Original Article

Holmium: Yttrium-aluminum-garnet laser for endoscopic decompression of ureterocele in the first months of life: A comparison with electrosurgery

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ABSTRACT

Introduction: Few case series report the use of holmium: yttrium-aluminum-garnet (Ho:YAG) laser to decompress ureterocele (UC) in pediatric population, and only two studies compared its outcomes with electrosurgery. This study aims to compare outcomes of Ho:YAG laser transurethral endoscopic puncture (TUP) versus electrosurgery TUP of UC in the 1st month of life, analyzing incidence of secondary surgery, redo TUP, and iatrogenic vesicoureteral reflux (VUR).
Patients and Methods: A retrospective study of patients treated by TUP of UC from 2008 to 2017 was performed. Those undergoing Ho:YAG laser TUP were included in Group A, those undergoing electrocautery TUP were included in Group B. Data were compared using Fisher's exact test.
Results: Group A included seven patients (mean follow-up 4 years). Two required a redo TUP. Two had preoperative VUR, which resolved after TUP. Two developed VUR after TUP, which resolved spontaneously. No secondary surgery was required. Group B included nine patients (mean follow-up: 9.5 years). One required a redo TUP. Preoperative VUR was detected in 4/9 and persisted after TUP in 2. Three developed post-TUP VUR, which persisted. Five required further surgery because of persistent and symptomatic VUR. Secondary surgery was significantly lower after Ho:YAG laser compared to electrocautery TUP ($P < 0.05$). The incidences of both redo TUP and postoperative VUR were not significantly different between the two groups (P = ns).
Conclusion: Ho:YAG laser TUP seems to be safe and effective in the decompression of obstructive UCs and maybe advantageous over electrocautery puncture. However, further studies with larger cohort are needed to corroborate our preliminary results.

INTRODUCTION

A prompt, minimally-invasive treatment in the 1st months of life is the current approach in patients diagnosed with obstructive ureterocele (UC).[1-4] Transurethral endoscopic decompression of UC can be performed by several techniques, according to experience and preference. While electrosurgery has been traditionally used, a recent technological advance consists in the use of laser, namely holmium: yttrium-aluminum-garnet (Ho:YAG) laser. It has been reported to be effective, accurate, versatile, and safe, especially in the young infant period.[5-7] In literature there are just a few case-series and two comparative studies.[5-10] However, these reports are inconsistent regarding inclusion criteria and operative techniques, while outcomes seem similar to those achieved with electrocautery decompression.

Based on the scientific evidence and clinical experience, it was hypothesized that Ho:YAG laser is highly-effective

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for the decompression of UC and as ultimate treatment for this uropathy. To test this hypothesis, the primary aim of the study was to compare outcomes of Ho:YAG laser transurethral endoscopic puncture (TUP) of UC versus conventional electrocautery TUP, analyzing incidence of secondary surgery, redo TUP, and iatrogenic vesicoureteral reflux (VUR) in the young pediatric population.

PATIENTS AND METHODS

This was a retrospective study, conducted at the pediatric surgery operative unit of the "Spirito Santo" Hospital of Pescara, Italy. After IRB approval, we reviewed the charts of all patients diagnosed with UC over a period of 10 years (2008–2017). Only patients followed since birth at our operative unit and treated with TUP as primary procedure in the 1st months of life were included in the study population.

All patients underwent renal and bladder ultrasound (US) and voiding cystourethrography (VCUG) or voiding urosonography (VUS) before TUP [Figure 1]. VUS was reserved only in those female patients with a single-system UCs. Renal scintigraphy was performed either before or after TUP, according to patient's age. Antibiotic prophylaxis was used in patients with Society for Fetal Urology hydronephrosis grade ≥3[11] or in presence of VUR.

TUP was performed under general anesthesia and conducted throughout a 9.5 Fr cystoscope. Before 2012, TUP was performed with a conventional electrocautery 3Fr catheter, puncturing the UC wall. In case of intravesical UCs, the puncture was made just above the junction of the UC and the bladder floor. For ectopic UCs, a puncture was carried out on the intravesical portion of the UC, just above the bladder neck. In 2012 we started to perform TUP with this Ho:YAG laser, at the setting of 6–8 Hz of frequency and 0.6–0.8 J of pulse energy. We used 200 μm laser fibers in the first patient, then we switched to 550 μm. Multiple punctures on the UC walls were made (4 to 8) until complete decompression was achieved.

In postoperative period all patients received antibiotic prophylaxis. Follow-up included: periodic US; VCUG or VUS at 3 months follow-up and afterwards in case of persistent or *de novo* VUR [Figure 2]; MAG-3 renal scan, performed in case of persistent high-grade hydronephrosis. Patients without an adequate UC and upper tract decompression (i.e., UC and/or upper tract dilatation >10 mm at US follow-up) underwent repeat TUP. The major criteria for secondary surgery were: increasing hydronephrosis due to inadequate UC decompression, with persistent obstructive pattern at renogram, recurrent febrile urinary tract infections (UTIs), persistence of high-grade preoperative VUR, development and persistence of high-grade iatrogenic VUR and/or loss of renal function.

All patients treated with Ho:YAG laser TUP (from 2012 to 2017) were included in Group A. All patients treated with conventional electrocautery TUP (from 2008 to 2012) were included in Group B. Statistical analysis was done with Fisher's 2-tailed exact test with $P < 0.05$ considered significant. Groups were compared regarding the need of a second surgery, the need of a repeat TUP, and the incidence of *de novo* VUR.

RESULTS

Group A included seven patients, all females and with a prenatal diagnosis of hydronephrosis. The preoperative

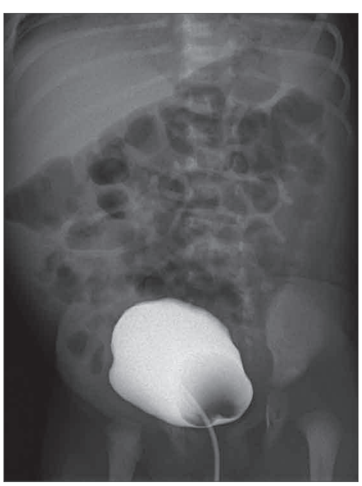

Figure 1: Voiding cystourethrography before transurethral endoscopic puncture. Evidence of ectopic left ureterocele in a female patient with ipsilateral duplex system. No vesico-ureteral reflux detected

Figure 2: Voiding cystourethrography posttransurethral endoscopic puncture. Same patient of Figure 1. No evidence of the ectopic left ureterocele. No vesico-ureteral reflux detected

characteristics of patients are outlined in Table 1. Mean age at Ho:YAG laser TUP was 92 days (range 17–160 days). Two of seven patients (29%) required repeat TUP due to persistent UC distention and hydronephrosis, which resolved after the second endoscopic procedure. None developed postoperative UTIs. In two patients with preoperative VUR (one Grade 3 contra-lateral VUR and one Grade 5 VUR in duplex system and ectopic UC), spontaneous resolution after TUP occurred. Two patients, both with duplex system and ectopic UC, developed iatrogenic Grade 3 VUR in the punctured moiety, which resolved spontaneously. Thus, all patients were in a VUR-free status at a mean follow-up of 4 years (range 2–7 years). None of the patients required secondary surgery (0/7 cases, 0%).

Group B included nine patients, 3 males and 6 females, all with a prenatal diagnosis of hydronephrosis. Preoperative characteristics of patients are outlined in Table 1. Mean age at TUP was 37 days (range 7–111 days). One patient required a further TUP due to persistent UC distention and hydronephrosis. It was resolved after the second endoscopic procedure. Preoperative VUR, detected in 4 of nine patients (one Grade 4 and two cases with Grade 5 VUR in duplex system and ectopic UC, one Grade 5 contralateral VUR), spontaneously resolved after TUP in 2. Three patients developed iatrogenic VUR in the treated moiety (one Grade 3, one Grade 4, and one case with Grade 5 VUR, all with duplex system and ectopic UC), which persisted during follow-up. The mean follow-up was of 9.5 years (range –11 years). TUP was the only treatment in 4 of nine patients (44.4%). The remaining five patients (55.6%) underwent further surgery. The reasons that led to secondary surgery were the recurrence of UTIs associated with persistent VUR (*de novo* VUR in three patients and persistent preoperative VUR in 2. Secondary surgery consisted of ureterocelectomy, repair of bladder floor and cross-trigonal ureteroneocystostomy in all patients. In one of these 5, heminephrectomy of a nonfunctioning upper moiety was also performed.

The postoperative characteristics of groups A and B are outlined in Table 2. Comparing groups, secondary surgery after TUP was required in 0 out of 7 (0%) versus 5 out of 9 (55.6%) patients in Groups A and B, respectively, which was statistically significant ($P < 0.05$). The incidence of a repeat TUP seemed to be superior in Group A (2 out of seven patients, 29%) compared to Group B (1 out of nine patients, 11%), even if it was not statistically significant (P = ns). *De novo* VUR persisted in 0 out of 7 (0%) versus 3 out of 9 (33.3%) patients in Groups A and B, respectively, which was not significant (P = ns).

DISCUSSION

TUP is an accepted, minimally invasive option to achieve a prompt decompression of UC. Electrosurgery has been traditionally used, with good decompression rates but a significant risk of developing iatrogenic VUR in the punctured/incised moiety (20%–50%).[1-4,12,13]

Laser application in pediatric urology includes patients with PUV, UC, urethral strictures, and urolithiasis.[5-8,10,14-20] An important challenge in the use of Ho:YAG laser was its application to neonates. Jankowski and Palmer were the first to report the use of this procedure in newborns in 2006,[5] followed by Pagano *et al.* in 2015.[6] Although the small populations (12 patients in total) and the inconsistent decompression techniques, these papers point out the main advantages of the use of laser fibers in the neonate. As we have already reported,[21] the small caliber of laser fibers, which can fit well through the working channels of the instruments and still allow for some irrigation flow.[6] In Pagano's series small laser fiber (200 μm) were used to decompress UC in newborns. Jankowski and Palmer used larger fibers (365 or 550 μm) except in one case (200 μm).[5] The only one failed attempt at decompression occurred using the smaller laser fiber, which was then successfully decompressed with a 550 μm fiber. As the size of the laser fiber has a direct correlation with the puncture size, this may explain why retreatment was required in the only patient treated with the smaller fiber.[5] We also used 200 μm fiber to puncture the first patient and we needed to do a redo TUP because of incomplete UC decompression. As a result, we switched to 550 μm fiber

Table 1: Preoperative characteristics of patients

Preoperative characteristics	Group A (*n*=7)	Group B (*n*=9)
Gender		
Male	0	3
Female	7	6
System		
SS	2	0
DS	5	9
UC location		
Intravesical	2	3
Ectopic	5	6
VUR at presentation		
Yes	2	4
No	5	5

SS=Single system, DS=Duplex system, UC=Ureterocele, VUR=Vesico-ureteral reflux

Table 2: Postoperative characteristics of patients

Postoperative characteristics (evolution after TUP of UC)	Group A (*n*=7)	Group B (*n*=9)
Preoperative VUR	2	4
Spontaneously resolved	2	2
Persistent	0	2
De novo VUR	2	3
Spontaneously resolved	2	0
Persistent, high grade (IV–V)	0	3
Only TUP intervention (including need of second look)	7	4
Re-do TUP	2	1
Secondary surgery	0	5

TUP=Transurethral endoscopic puncture, UC=Ureterocele, VUR=Vesico-ureteral reflux for the following cases, achieving very good outcomes regarding decompression rates (5/6 patients, with only 1 case requiring a second look). The only other study reporting the use of laser to decompress UC in newborns is that of Ilic *et al.*[7] Their population included ten neonates with intravesical UC. They made several punctures (4–8), until UCs collapsed. There were no complications during the procedures, and there was need for re-treatment only in 1/10. Authors concluded that Ho:YAG laser fenestration is minimally invasive, highly effective, and safe treatment for UC in the neonatal period, with minimal complication rates.

The second advantage is the energy supplied by the laser. It vaporizes the treated tissue rather than cauterizing, incising, or puncturing the tissue as performed with electrocautery, stylet, and cold knife incision, respectively. This may allow for the small incision or puncture made by the laser not to reseal compared with the other conventional techniques.[5]

Another advantage of laser fibers is the lack of thermal effect beyond the incision site compared with electrosurgery. This allows for precise puncture of the UC and if necessary, multiple, small punctures can be made rather than one comparably large puncture with the Bugbee electrode.[5] In our opinion, multiple small punctures with a laser fiber result in adequate drainage outlet for the obstructive UC, with a decreased possibility of *de novo* VUR into the ipsilateral renal unit. Jankowski and Palmer did not observe any case of *de novo* VUR after laser TUP.[5] Our results are comparable, as *de novo* VUR was only a transient phenomenon, with complete spontaneous resolution.

One of the major issues affecting outcomes is the preoperative VUR. It is well known as UC may distort and bend the lower pole ureteral orifice and/or the contralateral ureteral orifice, leading to VUR. As a matter of fact, VUR is reported as associated to UC in duplex systems in 50% on the ipsilateral side and on <20% on the contralateral side.[22] Therefore, management of VUR into the ipsilateral lower pole or contralateral renal unit must also be considered. In addition, VUR that is created by endoscopic decompression of the UC has the potential to further complicate management. In effect, there is still concern about new onset or worsening of reflux after primary puncture. Some evidence suggests that endoscopic puncture may be used irrespective of the presence of reflux, and that minimally invasive techniques may be used to treat children with VUR either inherent to a duplex system or resulting from previous endoscopic puncture.[21] However, as also reported in our experience, VUR after puncture can be also managed conservatively because it tends to disappear.[23]

Outcomes regarding laser decompression of UC could also be affected by the operative technique, namely single or multiple punctures, or incision. As previously stated, the endoscopic technique we performed with the assistance of Ho:YAG laser consisted in making multiple punctures on the UC wall (4–8). On the other hand, both Marr and Pagano performed a single laser incision on the UC wall.[6,8] Another technique to decompress UC is the one called "watering can" puncture (WCP), in which multiple punctures, 10–20, are done on the UC wall, creating a watering-can appearance, until stable decompression is obtained. It was first introduced by Palmer *et al.* in 2011.[24] In a more recent paper from the same group[25] a comparative retrospective study between two different UC decompressing techniques, namely incision and WCP, was conducted. Incision was performed throughout Collins knife, electrocautery hook, Bugbee electrode or Ho:YAG laser, while WCP with Ho:YAG laser only. The study population included patients aged 12 days to 44 months. Decompression rates were similar between the two groups, while incidence of *de novo* VUR and need of secondary, more invasive surgery were significantly lower in the WCP group. They concluded that WCP led to fewer complications associated with endoscopic UC management. However, it should be noted that the incision group is not consistent because they used either electrosurgery with different devices or laser to incise UCs. This could create a bias in the results.

A recent paper by Caione *et al.*[10] stressed the importance of an early endoscopic decompression of obstructing UC by Ho:YAG laser in infants and children. Moreover, authors underlined the requirement of multiple punctures at the basis of the UC, varying the energy and the frequency of the laser, depending to the quality and thickness of the UTC wall. Therefore, authors adopted 0.5–0.8 Joule energy (mean laser setting energy 0.6 Joule), with 5–9 Hz frequency (mean frequency pulse rate 7 Hz). This resulted a minimally invasive treatment, hence reducing the risk of further aggressive surgery.

In our study, we evaluated how effective Ho:YAG laser TUP is as primary and ultimate treatment. Furthermore, we focused on possible complications related to the procedure, in particular the development of *de novo* VUR. In the reported literature, outcomes of classic TUP regarding need of secondary surgery are up to 25% for intravesical UC and up to 100% for ectopic UC and the incidence of iatrogenic VUR is 20%–50%.[1-4,12,13] Although we got a wide experience with TUP performed with electrosurgery,[25] our preliminary results with laser TUP appear to be promising. The need of secondary surgery seems to be lower in the laser group. Given the small number of cases in our study, the incidence of *de novo* VUR seem to be lower in our laser treated patients. Moreover, we experienced a decrease in the grade of *de novo* VUR in the affected moiety during follow-up, until its complete resolution, attesting that iatrogenic VUR can be only a transient phenomenon.

In literature two studies compared the outcomes of electrosurgery and laser TUP. Ilic *et al.* retrospectively analyzed the results of laser-puncture of UC (LP group) in 12 patients and electrosurgery-incision (ES group) in 20 patients.[9] Only neonates with intravesical single or duplex system UCs were included in the study population. In ES group, electrocautery was used to incise the UC wall. In LP group, Ho:YAG laser was used, making several punctures (4–10) in the UC wall. There was no statistically significant difference between the groups regarding the need for retreatment, while there was a significantly higher rate of postoperative VUR in ES group. However, results could be partially biased by a different decompression technique in the two groups (incision vs. puncture). Caione *et al.* compared the results of TUP in both infants and children (laser-punctures in 64 patients, diathermic energy in 26 cases).[10] *De novo* VUR developed in 61.5% of patients instead of 29.7% observed in the laser energy punctures group ($P < 0.05$). The need of secondary decompression by re-do endoscopy for recurrent obstruction was similar in the laser group of patients (8%), compared with the diathermic group (7.7%; P = ns). The need of further open surgery was 18% (12 patients) in the laser group and in 50.0% (13 patients) in the diathermic group ($P < 0.05$).

Our study has a few limitations. The first limitation is the retrospective analysis of the results from a single center, without synchronous randomization with a historical control group. The patients treated by electrosurgery incision were recruited in the 5 years before the laser group: the different period of treatment could represent a possible bias on results, as consequence of higher surgical experience in the laser group. Furthermore, all the patients in our laser group were females, hence causing a possible gender bias. Additionally, all neonates in electrosurgery group were duplex system compared to 5/7 cases in laser group of patients. Moreover, the follow-up period was longer in the electrosurgery group. Finally, the treatment by Ho:YAG laser requires the availability of the specific laser energy equipment, not universally present in all the operating rooms, considering also the related costs.

CONCLUSIONS

Based on our experience, Ho:YAG laser proves to be safe and effective for the decompression of obstructive UCs in the 1st months of life, with no complications. The incidence of *de novo* VUR is similar to those TUP performed with electrosurgery and are transient. The need of secondary surgery seems to be lower after Ho:YAG laser TUP than electrosurgery TUP. The need for repeat TUP is comparable between the two procedures. Given the small number of patients in our study, further larger case-series with homogenous populations and/or a randomized controlled trial is necessary to corroborate our preliminary results.

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