Scientific Research Publishing

Open Journal of Urology, 2025, 15(3), 76-87
https://www.scirp.org/journal/oju
ISSN Online: 2160-5629
ISSN Print: 2160-5440

Uretero-Vesical Reimplantation Techniques According to Nesbit and Leadbetter Politano: Indications, Surgical Techniques and Results in Two Teaching Hospitals of Cameroon

Junior Barthélémy Mekeme Mekeme[1,2*], Jean Cedrick Fouda[1,2], Philipp Fernandez Owon'Abessolo[3], Jean Jacques Nwatchap[1], Axel Nwaha Makon[1,4], Landry Oriole Mbouche[1], Achille Aurèle Mbassi[5], Georges Kemegni[2], Junior Marcel Yon Mekeme[1], Devi Junior Ngue Ngue[1], Maurice Fonji[1], Pierre Joseph Fouda[1,2], Pierre Ongolo Zogo[1,6], Paul Owono Etoundi[1], Angwafo III Fru[1]

[1]Faculty of Medicine and Biomedical Sciences, University of Yaounde I, Yaounde, Cameroon
[2]Department of Urology and Andrology, Yaounde Central Hospital, Yaounde, Cameroon
[3]Faculty of Medicine and Pharmaceutical Sciences, University of Douala, Douala, Cameroon
[4]Laquitini Hospital, Douala, Cameroon
[5]Higher Institute of Medical Technology, Yaounde, Cameroon
[6]Medical Imagery Center, Yaounde Central Hospital, Yaounde, Cameroon
Email: *juniormekeme@yahoo.fr

How to cite this paper: Mekeme Mekeme, J.B., Fouda, J.C., Owon'Abessolo, P.F., Nwatchap, J.J., Nwaha Makon, A., Mbouche, L.O., Mbassi, A.A., Kemegni, G., Yon Mekeme, J.M., Ngue Ngue, D.J., Fonji, M., Fouda, P.J., Ongolo Zogo, P., Owono Etoundi, P. and III Fru, A. (2025) Uretero-Vesical Reimplantation Techniques According to Nesbit and Leadbetter Politano: Indications, Surgical Techniques and Results in Two Teaching Hospitals of Cameroon. *Open Journal of Urology*, **15**, 76-87.
https://doi.org/10.4236/oju.2025.153009

Received: December 24, 2024
Accepted: March 16, 2025
Published: March 19, 2025

Abstract

Introduction: The aim of this study is to determine the indications, surgical techniques and results related to ureterovesical reimplantation surgery based on two surgical techniques known and practiced daily in two university teaching hospitals in Cameroon. **Materials and Methods:** This is an observational longitudinal study with retrospective and prospective data collection arms over a 10-year 5-month period in the Urology and Andrology departments of the Yaoundé Central Hospital (YCH) and at the Douala Laquintini Hospital (DLH). The retrospective arm spanned from January 2012 to December 2022 and the prospective one from January 2023 to July 2023. **Results:** 27 patients were recruited for the purpose of this study with a mean age of 42.5 ± 7.5 years. The age range was from 35 to 50 years. The sex ratio (F/M) was 4.4 and the frequency of this surgical intervention was 2.7 cases/year. Delay to consultation and subsequent management were respectively 30 (7 - 150) and 90 (14 - 150) days on average. The clinical presentation was dominated by lower back pain on the ipsilateral side in all patients and permanent intravaginal urine leak in female patients. It should also be noted that damage to the pelvic ureter was the most common pathology found in women, seen on the right side in

14 cases. Ultrasound scan and CT urography were the most used imaging techniques for diagnosis in 85.2% and 44.4% respectively. Uretero-hydronephrosis was discovered in 22 patients with preservation of renal parenchyma architecture. We had 20 (74.1%) patients who presented with iatrogenic trauma of the ureter, 63% of which was secondary to hysterectomy and 11.1% post cesarean section. All our patients were operated by open surgery and the initial intraoperative lesion discovered was ligation of the pelvic ureter, seen in 13 (48.1%) patients. Direct Uretero-vesical reimplantation according to the Nesbit technique was carried out in 55.6% of cases and that by Leadbetter Politano in 14.8%. The postoperative period was satisfactory in 15 patients. Surgical site infections were recorded in 7 (25.9%), and intraoperative bleeding was seen in 4 (14.8%) other patients. We recorded 1 death in this study, occurring on the 21st day post-operation. It was secondary to chemical peritonitis. The average post op hospital stay was 15 (13 - 19) days and follow-up visits after 48 (34.5 - 85.5) months revealed patients who were asymptomatic at the time of reassessment, without elevation in serum creatinine, urinary infections, nor fistula formation. **Conclusion:** The results of ureterovesical reimplantation techniques according to Nesbit and Leadbetter Politano in our study had a very satisfactory clinical success rate.

Keywords

Hysterectomy, Cesarean Section, Lower Back Pain, Ureter, Bladder, Nesbit, Leadbetter Politano

1. Introduction

Iatrogenic damage to the pelvic ureter, although of varied origins, is a surgical complication quite common in our environment. Their occurrence can lead to serious complications in the upper urinary tract notably uretero-hydronephrosis, upper urinary tract infections, renal parenchyma atrophy and renal failure in cases where ureteral lesions were bilateral [1]. The Gold standard for the management of this pathology in industrialized countries is via laparoscopic or robotic surgery. In our context, open surgery remains relevant because of our limited technical platform [2]. Uretero-vesical reimplantation is a surgical intervention which consists of creating a bridge, either at the level of the natural ureterovesical junction, or by creating a totally new junction [2]. Epidemiological data in the literature of iatrogenic damage to the ureter tells us that the overall prevalence of such lesions to the lower ureter is 75% compared to all other locations. In the USA, we note that a frequency of 1% to 2% has been found in the population [3]. In Europe, a prevalence of 0.4% to 1.8% was recorded in several studies [4]. Adama *et al.* had a prevalence of 4.8% at POINT G Hospital in Bamako, Mali [5]. Similarly, in Congo, Otiobanda *et al.* found a prevalence of 1% after gynecologic surgeries. In Cameroon, a prevalence of 1.8 cases/year was reported by Fouda *et al.* at the Yaoundé

Central Hospital [6]. Our results, therefore aim to update the data already existing in the local and international literature on the indications and results of these surgical techniques according to Nesbit and Leadbetter Politano in two of our university teaching hospitals. We focused on these two techniques because they are the techniques best mastered by the urologist in this setting

2. Methodology

We conducted an observational longitudinal study with both retrospective and prospective data collection in the urology departments of the YCH and that of the DLH. The retrospective phase was conducted between January 2012 and December 2022 and the prospective phase between January 2023 and July 2023. Sampling was consecutive and exhaustive. Inclusion criteria was: patient files of both sexes with documented pathologies of the pelvic ureter and/or the ureterovesical junction that had benefited from ureterovesical reimplantation surgery according to the two surgical techniques cited above in one of these two study hospitals. The variables examined were the sociodemographic characteristics (age, sex, frequency),clinical data (history, side of the affected ureter, symptoms), paraclinical data before surgery (urea, creatinine, ultrasound scan of the urinary tree, urine microscopy and culture, renal scintigraphy, intravenous urography, and CT urogram), the surgical technique and documented results were studied (surgical indication, approach, type of reimplantation that was carried out, type of sutures that were used, intraoperative incidents, duration of surgery, estimated blood loss). Exclusion criteria involved files with incomplete data and patients who did not give consent. **Figure 1** illustrates the recruitment and exclusion of files across both hospitals.

The procedure was done after clearance from an anaesthetic team. All were done under general anaesthesia. Gibson incitions were mostly used, dissection down abdominal wall layers and concomitant haemostasis was done with diathermy. The bladder was identified, stay sutures placed in the bladder wall and a cystostomy done in between, exposing both ureteral meatii. The ureter was identified and the diseased segment cut at its upper margin. Spatulation was done. A submucosal tunnel was made in to out. The spatulated ureteral end was canalised with a double J stent then brought in via this new tunnel. A wide anastomosis to the bladder was then done with polyglactin 910 3/0. Bladder closure was then done with polyglactin 910 2/0 in two layers. Drains were systematically put into Retizus space and brought out via separate stab incisions. All patients had post op antibiotic cover and analgesic regimen was a function of individual tolerance to incitional site pain. The Retzius space drain was removed when its collection ceased. Removal of the ureteral stent was done at 7 weeks post op and an ultrasound scan was systematically done. Absence of ureterohydronephrosis was our marker of surgical success. Patient follow up was for 48 months.

All this data was entered and analyzed using the Epi-Info software version 3.5.4 on Windows. On an ethical level, we obtained authorization from the local committee and informed consent was obtained from all patients included in this study.

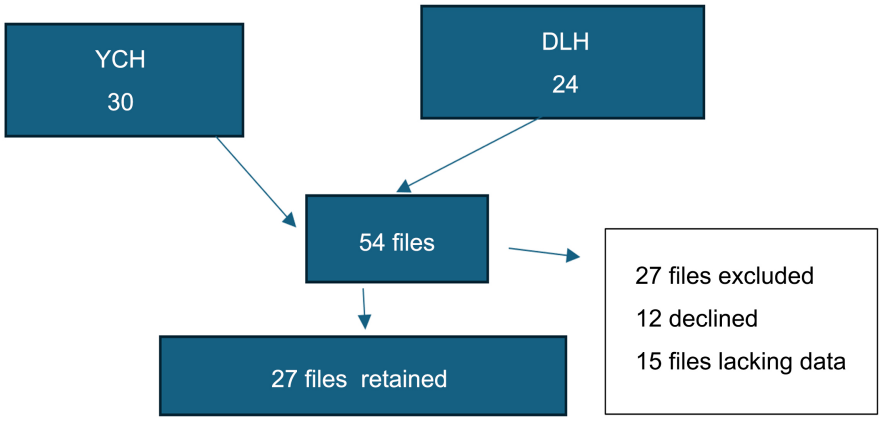

Figure 1. Patient flow chart.

3. Results

3.1. Sociodemographic and Clinical Data

Over the last ten years, 27 usable patient files of patients who had benefited from ureterovesical reimplantation according to Nesbit or Leadbetter Politano in the two study hospitals were found, with a frequency of 2.7 cases/per year and a sex ratio of 4.4 in favor of women. The average age was 42.5 ± 7.54 years with extremes ranging from 8 to 77 years. Specifically, the average age of men was 40.5 ± 20.5 years with extremes ranging from 8 to 77 years, while that of women was 43.25 ± 7.25 years with extremes ranging from 30 to 63 years. The oldest age group represented was the 40 to 50year age group. Delay to consultation in this study was on average 30 (7 - 150) days with extremes ranging from 1 day to 6 years (Figure 2).

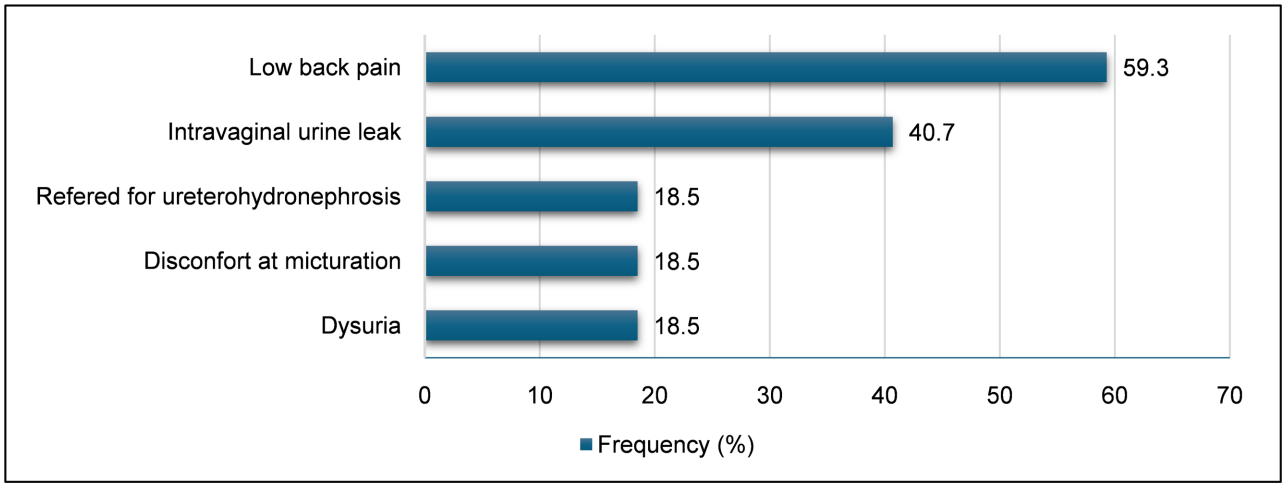

Figure 2. Distribution according to presenting symptoms.

3.2. Medical and Surgical Past Histories

Urinary tract infections were recurrent in 51.9% of patients and 63% had undergone a hysterectomy. We equally recorded 3.7% of patients who had ligated pelvic ureters secondary to laparoscopic varicocelectomies (Table 1).

Table 1. Distribution of patients according to their history (N = 27).

Variables	Number	Frequency
Medical		
Recent UTI	14	51.9%
Lithiasis	3	11.1%
Renal colic	14	51.9%
Recurrent fever	13	48.1%
Surgical		
C section	3	11.1%
Hysterectomy	17	63%
Laparoscopic varicocelectomy	1	3.7%

3.3. Clinical Presentation

Chronic low back pain was found in 12 (44.4%) of our patients. Continuous intravaginal urine leakage was found in 10 (37.0%) patients and was associated with urinary tract infections in 5 patients (Table 2).

Table 2. Patient spread according to surgical indication (N17).

Variables	Number	Frequency
Chronic pain	12	44.4
UTI	5	18.5
Persistent urine leakage	10	37

3.4. Paraclinical Examinations

The vast majority of our patients, a percentage of 85.2 had an ultrasound scan of the urinary tract. A CT urogram was performed in 44.4% of patients. Grade III uretero-hydronephrosis was found in 56.5% of patients and grade IV in 21.7%. The damage to the ureter concerned the right side in 51.5% of patients and the left in 33.3% (Figure 3).

3.5. Time to Management and Types of Lesions Discovered

Once the diagnosis was made, the time to surgical treatment was an average of 90 (14 - 150) days with extremes ranging from 1 day to 6 years. Iatrogenic injury was the most represented lesion 20 (74.1%), 63% was secondary to hysterectomy and 11.1% due to C section. The initial intraoperative lesion found was ligation of the pelvic ureter with suture material in 13 (48.1%) patients. Furthermore, we had 14.7% of our patients in whom ureteral stones were found in the intramural part of the pelvic ureter. Ureterocele, primary vesicoureteral reflux and punctal diverticulum were found with a frequency of 3.7% each (Table 3).

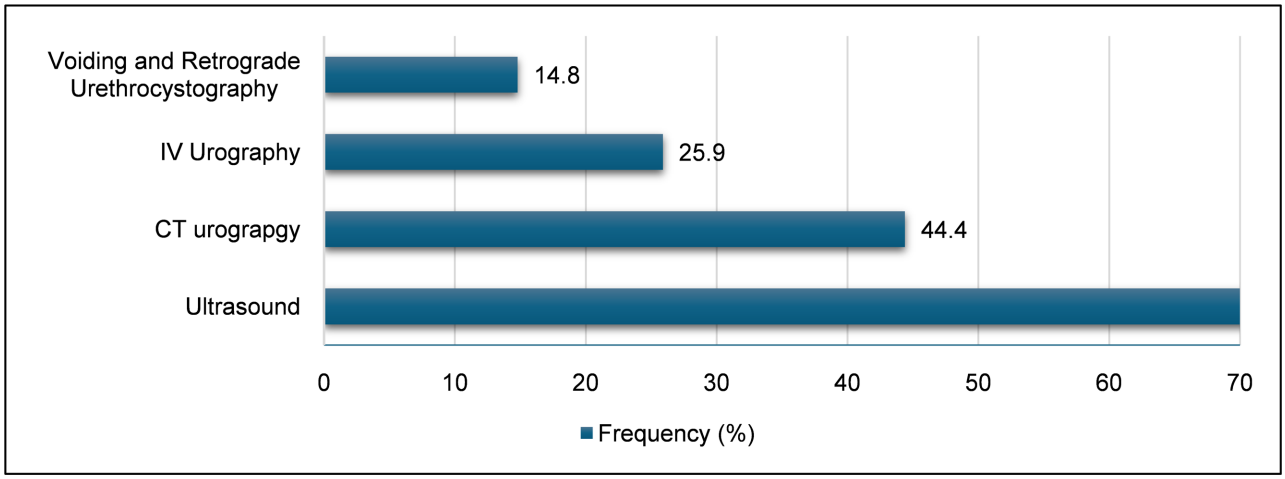

Figure 3. Distribution according paraclinical investigations.

Table 3. Distribution of patients according to lesions of the ureterovesical junction bladder found (N = 27).

Variable	Number	Frequency
Ureterocele	1	3.7
VUR	1	3.7
Meatal calculi	4	14.8
Iatrogenic injury	20	74.1
Ureteral meatus diverticulum	1	3.7

3.6. Surgical Technique

We noticed in this study by using patient files that, several surgical techniques had been used. However, the technique of direct ureterovesical reimplantation according to Nesbit had been the most regular, in 55.6% of patients, followed by that of Leadbetter Politano seen in 14,8% of cases (**Figure 4**).

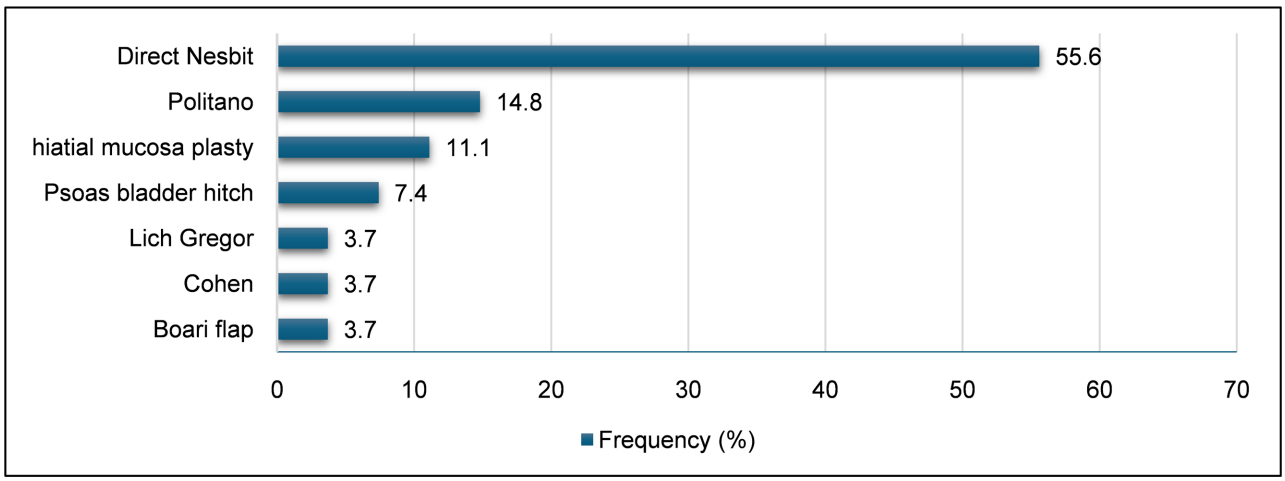

Figure 4. Distribution according to surgical techniques.

3.7. Type of Suture Material

The type of sutures used for the ureterovesical anastomosis had been specified in the operative reports of only 17 patients. These were resorbable polyglactin910 sizes 3/0, 4/0 or 5/0 all with round bodied needles. Braided sutures were used in 12 patients (44.5%) and monofilaments in 5 (18.5%) (Table 4).

Table 4. Distribution of patients according to the types of threads used (N = 27).

Variable	Number	Frequency
Monofilament	5	18.5
Braided	12	44.5
No information	10	37

3.8. Bleeding and Types of Drainage

Intraoperative bleeding around the point of fibrosis was the most common complication. Average blood loss was estimated at 145 ± 55 ml per intervention with extremes ranging from 80 to 500 ml. 33.3% of patients required whole blood transfusions. A ureteral stent across the anastomotic area was systematically placed in all patients (100%). This was externalized through a counter skin incision in 12 (44.4%) patients. For the internal stents, the DJ stent was the most used type, used in 15 (55.6%) patients (Table 5).

Table 5. Distribution of data according to drainage and bleeding operative (N = 27).

Variable	Number	Frequency
Stents		
External drainage	12	44.4
Internal drainage	15	55.6
Type of stent		
Ureteral stent	0	0
DJ stent	15	55.6
Paediatric NG tube	12	44.4
Intraoperative com [plications]		
None	11	40.7
Bleeding	16	59.3
Blood loss in cc		
<100 cc	7	25.9
100 – 200 cc	12	44.4
>200 cc	8	29.6

3.9. Duration of the Surgical Procedure

The average duration of interventions was 172.5 ± 7.5 min with extremes ranging from 90 to 300 min (Table 6).

Table 6. Distribution of data according to the duration of the intervention surgery and blood loss (N = 27).

Variables	Number	Frequency
Operation time (mins)		
<60	0	0
60 - 120	2	7.4
120 - 180	5	18.5
>180	20	74.1

3.10. Duration of Keeping the Ureteral Stent and Postoperative Surgical Site Infection

The trans-vesico-parietal ureterostomy was removed on the 12th day (8 - 14).

Post operation and the double J stent removed on the 49th (42 - 180) day. Removal of the drainage tube in the space of Retzius was done on the 9th post operation day (6.7 - 13) with extremes ranging from 5 to 17 days and that of the urinary catheter was made at the 10.5th (8 - 15) day with extremes ranging from 2 to 32 days. The postoperative period was unremarkable in 15 patients. 12 developed surgical site infections, 7 (25.9%) of whom benefitted from appropriate wound care. Unfortunately, one death was recorded in this study, it occurred on post operation day 21 in a context of chemical peritonitis.

3.11. Duration of Hospitalization and Reassessment of Patients

The hospital stay was an average of 15 (13 - 19) days with extremes ranging from 7 to 30 days. After an average follow-up of 48 (34.5 - 85.5) months, 26 patients were re-evaluated and none presented clinical signs of a failed anastomosis. Serum creatinine was normal in all patients, urine microscopy and culture was negative in 23 (88.5%) patients. Sterile pyuria was noted in 3 (11.5%) other patients. Control ultrasound scanning was the only paraclinical examination requested in the postoperative period for all 26 patients. No case of uretero-hydronephrosis was seen post op. The clinical success rate of the surgery was therefore evaluated at 96.29%.

4. Discussion

4.1. Sociodemographic and Clinical Data

All age groups were represented in our study, the age group the most represented was that from 40 - 50 years. Our figures show that this Intervention is mainly practiced on adult subjects, with a female predominance and sex ratio of 4.4. This

contradicts the series by Jellal *et al.* in Togo which reported an equal sex distribution [7].

4.2. Medical and Surgical History

Hysterectomy was the most common surgical past history in our study population with a percentage of 63%, followed by cesarean section with 11.1%. Fouda *et al.* at the YCH reported that 94% of patients who had undergone a hysterectomy complicated by a ureteral injury benefited from Uretero-vesical reimplantation surgery [6]. The techniques of hysterectomy should therefore be revisited or further mastered in future to reduce the incidents of these ureteral accidents

4.3. Clinical Presentation

Low back pain was the most frequent reason for consultation, seen in 59.3% of the cases. Chronicity of this pain was the indication for surgery in 44.4% of our patients. This indication was same in the study by Adama and al in Mali and that of Amri et al in Morocco [5] [8]. Recurrent urinary tract infection was found in 5 patients and persistent intravaginal urine leak in 40.7% of cases of patients who had a history of gynecologic surgery. This figure is higher than that of Amri *et al.* who had a value of just 20%. These symptoms were found in similar proportions by Amri *et al.* in Morocco [8] and by Adama Seydou *et al.* in Mali [5].

4.4. Paraclinical Examinations

The majority of our patients (85.2%) had an ultrasound scan of the urinary tract. This is the first-line examination mentioned in the diagnosis of ureteral lesions. IVU was only performed in 25.9% here, explained by the fact that IVU has gradually lost in value over the years with the advent of CT scanning. CT Urogram was performed in 44.4% of the cases. None had done renal scintigraphy. Renal differential function was therefore assessed based on the excretory phases of the CT urogram and/or IVU. We equally relied on the thickness of the renal parenchyma. The realities of our third world study settings did not permit us have renal scintigraphy done for direct renal function assessment. Any future study on this subject with use renal scintigraphy will definitely be of better quality.

A uretero-hydronephrosis grade 3 or 4 was present in 85.2% of patients. This result is comparable to that of Amri *et al.* who found 87% of uretero-hydronephrosis on ultrasound in his study population [8].

4.5. The Types of Lesions Discovered and Treatment Times

Iatrogenic injury was the most prevalent lesion, seen in 20 (74.1%) patients ,63% of which were secondary to hysterectomy and 11.1% to cesarean section. The initial intraoperative lesion found was ligation of the pelvic ureter, found in 13 (48.1%) patients. In the studies of Gambachidze *et al.* and those of Amri *et al.*, both reported iatrogenic lesions to the pelvic ureter (section, ligation, perforation, devascularization) of gynecological origin in 54% of cases and approximately 25%

of these lesions were secondary to hysterectomy. These lesions either caused an obstruction in more than two thirds the time, an immediate or a late fistula [7] [8]. Amri *et al.* in a study in Morocco reported stenosis of the pelvic ureter in 45.83% of cases and 25% of these were secondary to urogenital tuberculosis. Ureterovaginal fistulas was equally reported in 20.83% of cases in the same study [8]. Adama *et al.* in their study in Mali found stenosis of the pelvic ureter in 75.56% of cases and the etiology here had been parasitic (urogenital schistosomiasis) in 69.48% of cases.

Furthermore, we found 14.7% of patients with lithiasis in the intramural part of the pelvic ureter. Ureterocele, primary vesicoureteral reflux and punctal diverticulum were equally found with a frequency of 3.7% for each. These results are similar to those of Adama *et al.* in Mali, who had same position lithiasis in 17.78%, ureterocele and primary vesicoureteral reflux each in 4.17% of cases [5]. The intraoperative lesions here are similarly encountered in other studies across the globe. This gives further value to our study and to its potential to be exploited by the scientific community across the world.

4.6. Surgical Technique

The Nesbit direct ureterovesical reimplantation technique without an anti-reflux system was the most used in 55.6% of cases followed by that of Leadbetter Politano, in 14.8% of cases. This is contrary to standard literature information where the most used techniques are those of Leadbetter Politano, Lich Gregoir and Cohen [8]. Although this is contrary to standard literature, the techniques is mastered by surgeons here and still guarantees good results post op.

4.7. Type of Suture Threads

The type of suture material most used was Polyglactin 910 with sizes 3/0, 4/0 or 5/0. Braided suture was used in 12 patients and monofilament suture No. 4/0 in 5 patients. This is contrary to standard literature where resorbable monofilament suture is the recommended material to perform ureteral reimplantations.

4.8. Bleeding and Types of Drainage

Intraoperative bleeding around the fibrosis site was the intraoperative incident the most recorded, in 16 (59.3%) patients. Gambachidze *et al.* in a review of the literature published blood loss which varied from 163 to 610 ml in open surgery, 86 to 466 ml in laparoscopic surgery and from 44 to 104 ml in robot-assisted laparoscopy. These are contrary to the result of our study where the mean estimated blood loss was 145 ± 55 ml with extremes ranging from 80 to 500 ml. 33.3% of patients in this study received whole blood transfusions intraoperatively or during the immediate postoperative period. A ureteral stent, across the anastomotic site was systematically used in all patients (100%). This stent was exteriorized via a separate stab incision in 12 patients (44.4%), and an internal DJ stent used 55.6% of the time.

4.9. Duration of the Surgical Procedure

The average duration of these surgical interventions varies depending on the approach. Here It was 172.5 ± 7.5 minutes with extremes ranging from 90 to 300 mins. This time is close to that reported by Gambachidze *et al.* in a review of the literature where it varied between 176 and 235 minutes in open surgery, from 118 to 228 minutes in laparoscopic surgery and finally from 162.5 to 262.5 minutes in robot-assisted laparoscopic surgery [9]. In case of repeat surgery, estimated blood loss will depend on the experience of the surgeon and also on the degree of inflammatory fibrosis around the lesion.

4.10. Duration of Keeping the Ureteral Stent and Postoperative SSI

Removal of the DJ probe via endoscopy was carried out on average on the 49th (42 - 180) post-operative day. Other series offer removal around the 42nd day, a deadline close to ours [5] [7] [8]. We extended this time by a week further out of extra caution. Removal of the transurethral urine catheter was done on 10.5 (8 - 15) days post-operation, that of the drain located in the Retzius space on the 9th day (6.7 - 13) post-operation and from the external drain on the 12th (8 - 14) post-operative day.

4.11. Duration of Hospitalization and Reassessment of Patients

The postoperative course was unremarkable in 15 patients. Twelve patients had postoperative complications. Surgical site infections were found in 7 (25.9%). These complications were found in several other series [5] [7] and classified grade I according to the Clavien-Dindo system, therefore not requiring surgical interventions. Adama *et al.* in Mali found the same grade of complications [5]. Surgical site infections are quite common, nonetheless we should be relentless in our efforts to control them in future.

5. Conclusion

The indications for ureterovesical reimplantation surgery are reached in the face of discomfort secondary to continuous urinary incontinence or with recurrent urinary tract infections most often complicating an iatrogenic lesion to the pelvic portion of the ureter or due to pathology of the ureterovesical junction. The open reimplantation techniques recorded in this study proved to have a low rate of complications with fairly satisfactory results seen post operatively.

6. Study Limitations

This study was carried out in just two of the numerous urology units across Cameroon. Therefore, the data accrued here might not reflect the true post operative picture of this intervention nation wide.

The surgical procedures were carried out by different surgeons. Hence success or failure was highly surgeon dependent.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Oukhouya, M.A., Andaloussi, S., Tazi, M., Mahmoudi, A., Khattala, K. and Bouabdallah, Y. (2019) L'évolution à long terme du reflux vésico-rénal chez l'enfant. *Pan African Medical Journal*, **33**, Article 304. https://doi.org/10.11604/pamj.2019.33.304.18966

[2] Radmayr, C., Bogae, G. and Nijmanrt, J.M. (2022) EAU-Guidelines on Paediatric Urology. European Association of Urology, 186.

[3] Seideman, C.A., Huckabay, C., Smith, K.D., Permpongkosol, S., Nadjafi-Semnani, M., Lee, B.R., *et al.* (2009) Laparoscopic Ureteral Reimplantation: Technique and Outcomes. *Journal of Urology*, **181**, 1742-1746. https://doi.org/10.1016/j.juro.2008.11.102

[4] Sargent, M.A. (2000) What Is the Normal Prevalence of Vesicoureteral Reflux? *Pediatric Radiology*, **30**, 587-593.

[5] Adama Seydou, S. (2005) Les suites opératoires des reimplantations uretero vésicales dans le sevice d'urologie de l'hôpital du point G. Université de Bamako.

[6] Fouda, *et al.* (2021) Complications urologiques de la chirurgie gynécologique à l'Hopital Centrale de Yaoundé. Université de Yaoundé I.

[7] Jellal, C. (2019) Evolution des patients opérés pour reflux vesico-ureteral: Etude rétrospective à propos de 34 cas. Université Mohamed V de Rabat.

[8] Amri, H. (2012) La réimplantation urétéro-vésicale selon la technique de Lich Gregoir: Indications et résultats. Université Cadi Ayyad.

[9] Gambachidze, D., Phé, V., Drouin, S.J., Wolff, B., Parra, J., Mozer, P., *et al.* (2015) Étiologies et résultats fonctionnels après réimplantation urétéro-vésicale chez l'adulte: Revue de la littérature. *Progrès en Urologie*, **25**, 683-691. https://doi.org/10.1016/j.purol.2015.06.007