Percutaneous Nephrostomy Versus Retrograde Ureteral Stent for Management of Malignant Ureteral Obstruction in Adults: a Systematic Review of the Literature

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Abstract

Background Malignant ureteral obstruction (MUO) is a common presentation in advanced urological and non-urological malignancies. Percutaneous nephrostomy (PCN) and retrograde ureteral stent (RUS) are the most commonly performed procedures to relieve the obstruction. The comparative effectiveness of PCN and RUS for decompression of MUO remains uncertain.

Purpose To systematically review the literature for evidence of improved efficacy of one of these procedures in terms of renal function preservation and clinical outcomes.

Methods We searched Ovid Medline, Ovid EMBASE, CINAHL, Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus from the date of inception to October 2022. In addition, gray literature was searched through OpenGray (https://opengrey.eu/), dissertation and thesis database (ProQuest) via (https://www.proquest.com), and Clinical trial.gov website. The reference lists of all the included studies were also searched.

Two reviewers independently reviewed and selected studies, assessed the quality, and extracted the data.

Results Overall, 25 eligible studies including 1864 patients compared PCN and RUS (head-to-head). PCN and RUS were found to be similarly effective in improving renal function. However, PCN appears to be superior in maintaining this reduction. The complication rate and quality of life were comparable between the 2 methods, but the length of hospital stay and the financial cost were significantly higher in the PCN group. The mean technical success rate in RUS was 70.3% (21% to 100%) and in PCN was 98.8% (90% to 100%). The conversion rate from RUS to PCN ranged from 10% to 42.6% (mean = 22.5%), while internalization of the PCN occurred in 11.7% to 98% of the patients (mean = 45.5%).

Conclusions Both diversional methods are effective in management of MUO. However, because of the heterogeneity of the included studies, the superiority of one of the procedures cannot be concluded.

Key Words

Malignant ureteral obstruction, hydronephrosis, percutaneous nephrostomy, retrograde ureteral stent

Competing Interests

None declared.

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Abbreviations

MUO malignant ureteral obstruction
PCN percutaneous nephrostomy
RUS retrograde ureteral stent
UD urinary diversion

Introduction

Although the true incidence is poorly defined[1], ureteral obstruction is a common manifestation of advanced urological and non-urological malignancies. It is a concerning sign and could be the first indication of cancer progression[2]. Malignant ureteral obstruction (MUO) can arise from direct invasion of the ureters by various abdominopelvic malignancies, encasement by malignant lymph nodes, or compression from an external malignant retroperitoneal mass[3–5]. This obstruction can appear as a dilatation in the ureter and or kidney. Urinary diversion (UD) is usually required for symptomatic relief and renal function preservation, especially when systemic therapy such as chemotherapy is planned[6,7].

While MUO is often detected incidentally at the time of abdominal imaging[8], symptoms at initial presentation can range from subacute nonspecific symptoms to acute pain, fever, vomiting, and sepsis[3,4]. A variety of imaging modalities are available to detect upper tract dilatation and determine the degree and the location of the ureteral obstruction. These include abdominal ultrasound, intravenous pyelography, abdominal CT, abdominal MRI, and retrograde pyelogram[9]. Abdominal CT with intravenous contrast is most effective in identifying the abdominal and pelvic pathologies responsible for the obstruction[8]. When both ureters are involved, prompt intervention may be required. If left untreated, bilateral obstruction can lead to uremia and electrolyte imbalance, with a potentially lethal outcome.

Selecting the optimal method of intervention to treat MUO is a clinical challenge for urologists and interventional radiologists. Many interventional procedures for decompression of the upper tract in patients with MUO have been described. However, insertion of percutaneous nephrostomy (PCN) and retrograde ureteral stent (RUS) are the most established procedures. These have been reported to have varying success, efficacy, and complication rates, and potentially differential impact on quality of life. Ureteral stenting is an attractive first-line option in principle because it is less invasive and the patient does not have to manage an external device; however, adequate drainage can be monitored more effectively with a PCN, and it is more easily changed. Differences in efficacy and quality of life associated with these procedures have not been clearly determined[10], and although they are performed in everyday practice, no guidelines have been established regarding the optimal method of UD[10–12]. The selection of one method over the other to decompress the upper tract in patients with MUO remains controversial. Here we review studies that compare PCN and RUS with respect to preservation of renal function and clinical outcomes.

Methods

All study types that compared PCN and RUS (head-to-head comparison) and contained original data were eligible for this review. Studies were included regardless of language and publication status, including abstracts without full text.

Studies were eligible if they included adult (≥ 18 years) subjects who underwent PCN or RUS to drain a kidney with MUO. Studies involving pediatric participants, pregnant women, animals, or only participants with benign ureteral obstruction (BUO) were excluded. Studies that assessed a mixed population of BUO and MUO were included.

Primary outcomes were preservation of the renal function, technical success rate, and complication rate. Secondary outcomes were conversion from one diversional method to another; residual hydronephrosis; length of hospital stay; procedure time; financial cost of the intervention; quality of life of patients post intervention.

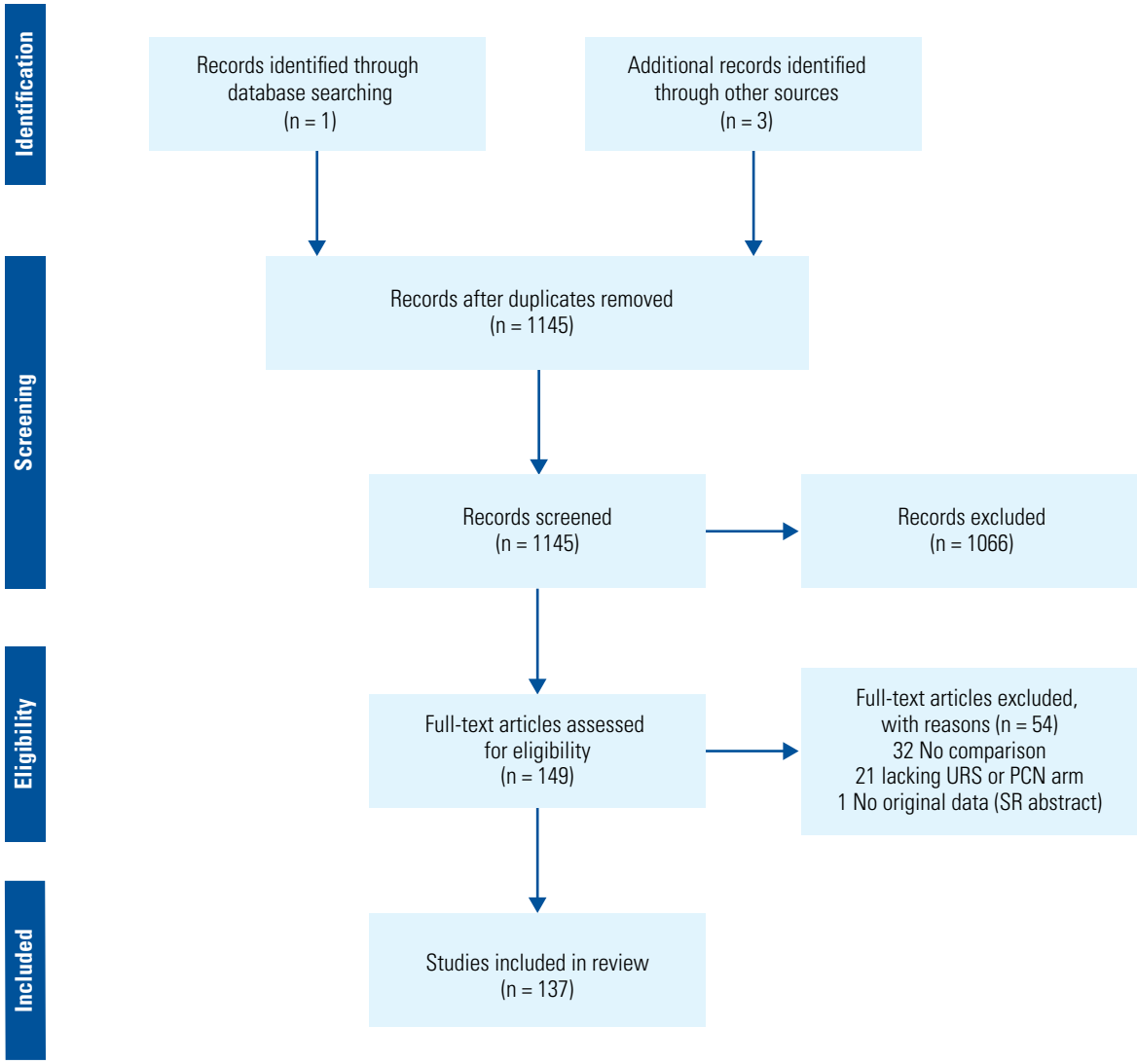
Search method for identification of the studies

A comprehensive electronic search was performed in Ovid Medline, Ovid EMBASE, CINAHL, Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus. Additionally, we looked for gray literature through OpenGray (https://opengrey.eu/), dissertation and thesis database (ProQuest) via (https://www.proquest.com). Also, we searched the Clinical trial.gov website and checked the reference lists of all the included studies. The date range for inclusion was inception of the database to October 2022. The result of the search was uploaded into Covidence software after potential duplicate studies were removed (identified using the reference management software RefWorks). The key words used in the search strategy were "neoplasm," "hydronephrosis," "percutaneous nephrostomy," "ureteral stent." Detailed search strategies are shown in the online **Appendix**. The search result is summarized in a PRISMA flow chart (**Figure 1**).

Selection of the studies

Two authors (W.E. and M.R.) independently screened the title and the abstract of each study for its eligibility for the systematic review using Covidence software (Melbourne, Australia). Each study was marked "yes," "no," or "maybe" according to its relevance to the review. Any conflict in the screening was solved by a discussion between the 2 authors. A full text was obtained for all studies that were

FIGURE 1.
PRISMA flow chart



marked "yes" or "maybe" and independently reviewed by the 2 authors to decide which met the inclusion criteria. Google Translate was used to translate the full text of the studies that were published in languages other than English.

Data extraction

The 2 authors extracted the data from the eligible studies into a data extraction sheet. These data include author names, year of publication, country of study, number of involved institutions, type of study, sample size, number of participants in each study arm, success rate, percentage and type of complications, mean and/or median age, creatinine at intervention and post intervention, residual hydronephrosis, percentage of conversion into another UD method, length of hospital stay, surgical time, cost of procedure in US dollars, and quality of life.

Quality assessment

The quality of the enrolled studies was assessed using the Newcastle-Ottawa Scale, which allocates a possible maximum of 9 stars for selection domain (4 items with 4 stars), comparability domain (1 item with 2 stars) and outcome domain (3 items with 3 stars). Studies with ≥ 7 stars are considered good quality, 6 stars fair quality, and ≤ 5 stars poor quality (**Table 1**).

Results and Discussion

Twenty-five studies were included: 21 reported on 1302 patients with MUO only[5,13–32] (**Table 1**). Four of these 21 studies were published in a language other than English[17,24,25,28]. Three additional studies and one abstract reported on a total of 562 patients, of whom 388 had BUO and 174 had MUO[33–36] (**Table 2**). Because we

TABLE 1.
Characteristics of the included studies with MUO patients

Author, Year	Country	Institutions No.	Study design	Study period	
Botkin et al., 2021	United States	Single	Retrospective	Jan 2004 to Dec 2019	
De Lorenzis et al., 2020	Italy	single	Retrospective	Jan 2010 to Jan 2020	
Tan et al., 2019	China	single	Retrospective	July 2008 to August 2018	
Monsky et al., 2013	United States	single	Prospective longitudinal survey	NR	
Song et al., 2012	China	single	Retrospective	Jan 2006 to Sep 2010	
Migita et al., 2011	Japan	single	Retrospective	Jan 1998 to Dec 2007	
Kraemer et al., 2009	Denmark	single	Retrospective	1997 to 2007	
Kanou et al., 2007	Japan	single	Retrospective	Jan 1990 and Dec 2003	
Wong et al., 2007	Australia	single	Retrospective	1991 to 2003	
Ku et al., 2004	South Korea	single	Retrospective	Jan 2000 to Dec 2002	
Chitale et al., 2002	United Kingdom	Single	Retrospective	July 1998 to July 2000	
Feng et al., 1999	United States	Single	Retrospective	Oct 1984 to August 1996	
Liaw et al., 1997	Taiwan	Single	Retrospective	1984 to 1996	
Hyppolite et al., 1995	United States	Single	Retrospective	July 1989 to June 1994	
Desportes et al., 1995	France	Single	Retrospective	Sep 1983 to Sep 1993	
Stevens et al., 1994	The Netherlands	Single	Retrospective	1987 to 1992	
Hubner et al., 1993	Austria	Single	Retrospective	April 1986 to April 1989	
Barton et al., 1992	United States	Single	Retrospective	Oct 1986 to Sep. 1991	
Kurita et al., 1992	Japan	Single	Retrospective	August 1989 to Sep.1991	
Gasparini et al., 1991	United States	Single	Retrospective	July 1986 to July 1989	
Zadra et al., 1987	Canada	Single	Retrospective	Jan 1978 to Nov. 1984	

Abbreviation: MUO, malignant ureteral obstruction; BUO, benign ureteral obstruction; NOS score, Newcastle-Ottawa Scale; NR, not reported
a15 patients had nephroureteral stent; b5 patients have not had urinary diversion; c1 patient was treated conservatively without urinary diversion;

could not get separate data for MUO patients (although the authors were contacted), the stated results in these 4 studies include both MUO and BUO patients. All but 2 of the included studies in the present review were conducted retrospectively[14,35]. The studies are summarized in **Table 3**.

Preservation of renal function

Few retrospective studies evaluated the difference in creatinine changes between the 2 groups. Ku et al.[20], Hyppolite et al.[23], Kurita et al.[28], and De Lorenzis et al.[32] investigated and reported the mean serum creatinine values before and after the intervention in patients treated with PCN and RUS (**Table 4**). Both UD methods successfully reduced creatinine and preserved renal function. Because of the greater reduction in creatinine after diversion by PCN compared with the RUS, Hyppolite et al.[23] stated that PCN was superior to RUS, especially in patients with bilateral PCN. The ratio of the creatinine reduction in the PCN was 78.8% compared with 70.7% in the RUS. This study has multiple limitations, including a small sample size, unequal groups, and lack of statistical

	Patients No.	PCN, No.	RUS, No.	Age (years)	Sex (M, F)	NOS Score
	[g]179	77	68	Mean 51.2	F = 179	7
	51	24	27	Mean 70	M = 20, F = 31	8
	89	29	60	Mean 50.3	F = 89	7
	[a]46	16	15	NR	M = 20, F = 26	7
	75	25	50	Mean 57.1	F = 75	6
	[b]25	5	15	Median 61	M = 13, F = 12	5
	[e]51	28	16	Median 71	M = 51	5
	75	38	37	Mean 62.7	M = 30, F = 45	7
	102	77	25	Median 62	M = 45, F = 57	6
	148	80	68	Mean 57.3	M = 68, F = 80	8
	65	60	5	Range 53-84	M=52, F=13	6
	37	15	22	Range 37–85	M = 17, F = 20	5
	[c]17	8	8	Mean 54	M = 8, F = 9	5
	[d]34	17	5	Mean 58	F = 34	5
	104	28	76	Mean 61.8	M = 54, F = 50	6
	57	36	21	Mean 55	M = 21, F = 36	6
	52	28	24	Median 67	M = 21, F = 31	7
	40	13	27	Mean 52.8	F = 40	6
	38	25	13	Mean 53.3	M = 13, F = 25	7
	22	15	7	Median 62	M = 8, F = 14	6
	[f]98	47	37	Mean 59.1	M = 41, F = 57	7

d12 patients were treated either conservatively or ileal conduit; e7 patients had antegrade stent insertion; f14 patients had other diversional methods; g34 patients did not receive any treatment.

analysis. Botkin et al.[31] supported this conclusion in their own study, in which the serum creatinine declined by 2.1 mg/dL in the PCN group and 0.3 mg/dL in the RUS group (PCN = 65.6%; RUS = 20%). However, the creatinine value before the intervention was at the upper limit of normal in the RUS group (1.5 mg/dL), but more than 2-fold higher in the PCN group (3.2 mg/dL). In contrast, the percentage of creatinine reduction was comparable between the 2 groups in the studies conducted by Kurita et al.[28] (PCN = 77.4%; RUS = 76.5%), Ku et al.[20] (PCN = 44.4%; RUS = 46.1%; $P = 0.058$), and De Lorenzis et al.[32] (PCN = 35.7%; RUS = 33.3%; $P = 0.8$). While no statistical analysis was performed by Kurita et al.[28], the statistically equivalent effect of PCN and RUS on the renal function was shown by Ku et al.[20] and De Lorenzis et al.[32]. Lack of reporting the time at which the creatinine was measured postoperatively might be the reason behind the variability in the percentage of the creatinine reduction among the studies. Among the above studies, only Kurita et al.[28] documented the time of the creatinine assessment, which was 2 weeks post intervention. Kanou et al.[18] noted that renal function

TABLE 2.

Characteristics of the enrolled studies that included both MUO and BUO patients

Author, Year	Country	Institutions No.	Study design	Study period	
Ghous et al., 2021	Pakistan	single	Cross sectional	Jan 2019 to Oct 2019	
Sabuncu et al., 2019a	Turkey	single	Retrospective	Dec 2014 to Dec 2016	
Ahmad I et al., 2013	Pakistan	single	Prospective cohort (randomized)	Jan. 2010 to Dec. 2011	
Chang et al., 2012	Taiwan	single	Retrospective	2003 to 2009	

TABLE 3.

Summary of the primary tumors, objectives, and the conclusions of the included studies

Author, Year	Primary tumors	Objectives	Conclusion
Stevens et al., 1994	11 cervical, 9 bladder, 7 prostate, 7 uterine, 4 ovarian, 4 ureteral, 4 lymphoma, 2 colon, 2 testicular, 2 sarcoma, 1 rectum, vulva, 1 breast, 1 renal and 1 unknown	To determine the indication and the results of PCN and RUS in MUO	RUS is generally preferred over PCN
Hubner et al., 1993	15 colon, 13 bladder, 9 cervical, 6 ovarian, 4 prostate, 5 others	Analyse the efficacy of the endo-urological procedures in MUO	MUO can be treated in most cases with little morbidity and frequently without the use of external collecting devices, no difference in QoI
Barton et al., 1992	NR	To identify the indications, complications, and efficacy of PCN and RUS in women with gynecologic cancer.	Both diversional methods are safe and often improve renal function
Kurita et al., 1992	NR	Evaluate the effects of PCN and RUS, indication and complications	No statistically significant difference between the two groups in improving renal function; more occlusion with RUS; PCN is preferable in MUO
Gasparini et al., 1991	5 cervical, 5 gastrointestinal ,5 bladder, 3 ovarian, 2 prostate cancers	Assess the outcome of urinary diversion	Urinary diversion can be performed with low morbidity and can improve quality of life, with improvement in renal function in most of the cases. More febrile UTI seen with PCN than RUS
Zadra et al., 1987	28 Cervical, 17 prostate, 16 bladder, 10 ovarian, 8 gastrointestinal, 8 breast, 5 lymphoma, 3 testicular, 2 lung, 1 uterine cancer	Evaluate the outcome of urinary diversion	MUO can be successfully relieved with little morbidity and mortality and frequently without the use of external collection devices. Renal function improved in most of the cases.
Ghous et al., 2021	3 bladder, 2 prostate, 5 cervical, 10 other cancers	To analyse the use of PCN and RUS in management of ureteral obstruction	PCN is better than RUS in preserve renal function and less complication.
Sabuncu et al., 2019	NR	To compare the efficacy of PCN and RUS on ureteral obstruction and QoI	Both of PCN and RUS adequately alleviated obstruction and the effect on renal function was similar; no difference in QoI
Ahmad et al., 2013	19 bladder, 10 prostate, 9 cervical, 18 other cancers	To compare the complications of the PCN and RUS in obstructive uropathy	PCN is better and safer method with fewer complications than RUS
Chang et al., 2012	28 cervical, 9 prostate, 8 colon, 3 bladder, 1 stomach, 1 ovarian, 1 lung, 1 endometrial, 1 lymphoma, 1 breast cancer.	To compare the efficacy and the complications of PCN and RUS for relieving ureteral obstruction	Irrespective of the etiology, PCN is better choice to preserve renal function. No significant different in complications.

	Patients No. Total	Patients. No. MUO	PCN, No. MUO	RUS, No. MUO	Age (years)	Sex (M, F)	NOS score
	110	54	28	26	Mean 60	M=47, F=63	4
	42	10	NR	NR	Mean 50.5	NR	5
	300	56	36	20	Mean 43	M=218, F=82	7
	110	54	28	26	63.6	M=47, F=63	6

TABLE 4.
Serum creatinine changes

Author, year	RUS		PCN		*P* value
	Cr. Before intervention Mean ± SD	Cr. Post intervention Mean ± SD	Cr. Before intervention Mean ± SD	Cr. Post intervention Mean ± SD	
De Lorenzis et al., 2020	1.5 (1–3.7) mg/dL	1 (0.6–1.5) mg/dL	1.4 (0.9–2) mg/dL	0.9 (0.7–1.2) mg/dL	0.8
Ku et al., 2004	2.6 ± 0.4 mg/dL	1.4 ± 0.4 mg/dL	4.5 ± 0.5 mg/dL	2.5 ± 0.2 mg/dL	0.058
Hyppolite et al., 1995	8.2 ± 7.7 mg/dL	2.4 ± 0.4 mg/dL	7.1 ± 4.5 mg/dL	1.5 ± 0.5 mg/dL	NR
Kurita et al., 1992	4.13 ± 2.63 mg/dL	0.97 ± 0.42 mg/dL	5 ± 3.09 mg/dL	1.13 ± 0.46 mg/dL	NR

RUS: retrograde ureteral stent; PCN: percutaneous nephrostomy; NR: not reported; Cr: creatinine; SD: standard deviatiodeviation

improved after UD in all MUO patients, irrespective of the UD method.

Regarding the studies that assessed renal function in a mixed population (MUO and BUO), Ghous et al.[33] and Chang et al.[36] concluded that PCN is superior to RUS. This was based on the higher residual hydronephrosis in the RUS group compared with the PCN group.

Although RUS successfully improved the renal function in MUO, some studies reported that it failed to maintain this improvement, and PCN was required. Liaw et al.[22] revealed that PCN was necessary to maintain renal drainage in 38% of the RUS group. Tan et al.[13] and Song et al.[15] recorded 13% and 18% respectively of the RUS converted into PCN because they failed to drain the kidney. Ganatra et al.[11] also reported that 24% of 133 patients with RUS required PCN because of late failure of the stents as a result of cancer progression. Domico and Dewolf reported that 46% of patients with extrinsic ureteral obstruction failed to maintain kidney drainage within 30 days of insertion[37] Jenkins and Marcus reported that 2 of 10 stents lost their patency during an average observation period of 20 months in patients with MUO[38]. Chang et al.[36] evaluated the difference between RUS and PCN in maintaining renal function after diversion. They reported a lower elevation in creatinine in the PCN group (0.21 mg/dL) compared with the RUS group (0.78 mg/dL; $P = 0.03$) during the diversion period. Kanou et al.[18] found that using stents without shaft vent holes was successful in improving and maintaining renal function.

In summary, both diversional methods are effective, and there is inconclusive evidence to suggest the superiority of one intervention over the other. However, the available evidence suggests that PCN provides more durable renal drainage than RUS and therefore maintains renal function better.

Technical success rate

In this review, the technical success rate is defined as the successful insertion of a RUS or PCN. The success rate was reported in 14 studies in patients with MUO [5,13,15,16,18,19,21,22,24,26,27,29,30,32]. The success rate of RUS in these studies ranged from 21% to 100% (mean 70.3%). The success rate for PCN was higher in these studies, ranging from 90% to 100% (mean 98.8%). Additionally, one study[35] included patients with MUO or BUO. Here the success rate of RUS was 83% and of PCN was 92% (**Table 5**).

TABLE 5.
Technical success rate

	Lorenzis et al. 2020	Tan et al., 2019	Ahmad I et al., 2013	Song et al., 2012	Migita et al., 2011	Kanou et al., 2007	Wong et al., 2007	
RUS success rate	80.4%	77.5%	83%	81.3%	88%	72.5%	84%	
PCN success rate	NR	100%	92%	100%	NR	NR	98.6%	

Author, Year	Primary tumors	Objectives	
Botkin et al., 2021	Cervical cancer	Determine efficacy of RUS vs PCN	
De Lorenzis et al., 2020	14 rectal, 28 colon, 5 gastric 3 pancreatic, 1 appendicular	Evaluate renal function, duration of hospitalization and complications in MUO patients with primary gastrointestinal malignancies treated with PCN or RUS	
Tan et al., 2019	Cervical cancer	Determine efficacy of RUS vs PCN	
Monsky et al., 2013	9 bladder, 9 cervical, 2 uterine, 3 prostate cancers	Evaluate QoL and complications	
Song et al., 2012	26 cervical, 22 endometrial, 20 ovarian, 4 leiomyosarcoma from uterus, 1 vaginal, 2 choriocarcinoma	Evaluate efficacy of RUS vs PCN	
Migita et al., 2011	Gastric cancer	Evaluate the clinical outcome	
Kraemer et al., 2009	Prostate cancer	Difference in use and stability of PCN and RUS	
Kanou et al., 2007	23 Cervical, 2 uterine, 4 ovarian, 17 rectal, 11 prostate, 11 stomach, 4 bladder, 2 retroperitoneal, 1 lymphoma	Effectiveness of urinary diversion	
Wong et al., 2007	NR	Evaluate the clinical outcomes of urinary diversion	
Ku et al., 2004	NR	To compare complications and morbidities after PCN or RUS in MUO	
Chitale et al., 2002	28 prostate, 30 bladder, 4 cervical, 3 rectal cancers	To evaluate PCN, staged antegrade stent and RUS	
Feng et al., 1999	12 cervical, 10 prostate, 5 bladder, 4 colon, 4 ovarian and 1 uterine cancer.	To determine the efficacy of drainage, QoI, success and complication rates	
Liaw et al., 1997	Gastric cancer	To present clinical picture, obstructive levels and management of MUO in gastric cancer	
Hyppolite et al., 1995	30 cervical, 3 ovarian and 1 vaginal	To evaluate any treatment modalities is superior in treatment MUO	
Desportes et al., 1995	20 bladder, 19 prostate, 23 uterine, 10 ovarian, 19 gastrointestinal, 6 breast and 7 other cancers	To clarify the indication PCN and RUS	
Stevens et al., 1994	11 cervical, 9 bladder, 7 prostate, 7 uterine, 4 ovarian, 4 ureteral, 4 lymphoma, 2 colon, 2 testicular, 2 sarcoma, 1 rectum, vulva, 1 breast, 1 renal and 1 unknown	To determine the indication and the results of PCN and RUS in MUO	
Hubner et al., 1993	15 colon, 13 bladder, 9 cervical, 6 ovarian, 4 prostate, 5 others	Analyse the efficacy of the endo-urological procedures in MUO	
Barton et al., 1992	NR	To identify the indications, complications, and efficacy of PCN and RUS in women with gynecologic cancer.	
Kurita et al., 1992	NR	Evaluate the effects of PCN and RUS, indication and complications	

	Chitale et al., 2002	Feng et al., 1999	Liaw et al., 1997	Desportes et al., 1995	Hubner et al., 1993	Barton et al., 1992	Gasparini et al., 1991	Zadra et al., 1987
	21%	71%	88.8%	74.5%	100%	65.8%	39%	41%
	100%	100%	100%	100%	100%	90%	100%	NR

	Conclusion
	High stent failure rate/ no significant difference in complications
	No significant difference between the two groups in post-interventional creatinine level and complication rate. Longer hospitalization in PCN group.
	RUS is preferable, PCN better in severe HN; no statistically significant difference in complications, cost, surgical time, and hospitalization
	No significant difference in QoL or complications between the groups
	RUS is first line in gynecological cancers, PCN is preferable with high cystatin C > 2.5 mg/dL and segmental ureteral stricture > 3cm
	Urinary diversion should be determined based on the symptoms, survival, and quality of life
	Both PCN and RUS are effective in improving renal function. PCN is recommended in severely ill patients and high creatinine.
	Stents without shaft vent holes have a high patency rate
	No statistically significant difference in complications between PCN and RUS
	No significant difference in complications, morbidities in both diversional methods are minimal, patients with ureteral stent should be carefully monitored for stent obstruction.
	RUS has unacceptably high failure rate
	PCN is safe and effective, should be considered as the primary method in MUO
	Both PCN and RUS improved renal function, RUS showed high failure rate with respect to patency
	RUS is more prone to urosepsis and should be avoided, PCN is better in renal function preservation.
	Internal drainage is better supported than external drainage, efficacy of drainage was comparable in the two groups. Recommend trying with internal stent first if failed do PCN and then internalize it.
	RUS is generally preferred over PCN
	MUO can be treated in most cases with little morbidity and frequently without the use of external collecting devices, no difference in Qol
	Both diversional methods are safe and often improve renal function
	No statistically significant difference between the two groups in improving renal function; more occlusion with RUS; PCN is preferable in MUO

TABLE 6.
Complication rate

Author	Pain		Dislodgement / migration		Infection		Clogged / obstructed		Hematuria		[1]Other complications	
	RUS	PCN	RUS	PCN	RUS	PCN	RUS	PCN	RUS	PCN	RUS	PCN
Botkin et al., 2021	33.8%	31.1%	NR	NR	27.3%	29.2%	NR	NR	22.1%	23.6%	1.3%	1.9%
Tan et al., 2019	NR	NR	10%	10.3%	NR	NR	NR	NR	NR	NR	NR	NR
Monsky 2013	6.6%	25%	6.6%	43.7%	6.6%	18.7	NR	25%	NR	NR	6.6%	6.25%
Ahmad et al., 2013	12%	NR	2%	4.5%	7%	3.5%	NR	NR	10%	4.5%	6%	NR
Migita et al., 2011	20%	NR	NR	40%	33.3%	20%	13%	NR	20%	NR	NR	NR
Wong et al., 2007	NR	1.2%	NR	3.8%	20%	35%	32%	25%	8%	2.5%	8%	2.5%
Kanou et al., 2007	5.4%	6.5%	NR	19.5%	NR	NR	17.2%	8.6%	NR	NR	2.7%	4.3%
Ku et al., 2004	NR	NR	NR	6.25%	10.3%	15%	11%	1.3%	NR	NR	NR	NR
Feng et al., 1999	9%	NR	4.5%	20%	NR	NR	NR	NR	NR	NR	4.5%	NR
Hyppolite et al., 1995	NR	NR	NR	NR	86%	5.8%	NR	NR	NR	NR	NR	17.6%
Desportes et al., 1995	NR	NR	NR	3.5%	NR	NR	15.7%	NR	NR	NR	NR	3.5%
Stevens et al., 1994	23.5%	NR	NR	NR	4.7%	NR	NR	NR	NR	NR	19%	NR
Hubner et al., 1993	23%	NR	2.9%	17.8%	NR	NR	NR	NR	NR	NR	NR	NR
Barton et al., 1992	NR	NR	10.3%	10.5%	44.8%	7.8%	NR	NR	65%	57%	NR	5%
Kurita et al., 1992	84.6%	NR	NR	8%	15.4%	16%	53.8%	NR	15.4%	100%	NR	NR

RUS, retrograde ureteral stent; PCN, percutaneous nephrostomy; NR; not reported RUS: ureteral perforation, fistula, encrustation, stent break, retention; PCN: leaking, bleeding at nephrostomy

According to some studies, the primary tumor type significantly impacts the success rate of the RUS. RUS has a high failure rate in MUO caused by bladder and prostate cancer[6,8,19,30]. Wong et al.[19] and Zadra et al.[30] recommended that PCN should be the primary UD method in bladder and prostate cancers. However, Ganatra et al.[11] found that the primary tumor type did not determine the need for PCN. Song et al.[39] reached the same conclusion, stating that the type of gynecological tumor was not a predictor of the need for PCN, and he recommended that RUS should be the first option in MUO caused by gynecological tumors. Regarding the primary tumor in the other studies with a high RUS success rate, Liaw et al.[22] and Migita et al.[16] enrolled

TABLE 7.
Conversion from one diversional method to the other

Author	Botkin et al., 2021	Ghous et al., 2021	Tan et al., 2019	Song et al., 2012	Chang et al., 2012	Kanou et al., 2007
Stent to nephrostomy	42.6%	10.4%	13%	18%	10.4%	21.6%
Nephrostomy to stent	11.7%	NR	NR	NR	NR	NR

NR: not reported

only gastric cancer patients in their studies, whereas Wong et al.[19] did not specify the initial tumor type of the included patients. While Kraemer et al.[17] did not report the success rate between the 2 groups in their cohort of 51 patients with prostate cancer, they reported that both UD methods were efficient in managing MUO in prostate cancer. **Online Appendix Table 1** shows a summary of the studies based on the type of the primary tumor as well as the material, size, and exchange time of RUS and PCN.

On the other hand, a very low success rate has been recorded in other studies. Chitale et al.[21] found a success rate of 21% among 65 patients, of whom 30 had bladder cancer and 28 had prostate cancer. Gasparini et al.[29] reported a success rate of 39% in their cohort of 22 patients, of whom 6 had bladder cancer and 2 had prostate cancer. In the hands of experienced urologists, RUS in MUO can reach a high success rate. However, we recommend PCN as the preferable UD method in MUO caused by bladder cancer and, to a lesser degree, prostate cancer.

Complication rate

Different complications associated with RUS and PCN were reported in 15 publications out of 25 in this review (**Table 6**)[5,13,14,16,18–20,23–28,31,35]. Botkin et al.[31], Ku et al.[20], Song et al.[15], Tan et al.[13], Wong et al.[19], and Monsky et al.[14] reported no statistically significant difference in the complication rate between PCN and RUS groups. In RUS, pain and symptoms of bladder irritation were documented in 9 studies[5,14,16,18,25,26,28,31,35], ranging from 5% to 85% of the included patients (mean = 24%), whereas pain associated with PCN was reported in 4 studies from 1% to 31% (mean = 16%)[14,18,19,31]. Dislodgment of the PCN is a frequently encountered complication reported in 12 studies, varying between 3% and 44% (mean = 15.6%),[5,13,14,16,18–20,24,26–28,35], while migration of the ureteral stent was noted in 2% to 10% of the patients in 6 studies (mean = 6%)[5,13,14,26,27,35].

Infection associated with PCN and RUS was investigated in 10 series[14,16,19,20,23,25,27,28,31,35]. Ahmad et al.[35], Migita et al.[16], Hyppolite et al.[23], Stevens et al.[25], and Barton et al.[27] found infection to be more common with RUS, while Botkin et al.[31], Monsky et al.[14], Wong et al.[19], and Kurita et al.[28] reported that it was higher with PCN. Nonetheless, the difference between the 2 groups in the infection rate was not statistically significant. In the RUS group the infection ranged from 6% to 86% (mean = 25.5%), compared with 3.5% to 35% (mean = 16.7%) in the PCN group.

Stent obstruction and nephrostomy blockage were reported in 7 publications. This occurred from 11% to 54% (mean = 23%) in the RUS group,[16,18–20,24,28] and from 1% to 25% (mean = 14.9%) after PCN[14,18–20]. All these studies showed that obstruction was more common after RUS than PCN with the exception of Monsky et al.[14].

Six studies evaluated the difference in the rate of hematuria between PCN and RUS. Ahmad et al.[35] Migita et al.[16] Wong et al.[19], and Barton et al.[27] reported that hematuria is more common in the RUS groups, while Botkin et al.[31] and Kurita et al.[28] observed it more commonly in the PCN group. Bleeding from the PCN site was reported in 4% of cases by Kanou et al.[18] and 18% of the patients by Hyppolite et al.[23] reported on one patient with arterial hemorrhage requiring embolization after RUS insertion.

Other complications of RUS have been reported in a small number of studies. Stent breakage was found in 4.7% of cases by Stevens et al.[25] and 4% by Wong et al.[19]. Stone formation was reported in 2.7% by Kanou et al.[18]. Ureteral perforation was described in 9.5% of cases by Stevens et al.[25] and 1% by Ahmad et al.[35]. Fistula formation was documented in 4.7% (to the iliac artery) by Stevens et al.[25] and 6.5% (to the vagina) by Monsky et al.[14].

In the PCN group, fistula was reported in 3.5% by Desportes et al.[24]. Leakage around the PCN was seen in 2.5% to 18%: 2.5% by Wong et al.[19], 5% by Barton et al.[27] 6% by Monsky et al.[14] and 18% by Hyppolite et al.[23]. Urinary retention occurred equally frequently in both groups in one study: PCN 1.9% versus RUS 1.3% [31].

Some studies compared the percentage of complication between the 2 groups in general without detailing the type of complication[15,30]. All studies reported equivalent complication rates between the diversion

	Wong et al., 2007	Chitale et al., 2002	Feng et al., 1999	Liaw et al., 1997	Desportes et al., 1995	Stevens et al., 1994	Hubner et al., 1993	Gasparini et al., 1991
	NR	NR	27.2%	37.5%	NR	NR	NR	NR
	27%	98.3%	NR	NR	60%	36%	72%	14%

TABLE 8.
Length of hospital stay in days

Author	RUS	PCN	*P*-Value
De Lorenzis et al., 2020	5* (2–13)	12* (4.2 - 21.7)	0.04
Tan et al., 2019	1.7* ± 0.3	3.2* ± 0.5	0.000
Song et al., 2012	1.9* ± 0.4	3* ± 0.5	0.0000
Kraemer et al., 2009	2§ (1–9)	2§ (0-23)	NR
Desportes et al., 1995	4.6*	13*	NR

*Keys: *mean; §median; NR: not reported*

types [13,16,19,20,31] except De Lorenzis et al.[32] who reported higher complications after RUS (PCN = 4.2%; RUS = 22.2%; $P = 0.06$). Overall, the global complication rate between procedures was comparable.

Conversion into another diversional method

While conversion from PCN to stent is the ultimate goal to eliminate external tubes and collecting devices, conversion from stent to PCN typically occurs secondary to stent complications or inability of the stent to drain the kidney. In this review, 8 studies showed switching from stents into PCNs, [5,13,15,18,22,31,33,36], and 7 studies showed internalization of the PCNs[19,21,24–26,29,31]. The rate of conversion into PCN ranged from 10% to 42.6% (mean = 22.5%), whereas internalization of the PCN ranged from 11.7% to 98% (mean = 45.5%) (**Table 7**).

Residual hydronephrosis

Only 2 studies explored the difference in the residual hydronephrosis between PCN and RUS[33,36]. These 2 studies included patients with MUO and BUO, and they revealed identical results, with 65.2% residual hydronephrosis in the RUS group and 27.2% in the PCN group.

Length of hospital stay

Five studies investigated the difference in hospital stay between PCN and RUS[13,15,17,24,32], and 3 of them showed a statistically significant duration of hospital stay in the patients with PCN[13,15,32]. This may be attributed to the decreased overall health of patients who undergo PCN (**Table 8**).

Procedure time

Three studies evaluated the difference in procedure time between the 2 groups. In all 3 studies, PCN required more time than RUS. Tan et al.[13], Song et al.[15], and Kanou et al.[18] reported mean procedure times of 30.6 ± 10.1, 39 ± 7.8, and 41.2 with RUS, and 51 ± 8.7, 52.4 ± 6.4, and 48.8 with PCN, respectively.

Financial cost

According to Tan et al.[13] and Song et al.[15], the PCN was more expensive than the RUS. The 2 studies were conducted in China in 2019 and 2012. The average cost was US$173.5 ± 4.1 and $89 ± 3.04 for RUS insertion compared with $595.14 ± 5.34 and $468 ± 3 for PCN insertion.

Quality of life assessment post intervention

Four studies compared the quality of life between PCN and RUS in patients with MUO[5,14,18,26]. However, only Monsky et al.[14] used a validated questionnaire to prospectively assess the quality of life (FACT-BL version 4). He assessed the emotional, functional, and physical well-being of patients after both types of UD at 7, 30, and 90 days post intervention and concluded that there was no statistically significant difference between the 2 groups. It is worth mentioning that the baseline quality of life was not assessed before intervention in both groups, which might induce bias in the result. "Useful life" was used to assess the improvement in the quality of life after the intervention in 2 studies[5,26]. It is calculated based on the presence of pain, complications, the ability to return home, and mental capacity. Feng et al.[5] reported that useful life was achieved in 82% of PCN patients and 87% of RUS patients. According to Hubner et al.[26] "useful life" was achieved in 96% of the RUS group and 68% of the PCN group. Kanou et al.[18] evaluated the difference in the quality of life between the 2 groups according to the number of days the patients spent out of the hospital. Only 60% of the RUS group patients left the hospital and were able to spend an average of 5.7 months out of it, whereas in the PCN group, 79% of the patients left and spent 4.5 months away from the hospital. Despite the heterogeneity in the assessment of the quality of life in MUO patients

among the 4 included studies in this review, none of these studies showed a statistically significant difference in the quality of life between the 2 groups.

Limitations

The systematic review has several limitations, including an unequal and/or small sample size of the 2 groups in many of the included studies. In addition, the heterogeneity among the studies reduce the reliability of the evidence in the findings. Very few studies investigated and compared the changes in the renal function after intervention, and most of these were single-centre studies with significant limitations. The retrospective nature of the included studies and the absence of randomization increase the possibility of bias in these studies, especially with respect to selection bias in determining which patients receive RUS or PCN. Other limitations in some studies that limited their generalizability were the inclusion of a specific type of tumor to compare the PCN and RUS as in the studies that involved only gastric or gynecological cancers.

Conclusion

Both procedures are effective in management of MUO. Because of the heterogeneity of the included studies, the superiority of one of the procedures over the other cannot be concluded.

A future randomized control trial with a large sample size will be required to eliminate the bias of retrospective studies. In the absence of such a trial, a larger multi-centre retrospective study with some form of propensity matching may provide a more accurate assessment of the differences. Special attention is required on the impact of these interventions on patient quality of life.

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