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Review

Percutaneous nephrostomy versus ureteral stent in hydronephrosis secondary to obstructive urolithiasis: A systematic review and meta-analysis

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Percutaneous nephrostomy;
Obstructive urolithiasis;
Urinary symptoms;
Quality of life

Abstract *Objective:* To assess if there is a preferable intervention between retrograde ureteral stent (RUS) and percutaneous nephrostomy (PCN) tube, in cases of upper urinary tract stone obstruction with complications requiring urgent drainage, by evaluating outcomes regarding urinary symptoms, quality of life (QoL), spontaneous stone passage, and length of hospital stays, since there is no literature stating the superiority of one modality over the other.
Methods: We searched MEDLINE and other sources for relevant articles in June 2019 without any date restrictions or filters applied. The selection was done first by the title and abstract screening and then by full-text assessment for eligibility. Only randomized controlled trials or cohort studies in patients with hydronephrosis secondary to obstructive urolithiasis that presented comparative data between PCN and RUS placement concerning at least one of the defined outcome measures were included. Lastly, MEDLINE database and PubMed platform were screened again using the same terms, from June 2019 until November 2022.
Results: Of 556 initial articles, seven were included in this review. Most works were considered of moderate-to-high quality. Three studies regarding QoL showed a tendency against stenting, even though only one demonstrated statistically significant negative impact on overall health state. Two works reported significantly more post-intervention urinary symptoms in stenting patients. One article found that PCN is a significant predictor of spontaneous stone passage, when adjusted for stone size and location. Findings on length of hospital stays were not consistent among articles.

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Conclusion: PCN appears to be the intervention better tolerated, with less impact on the patient's perceived QoL and less post-operative urinary symptoms, in comparison with RUS. Nevertheless, further studies with larger samples and a randomized controlled design are suggested.

1. Introduction

Urinary lithiasis is a multifactorial disease which involves abnormal crystallization conditions of urine in the urinary tract [1]. As a result, crystal concretions can form anywhere in the urinary apparatus and obstruct urine passage. It is an increasing urologic health issue in modern society with an estimated lifetime prevalence of 1%—15%, although it may vary by age, gender, or race [2,3].

An upper tract stone may completely block the collecting system and compromise adequate urine flow causing hydronephrosis which is linked to a variety of complications including infection or renal failure [2]. Such cases are regarded as urologic emergencies and need urgent urinary tract decompression, while definitive removal of the stone should not be completed until the patient's condition improves.

Current guidelines from European Association of Urology [4], American Urological Association [5], and Urological Association of Asia (UAA) [6] indicate placement of either a retrograde ureteral stent (RUS) or a percutaneous nephrostomy (PCN) tube in the setting of emergent drainage. However, the superiority of one method over the other remains a subject of controversy, as both appear to have similar efficacy and complications. The complications of PCN are well described and mostly associated with hemorrhage, while the complications of RUS are not as clearly documented [7,8].

The purpose of this systematic review and meta-analysis was to evaluate a preferable intervention between the two options available for urgent decompression in cases of hydronephrosis secondary to urinary calculi.

2. Methods

2.1. Search strategy

The main search was conducted in the MEDLINE database and the PubMed platform in June 2019 without any date restrictions or filters applied. Key words related to PCN and ureteral stenting in the setting of calculi obstruction were selected after verification of Medical Subject Headings terms. The following arrangement of search terms was used: (double J stent OR JJ stent OR ureteral stent OR ureteric stent) AND percutaneous nephrostomy AND (obstruction OR calculi OR urosepsis) NOT nephrolithotomy. In order to ensure a more complete data collection, the reference list of the review on this subject by Hsu et al. [8], published in 2016, was also screened for further articles that did not appear in the initial search results. Lastly, MEDLINE database and PubMed platform were screened again using the same terms, from June 2019 until November 2022.

2.2. Outcomes

The primary outcomes considered were patient-perceived quality of life (QoL) measured by self-report scales (EuroQoL-5 Dimension [EQ-5D] and a EuroQoL visual analogue scale [EQ-VAS]) and post-operative urinary symptoms (using an intervention-specific questionnaire to assess hematuria, dysuria, urgency and urinary frequency of the included participants, with a four-point rating scale) [9,10]. Secondary outcomes were spontaneous stone passage (when there was an image evidence in follow-up CT scan or when no stone was identified during the elective ureteroscopy) [10] and length of hospital stays after procedure.

2.3. Eligibility criteria and study selection

For this systematic review, only randomized controlled trials or cohort studies were considered. The studies had to include comparative data between PCN and RUS placement in patients with hydronephrosis secondary to obstructive urolithiasis, concerning one of the defined outcome measures. Studies with any of the following criteria were excluded:

i. studies that used nephrectomy as the primary treatment or additional open or percutaneous procedures, such as percutaneous nephrolithotomy;
ii. Studies done exclusively in pregnant women or pediatric patients (<18 years);
iii. Renal transplantation patients or patients with obstruction due to malignant or non-lithiasic pathology;
iv. Total study population of less than 20 patients;
v. Non-English language articles or animal studies.

Study selection was done according to Preferred Reporting Items for Systematic reviews and Meta-Analysis flow chart (Fig. 1). Search results were first screened by titles and then by abstracts. Screened articles were independently evaluated for eligibility by full-text reading of each article. Disagreements during this process were resolved by consensus.

2.4. Risk of bias assessment

The risk of bias was assessed by using Critical Appraisal Skills Programme (CASP) checklists [11,12]. CASP Cohort

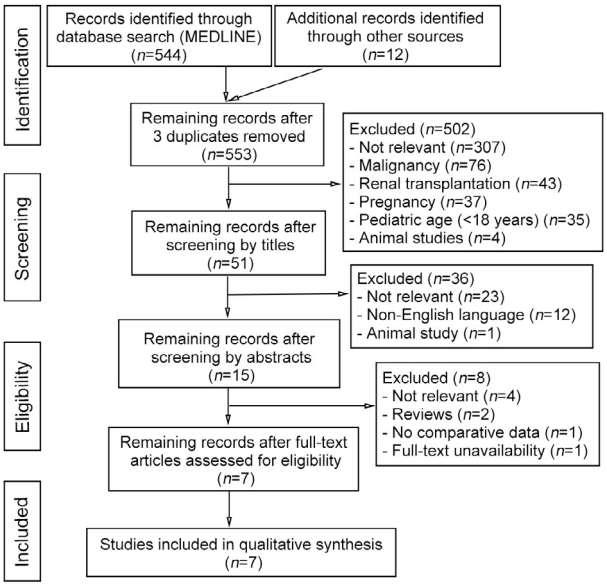


Figure 1 Flow chart of study selection.

Study Checklist was used for studies with a cohort design and CASP Randomized Controlled Trial Checklist was used for studies with a randomized controlled design.

2.5. Data extraction and analysis

Relevant data were extracted from the eligible studies and were confirmed twice by authors to avoid errors. A meta-analysis of the studies with comparable data was conducted for each reported outcome with the exception of length of hospital stays because of discrepancy in reporting measures across articles.

3. Results

3.1. Study characteristics

A summary of the demographic and clinical information of the included studies is presented in Table 1. All the articles were published between 1998 and 2019. Three studies were conducted in Europe, two in Asia, and two in North America. Five studies (71.43%) had a cohort design, three being prospective, and two retrospective. The other two studies were randomized controlled trials.

The total number of cases considered in this systematic review was 355 for patients who underwent PCN, while 300 patients had an RUS placed. Most studies lacked some of patient clinical information such as BMI, urolithiasis history, number of stones, and stone site.

3.2. QoL

Two prospective cohort studies, de Sousa Morais et al. [10] and Joshi et al. [9] evaluated the impact of PCN and RUS in QoL, using a validated generic questionnaire, EQ-5D, which includes questions on five health-related categories (mobility, self-care, usual activities, pain or discomfort, and anxiety or depression), and EQ-VAS for global health state appraisal.

Joshi et al. [9] only administered the questionnaire post-intervention, while de Sousa Morais et al. [10] applied it both before and after the urinary diversion (Table 2). Although there was no significant difference in the median EQ-VAS values between the two groups both pre- and post-intervention, there was a significant decrease in this value after the intervention, but only in the RUS group ($p<0.001$) [10].

The post-intervention results were then included in the meta-analysis (Fig. 2A). RUS was associated with significantly more reported problems regarding mobility (odds ratio [OR] 3.16, 95 % confidence interval [CI] 1.12–8.90, $p=0.03$). No significant difference was found in reported problems in the remaining categories: self-care (OR 0.75, 95 % CI 0.18–3.21, $p=0.70$), usual activity (OR 0.91, 95 % CI 0.30–2.74, $p=0.86$), pain or discomfort (OR 3.19, 95 % CI 1.00–10.21, $p=0.05$), and anxiety or depression (OR 1.32, 95 % CI 0.54–3.22, $p=0.54$). Overall, the total number of reported problems was significantly higher for the RUS group, when all categories were considered (OR 1.67, 95 % CI 1.04–2.68, $p=0.04$).

A third study by Mokhmalji et al. [13] applied a questionnaire to patients immediately post-intervention and 2 weeks to 4 weeks subsequently. Each questionnaire contained 42 questions which were used for establishing a QoL index. The index acquired immediately post-intervention was 7% higher after PCN than after RUS, although these results were not statistically significant. In the second assessment, it was observed further deterioration of QoL in stenting patients, while the PCN group had some improvement.

3.3. Urinary symptoms

Two articles compared the incidence of post-interventional urinary symptoms between PCN and RUS (Supplementary Table 1), and both revealed statistically significant results. Patients who underwent PCN presented fewer urinary symptoms than stenting patients, considering all four types of symptoms referred (de Sousa Morais et al. [10]: hematuria $p<0.001$; dysuria $p<0.001$; urgency $p=0.001$; frequency per day $p=0.018$; Joshi et al. [9]: hematuria $p=0.0227$; dysuria $p<0.0001$; urgency $p=0.0020$; frequency per day $p=0.0202$).

We included their results in our meta-analysis (Fig. 2B), and verified that patients in RUS group presented with significantly more urinary symptoms of any type (OR 10.78, 95% CI 5.50–21.14, $p<0.00001$) compared with PCN group: hematuria (OR 7.08, 95% CI 2.44–20.58, $p=0.0003$), dysuria (OR 19.12, 95% CI 5.94–61.58, $p<0.00001$), and urgency (OR 9.89, 95% CI 2.63–37.18, $p=0.0007$; Fig. 2B).

The article by Ahmad et al. [14] compared the incidence of complications between the two interventions, including hematuria. It was reported in 4.5% and 10% of the patients from PCN and RUS groups, respectively. However, no statistical analysis data were available.

Table 1 Summary of demographic and clinical information of the studies.

Study	Country	Study design	Case (PCN/RUS), *n*	Age, year	Gender ratio (M/F), %	BMI, kg/m^2	Urolithiasis background, %	Stone site, %			Number of stones, %		Stone size	
								Proximal ureter	Distal ureter	Renal	Single	Multiple	Area, mm^2	Diameter, mm
de Sousa Morais et al., 2019 [10]	Portugal	Prospective cohort	50 (18/32)	57.6[a]	50/50	27.5[a]	70	54	46	0	66	34	66.9[b]	NA
Ahmad et al., 2013 [14]	Pakistan	Prospective cohort	300 (200/100)	41[a]	73/27	NA	NA	NA	NA	NA	NA	NA	NA	NA
Goldsmith et al., 2013 [15]	USA	Retrospective cohort	130 (59/71)	56[b]	NA	NA	58	46[c]	49[c]	28[c]	70	30	NA	8[b]
Yoshimura et al., 2005 [16]	Japan	Retrospective cohort	59 (24/35)	62.6[a]	41/59	NA	NA	NA	NA	NA	NA	NA	NA	5.5[a]
Mokhmalji et al., 2001 [13]	Germany	Randomized controlled trial	40 (20/20)	52[a]	53/47	NA	NA	NA	NA	NA	NA	NA	NA	NA
Joshi et al., 2001 [9]	UK	Prospective cohort	34 (13/21)	55.4[a]	65/35	NA	NA	62	38	0	NA	NA	NA	9.6[a]
Pearle et al., 1998 [17]	USA	Randomized controlled trial	42 (21/21)	41.3[a]	43/57	27.6[a]	NA	48	52	0	NA	NA	NA	8.1[a]

BMI, body-mass index; F, female; M, male; PCN, percutaneous nephrostomy; RUS, retrograde ureteral stent; NA, not available.

[a] Mean.

[b] Median.

[c] Non-mutually exclusive.

Table 2 Quality of life assessment with EuroQol-5 Dimension.

Study	Intervention, *n*	EuroQol category (Pre/Post), %					EQ-VAS (Pre/Post)
		Mobility	Self-care	Usual activity	Pain or discomfort	Anxiety or depression	
de Sousa Morais et al., 2019 [10]	PCN, 18	27.8/22.2	0/0	27.8/27.8	27.8/22.2	44.5/50.0	70[a]/70[a]
	RUS, 32	21.9/37.5	6.3/9.4	6.3/15.6	25/46.9	37.6/59.4	80[a]/70[a]
Joshi et al., 2001 [9]	PCN, 13	NA/15	NA/23	NA/77	NA/85	NA/54	NA/61[b]
	RUS, 21	NA/32	NA/5	NA/91	NA/95	NA/57	NA/65[b]

Pre, before intervention; Post, after intervention; EQ-VAS, EuroQoL visual analogue scale; PCN, percutaneous nephrostomy; RUS, retrograde ureteral stent; NA, not available.
[a] Mean.
[b] Median.

3.4. Spontaneous stone passage

Two studies assessed the rate of spontaneous stone passage between PCN and RUS groups and were included in the meta-analysis (Fig. 2C). A higher rate of spontaneous stone passage was observed in PCN group, but there was no significant difference between interventions (OR 0.67, 95% CI 0.30–1.52, $p=0.34$).

de Sousa Morais et al. [10] also performed a multivariate logistic regression and included some other factors possibly associated with spontaneous stone passage (type of intervention, stone site, stone size, previous ureteral tract surgery, and expulsive medical therapy). According to this model, urinary diversion by PCN is a statistically significant predictor of spontaneous stone passage when compared with RUS (OR=6.667; 95% CI 1.034–42.970; $p=0.046$) [10].

3.5. Length of hospital stays

Two retrospective cohort studies, Goldsmith et al. [15] and Yoshimura et al. [16] found statistically significant and opposite results regarding length of hospital stays. Goldsmith et al. [15] performed an univariate analysis which revealed that PCN placement was associated with a longer hospital stays (4.2 days *vs*. 7.6 days for RUS and PCN groups, respectively; $p=0.001$). They confirmed this result by conducting a multivariable analysis, which included other factors that might influence hospital stays (patient age, Acute Physiology And Chronic Health Evaluation II score, and Charlson Comorbidity Index score). PCN was still the only factor associated with significantly longer hospital stays (5.6 adjusted days *vs*. 3.5 adjusted days; $p=0.001$) [15]. On the other hand, Yoshimura et al. [16] reported a mean hospital stay duration significantly higher for the RUS group (36.3 days *vs*. 17.6 days; $p<0.001$).

A prospective randomized trial by Pearle et al. [17] also evaluated this outcome and observed longer hospital stays in the PCN group (4.5 days *vs*. 3.2 days), even though these results were not statistically significant.

3.6. Risk of bias assessment

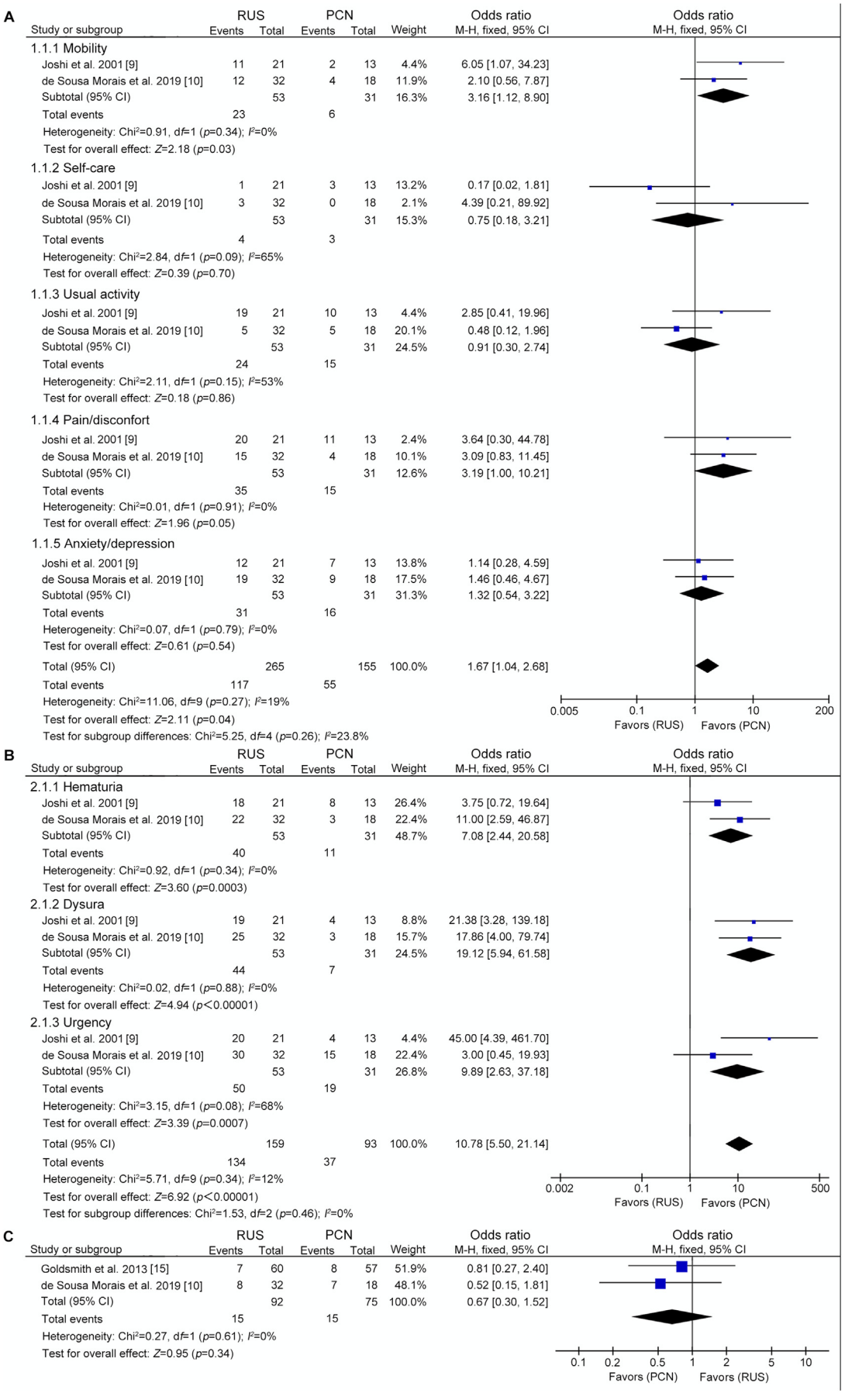
An overview of the risk of bias assessment of the studies addressed in this systematic review is displayed in Supplementary Figures 1 and 2. These works were generally of moderate-to-high quality for the evaluated parameters. However, common flaws in the cohort studies were the lack of identification of all important confounding factors and the little implications for practice owing to small sample sizes in most part. The fact that controlled randomized studies could not be blind is also a limitation.

4. Discussion

We aimed to analyze the available evidence comparing PCN and RUS placement as methods of urgent decompression in the setting of hydronephrosis secondary to obstructive urolithiasis. Despite the great prevalence of urolithiasis around the world, the supremacy of one of these procedures is still widely controversial [6,7], and not even recent international guidelines are able to recommend one procedure over the other [4–6].

The UAA guidelines [6] state, with high level of evidence and grade of recommendation, that for pyelonephritis accompanying urinary stone, active antibiotic treatment and timely drainage of kidney, through PCN or ureteral catheter insertion, should be done, and after the treatment of the infection, the removal and cure of the lithiasis should be performed. However, there is no evidence for the best drainage method; and these guidelines state that treatment should be individualized based on the age, general condition, and compliance of the patient [6]. In UAA guidelines, it is stated that RUS is appropriate for drainage of hydronephrosis [6]. However, it is also mentioned that PCN provides a way of draining off purulent content and determining possible residual renal function, and that if correctly placed, it is a fast, reliable, and quickly effective method of drainage in a single session [6]. Therefore, it might be inferred that PCN may have some advantages, at least, in pyonephrosis complicating urolithiasis, although there is not a clear statement of superiority of any modality over the other.

Even if we consider the recent and specific guidelines for infection control in the urological field [18], there is no guidance on the particular management of obstructive pyelonephritis, neither regarding the best method for upper urinary tract drainage, nor in how to deal with infections associated with PCN or double-J stents [18].


A
RUS
PCN
Odds ratio
Odds ratio
Study or subgroup
Events
Total
Events
Total
Weight
M-H, fixed, 95% CI
M-H, fixed, 95% CI
1.1.1 Mobility
Joshi et al. 2001 [9] 11 21 2 13 4.4% 6.05 [1.07, 34.23]
de Sousa Morais et al. 2019 [10] 12 32 4 18 11.9% 2.10 [0.56, 7.87]
Subtotal (95% CI) 53 31 16.3% 3.16 [1.12, 8.90]
Total events 23 6
Heterogeneity: Chi²=0.91, df=1 (p=0.34); I²=0%
Test for overall effect: Z=2.18 (p=0.03)
1.1.2 Self-care
Joshi et al. 2001 [9] 1 21 3 13 13.2% 0.17 [0.02, 1.81]
de Sousa Morais et al. 2019 [10] 3 32 0 18 2.1% 4.39 [0.21, 89.92]
Subtotal (95% CI) 53 31 15.3% 0.75 [0.18, 3.21]
Total events 4 3
Heterogeneity: Chi²=2.84, df=1 (p=0.09); I²=65%
Test for overall effect: Z=0.39 (p=0.70)
1.1.3 Usual activity
Joshi et al. 2001 [9] 19 21 10 13 4.4% 2.85 [0.41, 19.96]
de Sousa Morais et al. 2019 [10] 5 32 5 18 20.1% 0.48 [0.12, 1.96]
Subtotal (95% CI) 53 31 24.5% 0.91 [0.30, 2.74]
Total events 24 15
Heterogeneity: Chi²=2.11, df=1 (p=0.15); I²=53%
Test for overall effect: Z=0.18 (p=0.86)
1.1.4 Pain/disconfort
Joshi et al. 2001 [9] 20 21 11 13 2.4% 3.64 [0.30, 44.78]
de Sousa Morais et al. 2019 [10] 15 32 4 18 10.1% 3.09 [0.83, 11.45]
Subtotal (95% CI) 53 31 12.6% 3.19 [1.00, 10.21]
Total events 35 15
Heterogeneity: Chi²=0.01, df=1 (p=0.91); I²=0%
Test for overall effect: Z=1.96 (p=0.05)
1.1.5 Anxiety/depression
Joshi et al. 2001 [9] 12 21 7 13 13.8% 1.14 [0.28, 4.59]
de Sousa Morais et al. 2019 [10] 19 32 9 18 17.5% 1.46 [0.46, 4.67]
Subtotal (95% CI) 53 31 31.3% 1.32 [0.54, 3.22]
Total events 31 16
Heterogeneity: Chi²=0.07, df=1 (p=0.79); I²=0%
Test for overall effect: Z=0.61 (p=0.54)
Total (95% CI) 265 155 100.0% 1.67 [1.04, 2.68]
Total events 117 55
Heterogeneity: Chi²=11.06, df=9 (p=0.27); I²=19%
Test for overall effect: Z=2.11 (p=0.04)
Test for subgroup differences: Chi²=5.25, df=4 (p=0.26); I²=23.8%
0.005
0.1
1
10
200
Favors (RUS)
Favors (PCN)
B
RUS
PCN
Odds ratio
Odds ratio
Study or subgroup
Events
Total
Events
Total
Weight
M-H, fixed, 95% CI
M-H, fixed, 95% CI
2.1.1 Hematuria
Joshi et al. 2001 [9] 18 21 8 13 26.4% 3.75 [0.72, 19.64]
de Sousa Morais et al. 2019 [10] 22 32 3 18 22.4% 11.00 [2.59, 46.87]
Subtotal (95% CI) 53 31 48.7% 7.08 [2.44, 20.58]
Total events 40 11
Heterogeneity: Chi²=0.92, df=1 (p=0.34); I²=0%
Test for overall effect: Z=3.60 (p=0.0003)
2.1.2 Dysura
Joshi et al. 2001 [9] 19 21 4 13 8.8% 21.38 [3.28, 139.18]
de Sousa Morais et al. 2019 [10] 25 32 3 18 15.7% 17.86 [4.00, 79.74]
Subtotal (95% CI) 53 31 24.5% 19.12 [5.94, 61.58]
Total events 44 7
Heterogeneity: Chi²=0.02, df=1 (p=0.88); I²=0%
Test for overall effect: Z=4.94 (p<0.00001)
2.1.3 Urgency
Joshi et al. 2001 [9] 20 21 4 13 4.4% 45.00 [4.39, 461.70]
de Sousa Morais et al. 2019 [10] 30 32 15 18 22.4% 3.00 [0.45, 19.93]
Subtotal (95% CI) 53 31 26.8% 9.89 [2.63, 37.18]
Total events 50 19
Heterogeneity: Chi²=3.15, df=1 (p=0.08); I²=68%
Test for overall effect: Z=3.39 (p=0.0007)
Total (95% CI) 159 93 100.0% 10.78 [5.50, 21.14]
Total events 134 37
Heterogeneity: Chi²=5.71, df=9 (p=0.34); I²=12%
Test for overall effect: Z=6.92 (p<0.00001)
Test for subgroup differences: Chi²=1.53, df=2 (p=0.46); I²=0%
0.002
0.1
1
10
500
Favors (RUS)
Favors (PCN)
C
RUS
PCN
Odds ratio
Odds ratio
Study or subgroup
Events
Total
Events
Total
Weight
M-H, fixed, 95% CI
M-H, fixed, 95% CI
Goldsmith et al. 2013 [15] 7 60 8 57 51.9% 0.81 [0.27, 2.40]
de Sousa Morais et al. 2019 [10] 8 32 7 18 48.1% 0.52 [0.15, 1.81]
Total (95% CI) 92 75 100.0% 0.67 [0.30, 1.52]
Total events 15 15
Heterogeneity: Chi²=0.27, df=1 (p=0.61); I²=0%
Test for overall effect: Z=0.95 (p=0.34)
0.1
0.2
0.5
1
2
5
10
Favors (PCN)
Favors (RUS)

Despite the worldwide prevalence of urolithiasis, and even though there is no clear evidence of the best drainage procedure between PCN and RUS, it does not seem to have motivated much the execution of quality studies comparing both interventions throughout the years, as we only retrieved seven relevant articles for our systematic review and meta-analysis, even with no time period filters applied. Of these seven works, five had a prospective design, but only two were randomized. Some of the limitations we encountered were the lack of identification of all important confounding factors and small sample sizes in cohort studies, and the fact that the controlled randomized studies were not blind. Almost all selected studies assessed a variety of different outcomes, which complicated the direct comparison of results between publications. For this reason, we decided to evaluate a smaller set of two primary outcomes (QoL and urinary symptoms) and two secondary outcomes (spontaneous stone passage and length of hospital stays), which we considered the most relevant for clinical practice. In this way, studies with one of these outcome measures in common were compared and conclusions drawn, and generally, they were of moderate-to-high quality for the evaluated parameters.

Regarding patient's QoL assessment, our meta-analysis revealed that the RUS group showed significantly higher number of reported problems when all categories (mobility, self-care, usual activity, pain/discomfort, anxiety/depression) were considered, and particularly when considering only mobility (Fig. 2A). Individual studies on this subject were not able to present results with statistically significant differences, but they all pointed towards a greater deterioration of QoL in the RUS group [9,10,13]. Only de Sousa Morais et al. [10] found a significant difference between pre- and post-intervention EQ-VAS values in the RUS group, with a worsening of general well-being. These findings indicate that stent placement in obstructive urolithiasis has more implications in QoL and general well-being, physically and psychosocially, compared to PCN.

The EQ-5D and EQ-VAS are a generic, standardized, non-disease-specific instrument for describing and valuing global health-related QoL. These are measurement scales widely disseminated in the world medical community, developed by an international research group, the EuroQol group, established in 1987 [19]. After literature review, this group reached a consensus on five dimensions to define global health and QoL in terms of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension was divided into three levels: no problem, moderate or extreme problems. According to this classification, 243 potential health states were thus defined. Several research projects in different countries were carried out to elicit valuations (primarily by means of postal surveys) from general population and patient samples for EQ-5D health states, and multiple studies to validate these scales in many countries were carried out throughout the years and in different medical specialties; therefore, currently, it is a well-accepted assessment of the global health state [19,20].

Urinary symptoms were analyzed in two studies (de Sousa Morais et al. [10] and Joshi et al. [9]) using the same intervention-specific questionnaire that specifically addressed hematuria, dysuria, urgency, and urinary frequency. The results were consistent, and our meta-analysis confirmed that patients who underwent PCN presented significantly fewer urinary symptoms of any type than stenting patients. Therefore, RUS appears to induce more irritative urinary symptoms than PCN.

This intervention-specific questionnaire was designed for each group to assess the impact of these two procedures on the patients' health-related QoL. The questionnaires' development was based on literature review, which also included guidance on the construction of the questionnaires, and opinions of urologists and nurses based on their experience due to their daily management of such patients [9]. The preliminary developed questionnaires were piloted tested on three patients from each group, and then improved. Thus, the final intervention-specific questionnaires included urinary symptoms assessment (four items: dysuria, hematuria, urgency, and urinary frequency), pain (three items: site, duration, and relation to the posture), and additional problems with the stent or PCN in daily life (four items for patients with ureteral stent and eight items for patients with PCN). The answers to these questions were based on a four-point rating scale [9].

Therefore, although the initial development of these instruments for QoL and symptoms evaluation might be considered somewhat limited and not especially well-designed, their validation in multiple studies across the world supports their strength [9,10,19,20].

Spontaneous stone passage after each procedure was another outcome worth evaluating in our work, since it spares the patient from further complementary interventions for stone extraction. Unfortunately, it was compared by only two articles (de Sousa Morais et al. [10] and Goldsmith et al. [15]), which found no significant differences between groups in univariate analysis. Our meta-analysis revealed a tendency for higher rate of spontaneous stone passage in PCN group, but also without statistically significant difference. However, as there are other factors influencing spontaneous stone passage besides the type of urinary diversion [21], we highlight the results of de Sousa Morais et al. [10] that performed a multivariate logistic regression to adjust the results for some of these potentially relevant factors including type of intervention, stone site, stone size, previous ureteral tract surgery, and expulsive medical therapy, and showed that PCN is a statistically significant predictor of spontaneous stone passage, with 6.6 times more chance than RUS, when adjusting for these predictors [10].

Nonetheless, it is worth to note that spontaneous stone passage is expected to be lower in RUS patients due to the stent presence, which obviously reduces ureteral lumen, and its own retrograde placement can lead to stone upward displacement. However, the ureteral mucosa edema cannot be disregarded, and this can lead to increased urinary

Figure 2 Meta-analysis results. (A) The quality of life assessment with EuroQol-5 Dimension post-intervention; (B) The incidence of post-interventional urinary symptoms; (C) The rate of spontaneous stone passage after PCN and RUS. PCN, percutaneous nephrostomy; RUS, retrograde ureteral stent; CI, confidence interval.

symptoms and reduced spontaneous stone passage for its own, and not due to the ureteral stent presence for itself [22]. Although de Sousa Morais et al. [10] have considered medical expulsive therapy in their multivariate analysis, it will be also interesting to particularly evaluate, in each subgroup of patients (RUS *vs*. PCN), the need and the effect of drugs, such as corticosteroids, alpha-blockers, and calcium channel antagonists, on both urinary symptoms and spontaneous stone passage [22].

As for length of hospital stays after intervention, there were notorious contradictory results in the works considered, so we did not perform a meta-analysis on this outcome. Goldsmith et al. [15] found that PCN patients had significantly longer hospital stays than RUS patients, even when adjusting for other factors associated with disease severity. In fact, it was the only statistically significant predictor in the model. The results of the prospective randomized trial by Pearle et al. [17] were consistent with this finding, although without statistically significant differences. Yoshimura et al. [16], on the other hand, reported significantly longer hospital stays for the RUS group. However, the duration of stays in both groups was bizarrely much longer than what was observed in the other two studies [15,17], which made these results questionable. Moreover, in this article no multivariate analysis was done, which in our opinion would be essential for an accurate assessment, as in the absence of proper recommendations, the urologists' choice of intervention might be influenced by factors such as disease severity.

The main limitation of our work was the diversity of outcomes assessed between studies, which means a low amount of data to draw conclusions from. The sample sizes and the lack of relevant sample characterization in some studies have also promoted doubts on whether they are representative of the study population.

A specific limitation of the QoL assessment in these studies is the non-consideration of the effect of the externalized PCN tube on patient self-image. Although the self-report scales used address mobility, self-care, usual activities, and specific issues related to PCN, such as bag leak/slippage and own bag management [9], and these did not increase after PCN placement [10], some can infer that PCN handling did not affect their return to work. However, we did not find a specific assessment on this for working patients, which we consider a relevant matter to address in future research.

The second MEDLINE database and PubMed platform search, from June 2019 to November 2022, as described in our methodology, retrieved 99 articles. Adding the filters "Humans" on species, and "English" on language, these reduced to 61.

Among these, only one study [23] met all the criteria of our meta-analysis, which reflects once again the absence of studies addressing our theme. This was a prospective non-randomized bi-centered study, that compared QoL (with 2 questionnaires, EQ-5D and "tube symptoms") at two time points (discharge after drainage and before definitive treatment), between RUS and PCN in the setting of acute ureteral stone obstruction. Shoshany et al. [23] included 45 patients in RUS group and 30 in PCN, and innovatively evaluated symptoms evolution over time. Initially, PCN patients had worse symptoms relating to mobility and personal hygiene, and more difficulties to self-care and resume usual activities. However, these decreased over time, and at the second time of evaluation there were no differences between groups. On the contrary, pronounced urinary discomfort persisted in the RUS group. Surprisingly, more RUS patients reported anxiety or depressed mood (19.4 % *vs*. 0 % in PCN, $p<0.05$), and at the time of definite treatment, PCN patients had significantly higher overall health state scores. Therefore, this study is in line with our findings, and Shoshany et al. [23] raised another relevant matter when choosing the best method for urinary decompression: specific tubes related symptoms and their dynamics over time, and the expected time length for stenting maintenance.

Xu et al. [24] in 2021, published a prospective randomized study, comparing PCN and RUS for drainage of obstructive urolithiasis with urosepsis. Their outcomes measured were body temperature and changes in biochemical indicators after the treatment. Therefore, this article would not fit the criteria for inclusion in our meta-analysis. However, we highlight that despite the authors have concluded that both drainage methods are effective, they recommended PCN as the primary modality in patients with urosepsis since PCN improves their clinical condition faster.

In a retrospective study [25], PCN and RUS for drainage of obstructive pyelonephritis secondary to urolithiasis were also compared, but using four outcome measures (intraoperative outcomes, duration of fluoroscopy usage, time for normalization of infection parameters, and complications) different from our analysis; therefore, it will also not be included in our analysis. However, the authors also found both methods equally effective and safe, but with higher minor complication rates (such as hematuria and dysuria) in RUS group.

A systematic review on optimal method of drainage for obstructive urolithiasis was also performed by Weltings et al. [26]. Their outcome measures were success of procedure, efficacy, complications, QoL, and costs. Besides the studies that we analyzed, they only included two other studies, which were performed on pregnant patients. Their results are in line with ours: they reported comparable success rates and rare complications for both procedures with higher costs, rates of sepsis, and longer hospital stays for the PCN group (which might be explained by bias regarding patient selection), and worse QoL and urinary symptoms for the RUS group with more frequent need for analgesics [24].

Lastly, another systematic review and meta-analysis was published in 2021 [27], which also included seven studies, only two different from our analysis, Shoshany et al. [23] being one of them. Its conclusion also pointed towards a PCN benefit, as RUS has higher impact on patient QoL due to hematuria and dysuria.

Although beyond the scope of our analysis, we verified that there are some other questions raised by these studies, and yet to be answered: is the PCN preferred in cases associated with greater clinical severity, severe infection, larger calculi, or more lithiasic load? And is this selection bias that leads to longer hospitalization times and global costs associated with PCN, since the RUS procedure is more expensive in itself? Or are the costs, length of stays, and

infectious morbidity more dependent on whether the urinary diversion is emergent, or not, than on the type of intervention? We believe that some of these questions could be better answered with the realization of a large prospective randomized controlled trial.

An interesting European survey among urologists and radiologists was conducted and published in March 2022 [28]. Analyzing three different clinical scenarios requiring emergency upper urinary tract decompression, the perception on radiation dose, cost, and patient QoL was somewhat different among the two specialties. However, the majority was always in favor of double-J stents. This enhanced the need for more quality studies on this matter and to raise medical awareness to this question, as we found that many studies are favoring PCN.

In summary, we conclude that the analysis of the different outcomes for selecting the best urinary diversion method is influenced by several factors, hence the difficulty of obtaining global recommendations to guide clinical practice.

Nevertheless, we highlight the importance of our work, since it is one of the first meta-analysis addressing the optimal method for urgent decompression of hydronephrosis secondary to obstructive urolithiasis. We consider this a fundamental issue for the daily urology routine worldwide, given the high prevalence and morbidity associated with urolithiasis, sometimes even conditioning mortality in the context of urosepsis. Despite the limitations already mentioned, and the necessity of further confirmatory studies, contrary to what one might think, our results suggest that PCN seems to provide better QoL to patients, and may even prevent the need for subsequent procedures once it is associated with a higher spontaneous stone passage, comparing to RUS.

5. Conclusion

The scarcity of studies prevents the establishment of strong conclusions regarding the effects of each emergency drainage procedure. However, our work suggests an advantage of PCN, in comparison with ureteric stent, once it is the intervention better tolerated (with less impact on the patient's perceived QoL and less post-intervention urinary symptoms) and also presents a higher chance of spontaneous stone passage after adjusting for stone site and size. On the other hand, it appears to be a tendency towards longer hospital stays in PCN patients, even though the results are not absolutely clear. This may probably reflect a selection bias of more fragile patients that will not tolerate general anesthesia for RUS, towards PCN fast placement under local anesthesia.

In the future, we suggest that more studies are conducted, preferably with larger samples and a randomized controlled design, reporting at least on these four outcomes addressed and on the psychological effect of the externalized PCN tube, so that in the future direct comparison between articles can be more straightforward and more valuable evidence can be achieved, in order to guide clinical practice across the world towards achieving the better results for our patients, in such a frequent and relevant matter as the daily management of obstructive urolithiasis.

Author contributions

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Conflicts of interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajur.2023.03.007.

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