal models to reduce the ischaemia/reperfusion damage during TT, *e.g.* a selective endothelin-a receptor inhibitor, apocynin, nifedipine, phosphodiesterase type 5 inhibitors, coenzyme Q10, lycopene, ginkgo biloba, rosuvastatin or tyrosine kinase inhibitors[80–88]. Hyperbaric oxygen and external scrotal cooling can reduce the severity of the injury[89,90]. These positive results demonstrate the potential role of anti-inflammatory drugs in the treatment of TT in the future. Unfortunately, such attempts have not proved successfully in humans to date.

A recently published experimental study evaluated the effectiveness of electroacupuncture (EA) in changing the blood flow in a 180° TT rat model. A total of 10 Hz EA was used over T13 and L4 dermatomes for 5 min and the testicular circulation was observed by CDUS. Significantly better blood flow was detected in both the ipsilateral and contralateral testicles in the EA group. EA may be suitable in combination with medication or surgical treatment in the future[91].

6. Late impact

Testicular atrophy was observed after adequate surgical treatment in 25% of the cases. Moritoki *et al.* described that the intratesticular pressure increased during torsion and decreased following detorsion[92]. The inadequate intratesticular pressure after detorsion was correlated with the impaired subsequent spermatogenesis in a rat model. It provides a preliminary outcome concerning testicular viability and facilitates the decision relating to orchiectomy during the first exploration[92].

TT and further orchiopexy or orchiectomy may influence male fertility. Merely 0.5% of infertile patients have a positive history of TT and TT has only a low impact on worsening fertility data. Some authors earlier reported poor results of semen analysis after TT[3]. Recent articles described no significant dissimilarity in sperm motility and sperm count, though irregular sperm morphology and a higher level of anti-sperm antibody were observed[73,93]. Hormonal levels were also evaluated and normal testosterone, follicle stimulating hormone and luteinizing hormone concentrations were found[73,94]. The level of inhibin B was decreased after TT relative to that in the control group[94].

7. Discussion

TT is a real urological emergency, encountered mainly in young males. It may be associated with a high risk of infertility and it therefore demands prompt and urgent treatment, without any delay. In contrast, there are still several unsettled debates, mostly about the diagnosis and the treatment of TT. After the diagnosis of TT, urgent treatment is needed to save the affected testicle. Despite attempts with many other tissue-protective and

ischaemic/reperfusion injury-limiting drugs or other approaches, the only permanent treatment option is surgical intervention, which can be an elective or emergency exploration. Are there new concepts in the aetiology? Are the physical examination and relevant history-taking sufficient to exclude other possible causes of an acute scrotum? Are diagnostic examinations, such as CDUS or radionuclide imaging, vital before urgent surgical exploration? What is the place of manual detorsion in the treatment of TT? What are the novel treatment options? These are only a few of the questions that have arisen as concerns the controversial aspects of TT.

A new concept of the aetiology is the relation to the genes. Certain suspected genetic disorders may be associated with TT[3]. Many cases have been published involving the frequent incidence of TT in the same family through generations[3,18–20]. Unfortunately, none of these mutations have been proven definitely to be responsible.

The role of the weather is still uncertain. In spite of the fact that thousands of cases have been investigated worldwide, it is not completely clear whether the weather conditions have an impact on TT or not[3,21,22,24,32]. A comprehensive worldwide study appears necessary to investigate the seasonal influence on TT, including regional variability, race, atmospheric temperature and humidity.

Although some symptoms are observed more frequently in acute scrotum, there is no evidence to exclude any disease on the basis of the medical history or physical examination. The various causes of acute scrotum can all mimic each other and each of the symptoms can be absent or present in any condition[39]. Unfortunately, grey-scale sonography and even CDUS cannot establish a 100% correct diagnosis either[41,42]. The reviewed literature indicates that if any uncertain finding is detected by an imaging technique, the patient must be converted to urgent surgical exploration[54,55]. Scintigraphy, MRI, near-infrared fluorescence, NIRS and OPS display good, but not 100% diagnostic efficiency for TT and the first three are dye-dependent and the last three are not widely available[47–51]. Hopefully, these imaging techniques will become more generally accessible in the near future.

Some authors have described a very good success rate of manual detorsion[62]. Nevertheless, manual detorsion can only be a temporary solution, because postponed orchiopexy is mandatory after TT. If the doctor does not possess sufficient experience with manual detorsion, wasting time with unsuccessful attempts is forbidden[7,9].

Protection of the tunica albuginea during orchiopexy is suggested. Injuries can lead to impairing the spermatogenesis of contralateral testicle[69]. A number of novel surgical techniques have been described which prevent the recurrence of TT, such as the four-point axial fixation and testicular fasciotomy combined with tunica vaginalis flap coverage[65,75]. Numerous drugs and chemicals have been described in recent years[80–88]. These successfully reduced ischaemic/reperfusion injuries in animal models and would be drugs of great potential for humans in the future, but human studies are first needed. Promising animal studies have additionally been performed with EA, external scrotal cooling and hyperbaric oxygen therapy[89–91].

Conflict of interest statement

The authors report no conflict of interest.

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