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INTERVENTIONAL

Comparison of single and tandem ureteral stenting for malignant ureteral obstruction: a prospective study of 104 patients

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Abstract

Objectives The aim of this study was to compare single and tandem ureteral stenting in the management of malignant ureteral obstruction (MUO).

Methods Our hospital's institutional review board approved this prospective study. Between November 2014 and June 2017, single ureteral stenting was performed in 56 patients (94 renal units) and tandem ureteral stenting in 48 patients (63 renal units) for MUO. A comparative analysis of the technical success rate, patient survival, stent patency, and complications was performed.

Results Similar demographic data were observed in patients receiving either single or tandem ureteral stenting. The technical success rate was 93.6% (88/94) for single ureteral stenting and 95.2% (60/63) for tandem ureteral stenting. There was no difference in overall survival between patients receiving single or tandem ureteral stenting ($p = 0.41$), but the duration of stent patency in tandem ureteral stenting was significantly longer ($p = 0.022$). The mean patency time was 176.7 ± 21.3 days for single ureteral stenting, and 214.7 ± 21.0 days for tandem ureteral stenting. The complications of ureteral stenting were urinary tract infection ($n = 18$), lower urinary tract symptoms ($n = 5$), haematuria (n = 3), and stent migration ($n = 1$).

Conclusions Tandem ureteral stenting is a safe and feasible treatment for MUO, and had better efficacy compared to single ureteral stenting.

Key Points

- *Ureteral stenting is an established treatment for the management of malignant ureteral obstruction (MUO)*
- *Prospective single-centre study showed that tandem ureteral stenting is a safe and feasible treatment for MUO*
- *Tandem ureteral stenting provides longer stent patency compared to single ureteral stenting in patient with MUO*

Keywords Humans · Hydronephrosis · Prospective studies · Stents · Ureteral obstruction

Abbreviations

MUO Malignant ureteral obstruction
PCN Percutaneous nephrostomy

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Introduction

Malignant ureteral obstruction (MUO) can be caused by an intrinsic urological malignancy, or by another malignancy that compressed the ureter externally, and is associated with a median survival of between 3 and 7 months [1, 2]. Immediate urinary diversion for symptomatic relief and preservation of renal function is required for MUO, especially when further treatment or chemotherapy is considered [3–5].

Ureteral stenting is an established treatment for the management of MUO, which most typically involves insertion of a polymeric stent into the obstructed ureter in an antegrade or retrograde fashion. However, the efficacy of a conventional polymeric stent is not satisfactory, with a reported failure rate of between 19 and 58%, and external diversion through percutaneous nephrostomy (PCN) may be required if further stent

exchange fails [3, 6–9]. The use of tandem ureteral stents, which provide additional drainage capacity from the extra space between the stents and the ureteral wall, is regarded as a viable alternative to a single ureteral stent for MUO and has been shown to have a good clinical result [10–15]. To our knowledge, few studies have been performed that made a direct comparison between single and tandem ureteral stent placement in MUO, and whether tandem ureteral stenting outperforms single ureteral stenting remains unknown. The aim of this study was to compare the success rate and clinical outcomes of single and tandem ureteral stenting for patients with MUO.

Materials and methods

Patients

This prospective study is Health Insurance Portability and Accountability Act compliant and was approved by the Institutional Review Board of our centre. Between November 2014 and June 2017, we enrolled 104 patients with MUO who were referred to our department for antegrade ureteral stenting (Fig. 1). Exclusion criteria included active urinary tract infection, ureteroplasty, ureteroscopic lithotripsy and ureteroscopic tumour resection (n = 0). Patient with previous treatment of ureteral stenting without ureteroplasty was eligible for the study (n = 8). After a thorough discussion about the benefits and risks of single and tandem ureteral stenting, 56 patients opted to receive conventional single ureteral stenting, and the other 48 patients were willing to undergo tandem ureteral stenting. Written informed consent was obtained from each patient before the procedure begins. An experienced interventional radiologist (K.L.L.) performed or supervised all the single or tandem ureteral stenting. In this study, the ureteral stents were placed percutaneously due to inaccessible retrograde option (n = 52), existing PCN (n = 47), inability to withstand general anaesthesia (n = 2) and patient preference (n = 3). Patients with inaccessible retrograde option consisted of those who received failed retrograde attempts due to severe compressed ureter or inaccessible ureteral orifice buried inside the tumour (n = 47), and those considered unsuitable for retrograde ureteral stenting by a urologist (n = 5). Most frequently, the patient was put in a prone position and local analgesia without conscious sedation was used during the procedure.

Tandem ureteral stenting

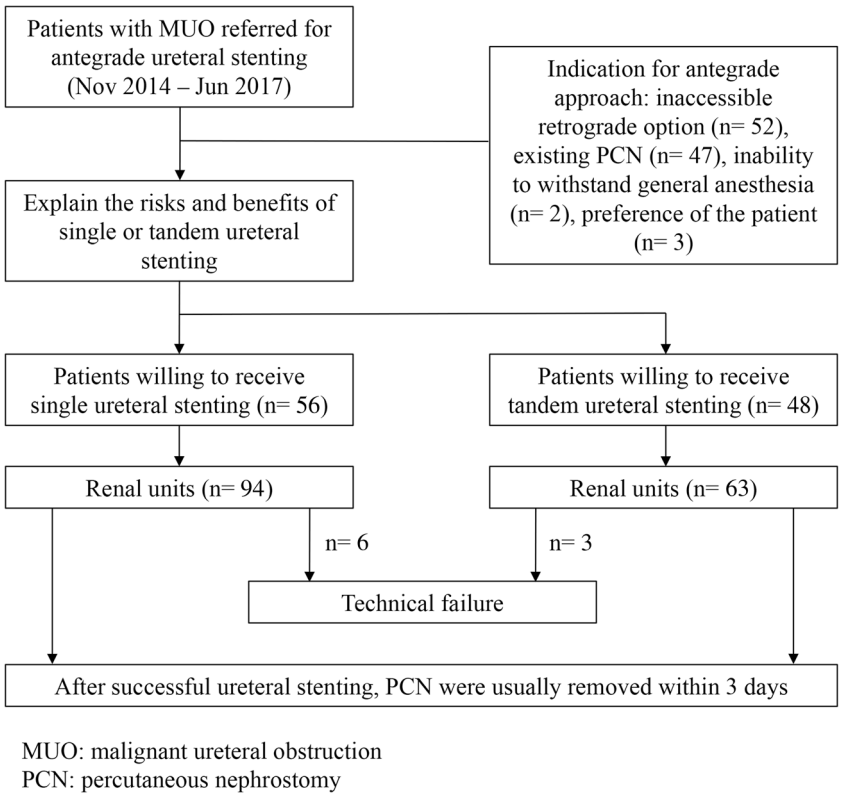
The procedure steps for tandem stenting are shown in Fig. 2. After creation of a percutaneous route into the renal pelvis with a 10-F vascular sheath under ultrasound and fluoroscopy guidance, a 5-F KMP or Cobra catheter (Torcon NB; Cook Medical, Bloomington, IN, USA) with a 0.035-inch hydrophilic guidewire was inserted into the ureter to cannulate the stenotic site. If a large amount of resistance occurred, or placement failed, a 2.7-F microcatheter (Progreat; Terumo, Somerset, NJ, USA) was used. After the guidewire was curved and secured inside the bladder, dilatation of the ureteral stenosis with an 8-mm balloon catheter was performed. A 6-F guiding catheter (Radiofocus; Terumo) was inserted into the urinary bladder. Then, another 0.035-inch hydrophilic stiff guidewire was inserted into the bladder via the guiding catheter parallel to the original guidewire. A 7-F ureteral stent (Inlay Optima; Bard Medical, Covington, GA, USA) was placed over the guidewire until a desired position was reached. Afterwards, the second 7-F ureteral stent was inserted, and the nylon thread attached to the neck of the original stent was held firmly to avoid any inadvertent downward migration caused by the second stent. Finally, the nylon thread was removed and an antegrade pyelogram was used to check the position and function of the stent. An 8-F or 10-F PCN was left in place and was usually removed within 3 days.

Single ureteral stenting

An 8-F vascular sheath was used to create a percutaneous route to renal pelvis under ultrasound and fluoroscopy guidance. The stenotic segment was catheterised and dilated similarly to as in tandem ureteral stenting. A 7-F ureteral stent (Angiomed UROSOFT tumour stent set; Bard Medical) was advanced through the guidewire. After proper position and function of the stent was confirmed by antegrade pyelogram, an 8-F PCN was left in place, and was usually removed within 3 days.

Follow-up of stent function

Patients were examined with ultrasound and computed tomography before and after ureteral stenting. Serum creatinine levels were checked within 1 week after stenting. Technical failure was defined as failure to catheterise the ureteral obstruction or improper stent position. Stent failure was defined as worsening hydronephrosis, creatinine elevation >50% of baseline, new PCN placement, failure to remove an existing PCN, or early stent removal due to intolerable side effects such as gross haematuria or lower urinary tract symptoms. The time interval from the initial placement to stent failure, next exchange time or death was defined as the duration of stent patency. Most patients were followed at 1-month intervals for their primary malignancy. The primary method for stent replacement was cystoscopic stent exchange, even for patients with initial inaccessible retrograde option. Complications after ureteral stenting were recorded for analysis.



MUO: malignant ureteral obstruction
PCN: percutaneous nephrostomy

Fig. 1 Flow diagram of patient enrolment

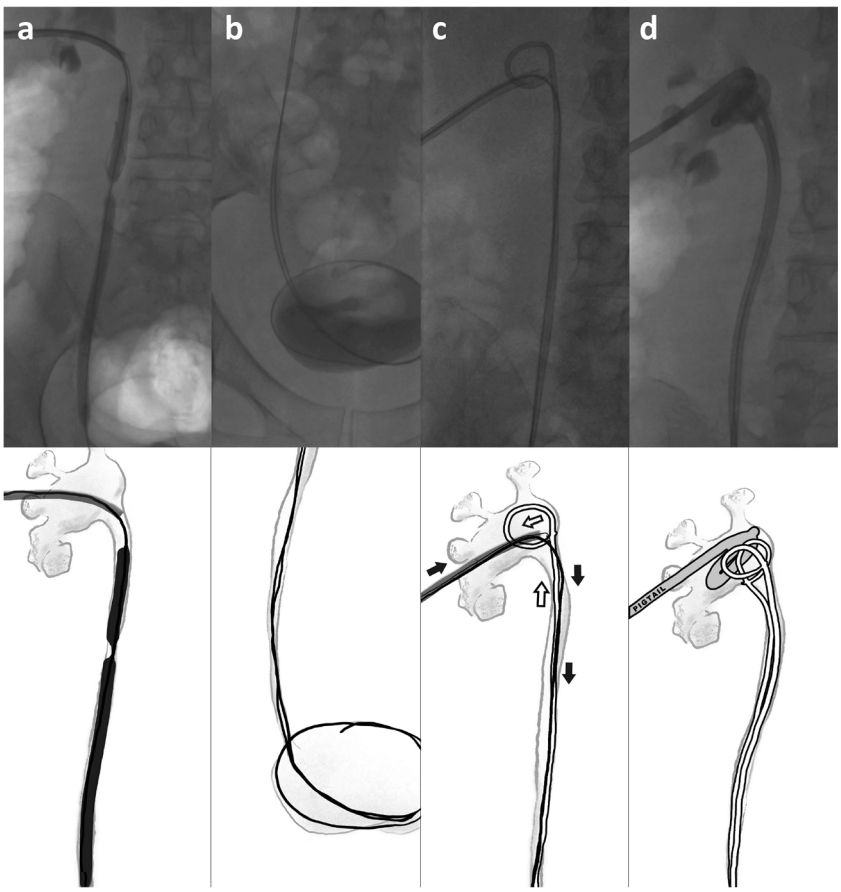


Fig. 2 The procedure steps of tandem ureteral stenting. **a** Dilatation of the ureteral stenosis after the guidewire was navigated into the bladder. **b** Insertion of another guidewire into the bladder parallel to the original one. **c** The first ureteral stent was placed to the desired position. Afterwards, the second ureteral stent was inserted while pulling the first ureteral stent tight by a nylon thread to avoid unwanted downward migration. **d** Finally, a PCN was left in the renal pelvis

Statistical analysis

Statistical analyses were performed using MedCalc statistical software (version 15.4.0.0; MedCalc, Ostend, Belgium). Assuming a patency rate of 30% for single ureteral stenting and 60% for tandem ureteral stenting in an estimated 1-year follow-up, the required sample size was 62 renal units for single ureteral stenting and 41 renal units for tandem ureteral stenting to detect a difference in stent patency (power = 80%, two-sided α level = 0.05, allocation ratio $N_{\text{single ureteral stenting}}/N_{\text{tandem ureteral stenting}} = 1.5/1$). Independent *t*-test was used for comparisons of continuous data. For comparison of categorical variables, the χ^2 test was used. The Kaplan-Meier method and log-rank test were used to compare patient survival and stent failure. A value of $p < 0.05$ was considered to indicate statistical significance.

Results

Patient characteristics are summarised in Table 1. A total of 56 patients (94 renal units) underwent single ureteral stenting and 48 patients (63 renal units) underwent tandem ureteral stenting. Patients with single ureteral stenting (mean age, 63.6 ± 13.5 years) were 55.4% (31/56) male, and patients with tandem ureteral stenting (mean age, 63.0 ± 11.8 years) were 47.9% (23/48) male. The laterality of MUO was similar between patients receiving single or tandem ureteral stenting ($p = 0.972$), and both bilateral MUO ($n = 44$) and unilateral MUO ($n = 60$) were included in this study. Ureteral obstruction was at the distal segment in 69.1% (65/94) of patients with single ureteral stenting, and 73.0% (46/63) of patients with tandem ureteral stenting. The mean follow-up duration for all patients was 217.8 ± 204.1 days. Causes of MUO were colon cancer in 33 (31.7%, 33/104) patients, bladder cancer in 12 (11.5%, 12/104) patients, gastric cancer in 10 (9.6%, 10/104) patients, prostate cancer in 10 (9.6%, 10/104) patients, cervical cancer in 9 (8.7%, 9/104) patients, ovarian cancer in 7 (6.7%, 7/104) patients and other solid organ malignancy in 23 (22.1%, 23/104) patients. Patients in the two groups were similar with respect to demographic characteristics.

All ureteral stenting procedures were performed with an antegrade approach. The technical success rate was 93.6% (88/94) for single ureteral stenting and 95.2 (60/63) for tandem ureteral stenting. Inability to cannulate the stenotic segment of the ureter was the main reason for technical failure (88.9%, 8/9). One (11.1%, 1/9) patient had failed tandem ureteral stenting because of failed second stent insertion due to tight stenosis.

Kaplan-Meier analysis of both groups showed that patients receiving single or tandem ureteral stenting had similar overall survival during follow-up ($p = 0.41$) (Fig. 3). The mean survival time was 272.0 ± 33.6 days for patients with single ureteral stenting and 361.8 ± 56.4 days for patients with tandem ureteral stenting. As for the duration of stent patency, tandem ureteral stenting performed significantly better than single ureteral stenting ($p = 0.022$) (Fig. 4). The mean patency time was 176.7 ± 21.3 days for

Table 1 The demographics data of patients receiving single or tandem ureteral stenting

	Single ureteral stenting	Tandem ureteral stenting	*p* value
Patients/renal units	56/94	48/63	
Age, years	63.6± 13.5	63.0± 11.8	0.815
Gender (male/female)	31/25	23/25	0.449
Laterality			0.972
Right	51	34	
Left	43	29	
Level of obstruction			0.463
Proximal	17	7	
Middle	12	10	
Distal	65	46	
Origin of malignancy			0.107
Gastrointestinal	20	27	
Genitourinary	15	8	
Others	21	13	
Pre-stenting creatinine (mg/dL)	3.1± 3.1	2.5± 2.3	0.32
Post-stenting creatinine (mg/dL)	1.4± 0.8	1.2± 0.9	0.483
Technical success (%)	93.6 (88/94)	95.2 (60/63)	0.668
Use of microcatheter (%)	11.7 (11/94)	15.9 (10/63)	0.723

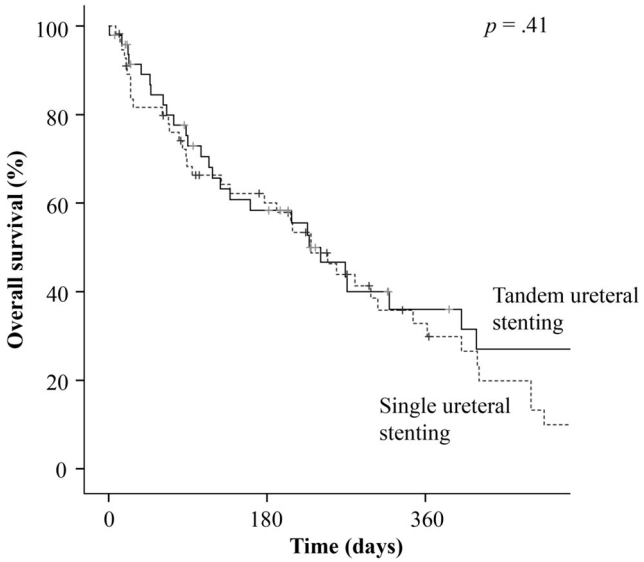


Fig. 3 Kaplan-Meier analysis for overall survival in patients with MUO treated by single or tandem ureteral stenting

single ureteral stenting and 214.7 ± 21.0 days for tandem ureteral stenting.

No procedure-related mortality occurred. Urinary tract infection developed in 18 (11.5%, 18/157) procedures within 1 week after stenting (single ureteral stenting, 12; tandem ureteral stenting, 6; $p = 0.23$). Self-limiting lower urinary tract symptoms were reported in 5 (3.2%, 5/157) procedures (single ureteral stenting, 3; tandem ureteral stenting, 2; $p = 0.78$) shortly after stenting. Haematuria occurred in 3 (1.9%, 3/157) procedures (single ureteral stenting, 1; tandem ureteral stenting, 2; $p = 0.47$), and no blood transfusion was needed. Inadvertent stent migration was found during follow-up in 1 (1.6%, 1/63) procedure with tandem ureteral stenting.

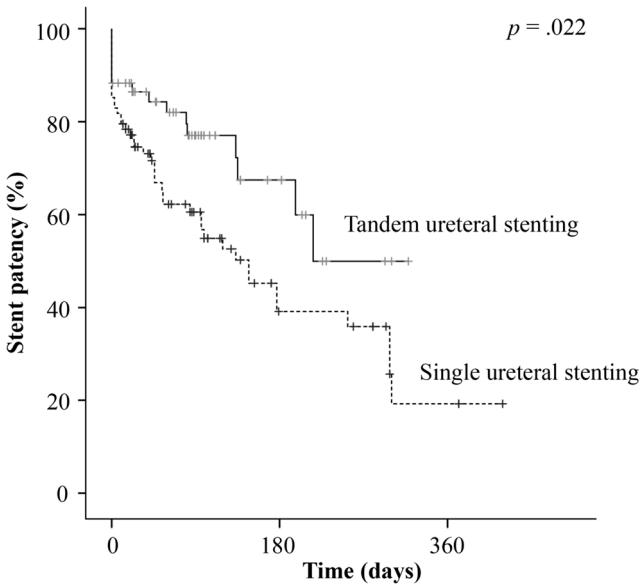


Fig 4 Kaplan-Meier analysis for stent patency in patient with MUO treated by single or tandem ureteral stenting

Discussion

This study is the first comparative study to examine the clinical outcomes of single and tandem ureteral stenting for MUO. With similar technical success and complication rates, tandem ureteral stenting outperformed single ureteral stenting in stent patency time, which supports the hypothesis that tandem ureteral stenting is a safe and feasible procedure for the management of MUO.

MUO implies an advanced status of malignancy, and recent studies revealed that the median survival of patients with MUO ranges from 3 to 5 months after urinary diversion [16, 17]. Given the unfavourable prognosis of these patients, the decision to pursue urinary diversion is not always justified. However, urinary diversion for MUO, either by ureteral stenting or PCN, may be needed if preservation of renal function enables chemotherapy or achieves symptomatic relief. While PCN offers good external drainage, its drawbacks include infection, tube dislocation, and discomfort from the existence of catheter and drainage bag which adversely affect quality of life in patient with MUO [18, 19]. Although a web-based survey showed that both urologist and oncologist favour ureteral stenting over PCN for its superiority in patient comfort and quality of life [20], a small study revealed no significant quality of life improvement in ureteral stenting over PCN for patient with MUO [21]. Further large-scale multicentre studies are thus needed to assess the quality of life in patient with MUO receiving PCN or ureteral stenting.

Conventional single ureteral stenting with a polymeric stent might be an appealing first option for patients with MUO since it is familiar to all radiologists and urologists. However, single ureteral stenting is not effective against malignant external compression or intrinsic obstruction, resulting in a limited stent patency time [22]. Moreover, subsequent stent exchanges after single polymeric stent failure rarely works [23]. The mechanism of stent malfunction in MUO includes obstructed flow around the stent, decreased ureteral peristalsis, and intrusion of tumour from side holes [24].

Tandem ureteral stenting utilises two parallel polymeric stents to relieve the ureteral obstruction. Although first described over a decade ago by Liu et al [10], only several retrospective studies with limited case numbers have reported its use [12–15, 25, 26]. Most studies performed tandem ureteral stenting under retrograde cystoscopic guidance, while only two studies performed antegrade tandem ureteral stenting [12, 15]. Chen et al [12] showed that insertion of a second stent parallel to the old malfunctioning stent is efficient for relieving the obstruction. However, sequential insertion of ureteral stents may cause downward migration of the original stent according to our experience, especially when tight stenosis is encountered. Another study by Ozyer et al [15] reported seven cases of antegrade simultaneous insertion of tandem ureteral stents [15]. To our knowledge, our study is the

largest series regarding the feasibility of antegrade tandem ureteral stenting, and the technique of simultaneous insertion is described in detail.

Metallic stents have been developed to maintain patency and drainage function against severe ureteral compression. Being the most-studied metallic stent, Resonance (Resonance stent; Cook Medical) is made of spiral unfenestrated coils with a 79% overall success rate and a 1% migration rate for MUO [27]. Also, Chow et al [28] demonstrated a 4-month extension of stent patency using the Resonance stent compared to conventional polymeric ureteral stents, but the lack of an end hole may make the insertion technically difficult. Uventa (Uventa ureteral stent; Taewoong Medical, Gyeonggi, South Korea) is a self-expandable coated metallic stent with demonstrated clinical effectiveness in the treatment of MUO [27, 29–31]. Another available model of metallic stent is Memokath 051, which is a thermo-expandable metal mesh stent (Memokath 051; Pnn Medical, Kvistgaard, Denmark) for benign ureteral stenosis and MUO with promising results. However, the migration rates of Memokath 051 was relatively high, ranging between 17.6% and 27.0% [27, 32, 33]. Moreover, a recent report by Kim et al [34] showed a higher clinical success rate (82.4% versus 42.9%; p=.031) achieved by UVENTA over Memokath 051 in treating patients with benign ureteral stenoses and MUO. Finally, Allium (Allium ureteral stent; Allium Medical, Borehamwood, UK) is another covered self-expandable metallic stent with a paucity of data regarding its use in MUO [27], and the only study by Moskovitz et al [35] reported 0% obstruction rate in 25 patients. Despite the overall advantage of metallic stent for MUO, it is more expensive than the conventional polymeric alternative and the cost-effectiveness remained questionable for patients with expected short life-expectancy. Further prospective, randomised studies comparing tandem stenting, metallic stents and metal mesh stents are needed to clarify the clinical utility of each type of stent [36].

Most ureteral stents are placed in a retrograde fashion under cystoscopic guidance, and intra-ureteral biopsies and incisions of strictures can be performed [9, 37]. However, retrograde ureteral stenting in MUO is technically challenging, and placement may fail in up to half of cases [9, 38, 39]. Gross bladder invasion is associated with difficult retrograde ureteral stenting, and a lowered success rate [7]. Alternatively, fluoroscopic-guided antegrade ureteral stenting can be performed in patients with MUO with a high success rate. Unlike retrograde ureteral stenting that usually requires general anaesthesia, antegrade ureteral stenting can be safely performed under local anaesthesia, which is especially useful for patients who are critically ill. Moreover, many patients with MUO have an existing PCN, which simplifies the creation of a percutaneous route for antegrade ureteral stenting, and thereby decrease the risk of complications [40–42].

Complications of ureteral stenting have been reported [24]. Irritation of the urothelium from ureteral stenting often causes mild haematuria. Also, patients commonly experience lower urinary tract symptoms and flank pain after ureteral stenting, necessitating pain control medication in over half of patients within the first week after the procedure [43]. Other well-documented complications include stent encrustation, ureteral injury, stent migration and fracture, and the forgotten stent [44, 45]. The use of antegrade insertion for ureteral stenting also carries complications similar to PCN placement, such as renal bleeding [46].

In this study, we used a reinforced polymeric stent with a strengthened middle shaft (Angiomed UROSOFT tumour stent set; Bard Medical) for single ureteral stenting, which was different from the regular polymeric stent for tandem ureteral stenting (Inlay Optima; Bard Medical). There was a paucity of data regarding the use of reinforced polymeric stent in patient with MUO. The only study by Hung et al [47] reported a median stent patency of 6.8 months, but no comparison with the regular polymeric stent was made. The clinical efficacy of the reinforced polymeric stent is generally presumed to outperform the regular polymeric stent; therefore, the study design might potentially underestimate the clinical efficacy of tandem ureteral stenting. However, our results showed that patients with tandem regular polymeric stents showed longer stent patency compared to those with a single reinforced polymeric stent, which further supported the notion that tandem ureteral stenting is an efficient treatment for patient with MUO.

The present study has several limitations. First, patients were subjected to different treatments according to their willingness at enrolment, and the non-randomised study design may be subject to selection bias. For example, patient with more severe MUO might be led by physicians to receive more effective treatments. However, patients receiving different treatments had been shown to have similar demographic data and overall survival, implying that the patient characteristics were comparable even under non-randomised enrolment. Moreover, even though the physicians believed that tandem ureteral stenting is better than single ureteral stenting, our result would be an underestimate of the efficacy of tandem ureteral stenting because of the more severe MUO of the patients. Second, periodic replacement of the expired indwelling stent during follow-up was performed based on individual physician's judgment. According to the manufacturer, the recommended indwelling time can be up to 1 year for the polymeric stent used in this study. Nevertheless, the possible inconsistent time for replacement between physicians may lead to bias with respect to the duration of stent patency between single and tandem ureteral stenting. Third, all tandem ureteral stenting was performed or supervised by the same physicians, making the generalisability of the procedure questionable. Large-scale prospective multi-centre studies regarding tandem ureteral stenting are needed to replicate our observations.

Conclusions

Tandem ureteral stenting is a technically feasible procedure for patients with MUO and has longer stent patency time compared to single ureteral stenting.

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Compliance with ethical standards

Guarantor The scientific guarantor of this publication is Kao-Lang Liu.

Conflict of interest The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

Statistics and biometry No complex statistical methods were necessary for this paper.

Informed consent Written informed consent was obtained from enrolled patients.

Ethical approval Institutional Review Board approval was obtained.

Methodology
- Prospective
- Prognostic study
- Performed at one institution

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