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# Use of the ureteral access sheath during ureteroscopy: A systematic review and meta-analysis

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## Abstract

The debate still rages on for the usefulness of ureteral access sheath (UAS). Therefore, a meta-analysis to discuss the effects of applying UAS during ureteroscopy was performed. The protocol for the review is available on PROSPERO (CRD42017052327). A literature search was conducted up to November, 2017 using the Web of science, PUBMED, EMBASE and Cochrane Library. The quality of articles was assessed by the Jadad scale and Newcastle Ottawa Scale (NOS). Egger's test and the trim-and-fill method were used to evaluate publication bias. Effect sizes were calculated by pooled odds ratio (ORs) and mean differences (MDs). Sensitivity analyses and subgroup analyses were performed to explore the origin of heterogeneity. Eight trials with a total of 3099 patients and 3127 procedures were identified. Results showed no significant difference in stone-free rate (SFR) (OR = 0.83, 95% CI 0.52–1.33, P = 0.45), intraoperative complications (OR = 1.16, 95% CI 0.81–7.69, P = 0.88), operative time (MD = 4.09, 95% CI -15.08–23.26, P = 0.68) and hospitalization duration (MD = -0.13, 95% CI -0.32–0.06, P = 0.18). However, the incidence of postoperative complications was higher in UAS group (OR = 1.46, 95% CI 1.06–2.00, P = 0.02). Evidence from meta-analysis indicated that the use of UAS during ureteroscopy did not manifest advantages. However, given the intrinsic restrictions of the quality of selected articles, more randomized controlled trials (RCTs) are warranted to update the findings of this analysis.

## Introduction

Ureteral access sheath (UAS) was first introduced in 1974 to facilitate passing ureteroscope into the ureter [1]. With the progress of technology, hydrophilic coating of UAS minimized shear force and enabled smoother passage of the sheath into the ureter, hub-locking mechanism enabled the sheath and the dilator to be passed through the ureter as a whole one unit.

and analysis, decision to publish, or preparation of the manuscript.

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Those modifications have increased the safety and wide use of UAS [2]. Theoretically, it provides an access to the collecting system with the ability for multiple entries and exits of the ureter, allowing for evaluating any portion of the kidney, decreasing intrarenal pressure during irrigation, and improving drainage around the scope and visibility, thus protecting the scope when performing lithotripsy and extracting stone fragments [3–6]. Nevertheless, there have been some misgivings concerning UAS use and the risk of ureteral injury [7]. Whether the UAS is an efficacious equipment remains hang in the wind and the debate rages on. Several studies on this issue had been conducted, while the results were contradictory [8–15]. Here, we performed a systematic review and meta-analysis based on current evidence to assess the effectiveness and safety of the use of ureteral access sheath during ureteroscopy, in aim to conclude an evidence-based recommendation for clinical practice.

## Materials and methods

### Search strategy

This systematic review and meta-analysis was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement. The protocol for the review was available on PROSPERO (CRD42017052327; https://www.crd.york.ac.uk/prospero/). Literature retrieval was conducted up to November, 2017 using Web of science, PUBMED, EMBASE and Cochrane Library. The following Medical Subject Heading (MeSH) or Emtree terms combined free terms of "ureteroscopy" and "ureteral access sheath" were searched in different databases. The methodology filters about study design was derived from the Francis A. Countway Library of Medicine (http://guides.library.harvard.edu/meta-analysis). Additionally, we performed a manual search from references of included articles to retrieve other applicable studies. There were no language or publication date restriction in retrieval strategy.

### Selection criteria

All processes including literature search, selection criteria, data extraction, quality assessments, and statistical analyses were performed by two authors independently and double-checked by both. Any divergence was disposed by a senior author. Eligibility criteria for the included studies were defined base on the PICOS principles: (1) Participants (P): Patients were diagnosed or treated by ureteroscopy. (2) Interventions (I) and comparisons (C): Exploring the effect of UAS during ureteroscopy. (3) Outcomes (O): Including at least one of the following outcomes: stone-free rate (SFR), intraoperative or postoperative complications, operative time and the hospitalization time. (4) Study design (S): RCTs or comparative studies with the relative data could be used directly or indirectly. Articles met the following points were abandoned: (1) Letters, review articles, laboratory studies, case reports and animal experimental studies. (2) Absence of key information such as sample size, 95% CI, and P value or this value could not be calculated. (3) The study design without a comparative group. (4) A repetitive publication article.

### Data extraction

The relevant data of included studies were extracted with a well-designed form. Data collectors were blinded to authors or journals. The following data were extracted from each article independently: sample sizes, procedures performed, study period, country, follow-up time, article type, age, stone burden, preoperative or postoperative stent, outcomes and so on. The collecting data were gathered with the primitive form from article to insure the veracity. Only the optimal research design and the most holonomic data included when a repeated article was met. We contacted the original authors to obtain more detail information when necessary. The primary outcome was SFR. The secondary outcomes included intraoperative and postoperative complications, operative time and hospital stay.

### Quality assessments

The quality of RCTs were assessed with Jadad scale [16]. A 9-score system named Newcastle Ottawa Scale (NOS) [17,18] was used when non randomized controlled trials (non-RCTs) were met. Studies estimated with this system were considered of high-quality if achieved a score of seven or more.

### Statistical analysis

The relevant data were analyzed by Review Manager Version 5.3 software (Review Manager, Version 5.3 for Windows, The Cochrane Collaboration, 2013) and STATA 12.0 (StataCorp, College Station, TX, USA). Pooled odds ratios (ORs) and mean differences (MDs) were respectively calculated as the summary statistic for dichotomous variables and continuous variables with 95% confidence intervals (CIs). The Z test was used to analyze pooled effects, and a P-value of less than 0.05 was considered statistically significant. The standard deviation (SD) was converted by sample size and range using the theory described by Hozo et al if necessary [19]. Heterogeneity was appraised using Cochran's Q test (reported with a $x^2$-value and P-value) and $I^2$ statistic [20,21]. A P-value of less than 0.1 means the presence of heterogeneity when the Q test was performed. An $I^2$ value of more than 50% was considered an indication for moderate to serious heterogeneity. Reasons for statistical heterogeneity were explored with sensitivity analyses. Sensitivity analyses were conducted by exclusion of individual studies. A random-effects model was used for pooling when there was evidence of heterogeneity [22]. Otherwise, the combined estimates were shown with a fixed-effects model [23]. Subgroup analyses were performed according to patient age, stone site, study design, the control of stone size, and the bias from semirigid ureteroscopy to evaluate UAS and non-UAS groups. The Egger linear regression test [24] and the non-parametric trim-and-fill method [25] were conducted to explore the publication bias for SFR.

## Results

### Literature search

The whole process of literature search was presented in Fig 1. The initial search identified 311 potentially relevant studies. Additionally, two studies were available by manual search with references. Then 142 duplicates were distinguished and excluded by the "duplicates check" function of NoteExpress. After the exclusion of case reports, non-comparative studies, reviews, in-vitro model studies and irrelevant-topic studies with the first browse of title and abstract, the full-text versions of 11 papers were identified to determine eligibility. In these articles, two studies were recognized as irrelevant topics, one of them was associated with an in-vitro model. Finally, eight eligible studies [8–15] including 3099 patients, a total of 3127 procedures of which 1994 procedures for UAS group and 1133 procedures for non-UAS group, fulfilling the inclusion criteria were recognized.

### Study characteristics and quality assessment

Included trials were published between 2001 and 2016, and conducted in the United States (3), Switzerland (1), Greece (1), France (2), and England (1). The sample sizes ranged from 28 to 2239. Among the 8 included studies, there were 2 RCTs [8,11] between UAS group and non-

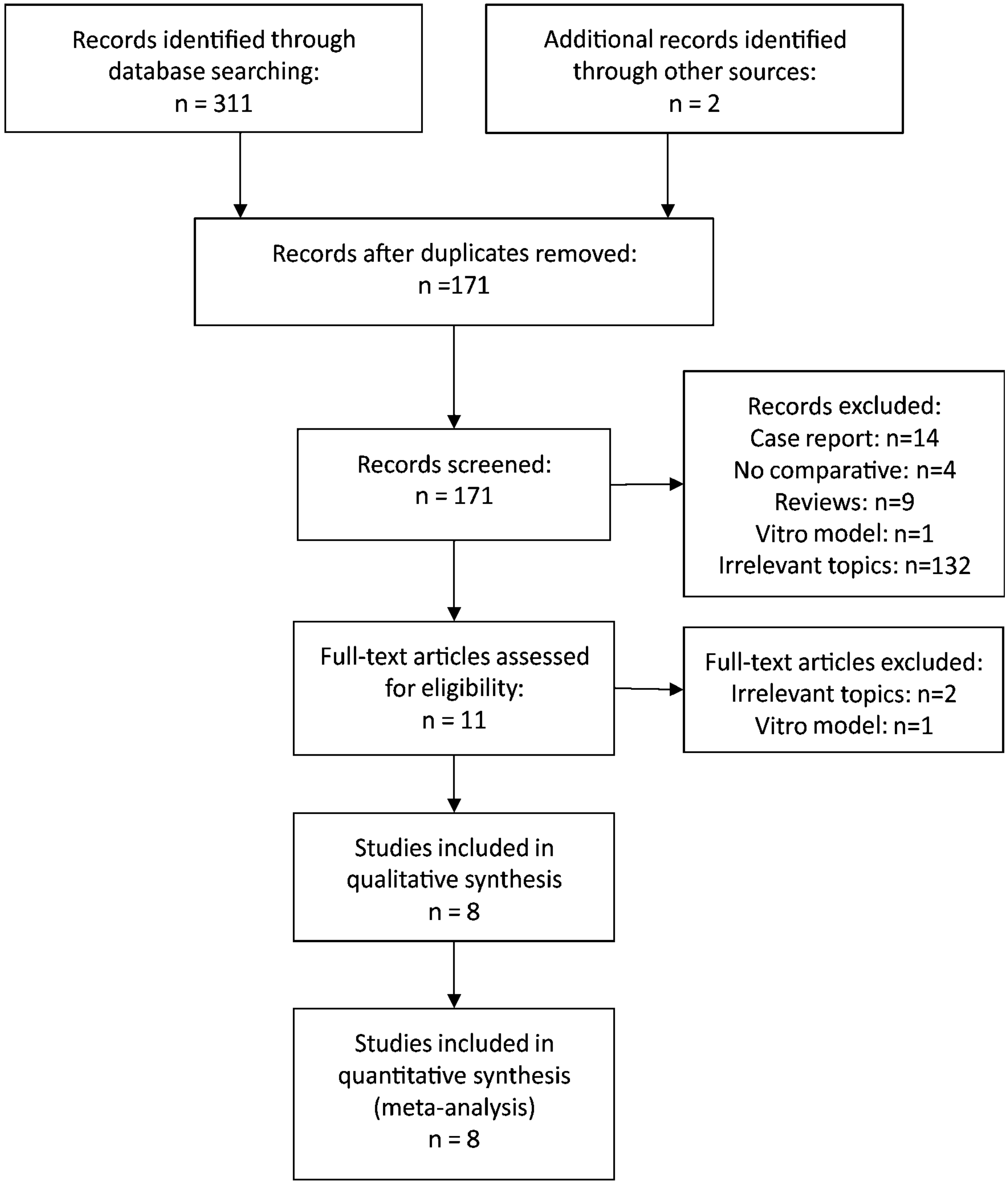


**Fig 1. Flow diagram of studies selection process.**

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UAS group. Two studies belong to prospective cohort studies [14,15], four studies were classified to be retrospective cohort studies [9,10,12,13]. The quality of included non-randomized studies were granted a score between 5 and 7. Both of RCTs got 2 scores on the Jadad scale (Table 1). One of the included studies was related to pediatric stone management [12] and three of them were involved in distal ureteral abnormalities [9,11,12].

The baseline characteristics of the relevant literatures were indicated in Table 2. The adjusted variables were recorded to develop a better understanding of the comparability

**Table 1. UAS versus non-UAS: Summary of selected studies.**

| Reference | Sample sizes/procedures performed, n | Study period | Country | Follow-up time | Article type | Quality score |
|---|---|---|---|---|---|---|
| Kourambas 2001 | 59/62 | Oct. 1999-Jan. 2000 | United States | 3 month | RCT | 2[b] |
| De Sio 2004 | 28 | 1999 to May 2003 | Switzerland | NR | Retrospective cohort study | 5[a] |
| L'esperance 2005 | 256 | 1997 to 2003 | United States | 2 month | Retrospective cohort study | 7[a] |
| Pardalidis 2006 | 98 | Jan. 2001 to Dec. 2004 | Greece | 1 year | RCT | 2[b] |
| Wang 2011 | 96 | 1999 to 2009 | United States | 11 month (0.2-110month) | Retrospective cohort study | 5[a] |
| Berquet 2014 | 280 | 2009 to 2012 | France | 1–3 month | Retrospective cohort study | 7[a] |
| Traxer 2015 | 2239 | Jan. 2010 to Oct. 2012 | France | NR | Prospective cohort study | 5[a] |
| Geraghty 2016 | 43/68 | Mar. 2012 to Oct. 2014 | England | 2–3 month | Prospective cohort study | 6[a] |

RCT randomized controlled trials, NR not reported.

[a] Using Newcastle-Ottawa Scale (score from 0 to 9).

[b] Using Jadad scale (score from 0 to 5).

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between groups. A very important parameter, stone burden, was no significant differences in 6 original documents [8,10,11,13–15].

## Primary outcomes

**SFR.** The definition of SFR was made in five studies [10,11,13–15]. There were two studies [10,11] identified SFR as having none of the stone left. One of the article [14] recognized it as residual stone less than 1 mm, while one [15] defined it as having a residual stone fragment that is less than 2 mm, and the other one [13] described it as residual stone less than 3 mm. Computed Tomography scan and X-ray were the principal imaging examination to evaluate the residual stone. All studies have compared the difference of SFR between the UAS and non-UAS groups. The data of each articles were summarized with a random effects model and showed no significant difference between arms (OR = 0.83, 95% CI 0.52–1.33, P = 0.45, Fig 2A). This result showed moderate heterogeneity (Q = 16.49, P = 0.02, $I^2$ = 58%, Fig 2A). Sensitivity analysis by removing individual studies showed clinical heterogeneity of being due to the article of L'esperance et al [10]. Combining results of the remaining 7 studies with fixed effects model demonstrated a higher SFR for the non-UAS group rather than the UAS group (OR = 0.62, 95% CI 0.50–0.75, P $<$ 0.00001, Fig 2B) and revealed no heterogeneity between groups (Q = 4.72, P = 0.58, $I^2$ = 0%, Fig 2B).

**Subgroup analysis.** Subgroup analyses were conducted on account of age, diseased region, study design, the control of stone size, and the use of semirigid ureteroscopy to further estimate the efficiency of UAS in SFR. However, only the sort of prospective cohort study [14,15] in the subgroup analysis of study designs presented the different result with the original outcome, which was favoured of non-UAS group (OR = 0.59, 95% CI 0.47–0.74, P $<$ 0.00001; Q = 0.18, P = 0.68, $I^2$ = 0%, Table 3).

**Publication bias.** Base on the SFR, there was no evidence of significant publication bias from the Egger test (t = 0.77, P = 0.47). A well-proportioned funnel plot was formed in a sensitivity analysis using the trim-and-fill method. After the performance of trim-and-fill method,

**Table 2. Characteristics of selected studies.**

| Reference | Group | Procedures, n | Age, years | Stone burden, mm | Preoperative stent, procedures, n (%) | Postoperative stent, procedures, n(%) | Flexible or semirigid ureteroscopy, F:S | The definition of SFR | Adjusted variable |
|---|---|---|---|---|---|---|---|---|---|
| Kourambas 2001 | UAS | 30 | 43.8 (21–85) | 13.00 | NR | 15 | 25:5 | NR | Stone burden, the use of flexible or semirigid ureteroscopy, fragmentation device |
| | Non-UAS | 32 | | 10.35 | | 19 | 23:9 | | |
| De Sio 2004 | UAS | 12 | 54 (26–71) and 61 (54–68) | 1.4 (1–2.5) and 0.7 (0.4–0.9) | NR | NR | Semirigid ureteroscopy | NR | NR |
| | Non-UAS | 16 | 45 (18–74) and 63 (61–75) | 1.6 (1.1–2.8) and 0.9 (0.4–1.2) | | | | | |
| L'esperance 2005 | UAS | 173 | 49 | 8.7 | NR | 77% | Flexible ureteroscopy | Completely clean | Age, gender, stone burden, stone location, postoperative stent |
| | Non-UAS | 83 | 47 | 7.3 | | | | | |
| Pardalidis 2006 | UAS | 48 | 48.5 (18–73) | 7.1 | NR | 100% | Flexible ureteroscopy | Completely clean | Stone burden, Use of EHL |
| | Non-UAS | 50 | | 7.8 | | | | | |
| Wang 2011 | UAS | 40 | 13.6±4.2 (4.0–20.9) | 12.5 ± 9.7 (3.0–54.0) | 12 | 38 | NR | NR | Age, BMI, gender, race, urinary tract abnormalities, preoperative stent |
| | Non-UAS | 56 | 12.7±4.6 (1.5–19.9) | 7.6 ±4.5 (0.8–27.0) | 14 | 37 | | | |
| Berquet 2014 | UAS | 157 | 50±15.2 | 15.15±9.8 | 39 (24%) | 134 (85%) | Flexible ureteroscopy | Residual stone ≦3mm | Age, stone number, stone burden, postoperative stent |
| | Non-UAS | 123 | 52±17.3 | 13.75±8.0 | 62 (50%) | 94 (76%) | | | |
| Traxer 2015 | UAS | 1494 | 51.2 ±14.98 | 108.3 ±114.4[a] | 511 | 1352 | Flexible ureteroscopy | Residual stone ≦1mm | Age, gender, BMI, renal congenital abnormality, stone burden, previous calculus treatment, solitary kidney, preoperative stent, case volume |
| | Non-UAS | 745 | 50.2 ±14.95 | 99.2±100.5[a] | 278 | 611 | Flexible ureteroscopy | | |
| Geraghty 2016 | UAS | 40 | 54 (7–84) | 29.2 (20–60) | 15 | 64 (94.1%) | Flexible ureteroscopy | Residual stone ≦2mm | Stone burden |
| | Non-UAS | 28 | | | 11 | | | | |

NR not reported, SFR stone free rate, UAS ureteral access sheath, non-UAS without an ureteral access sheath, BMI Body Mass Index, F:S Flexible ureteroscopy: Semirigid ureteroscopy, EHL electrohydraulic lithotripsy, SD standard deviation.

Values are given as mean ± SD (range).

[a] Stone burden was calculated as the sum of all stone sizes (length × width × 0.25 × 3.14159).

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we observed the OR was 0.78 (95% CI = 0.49–1.23, P = 0.28), which indicated the result of trim-and-fill method didn't convert comparatively.

## Secondary outcomes

**Intraoperative complications.** The intraoperative complications comprising bleeding, perforation and avulsion etc. Analyzing the data of 3 studies [11,12,14] with random effects model, including 2428 procedures, yielded no significant difference between case and control

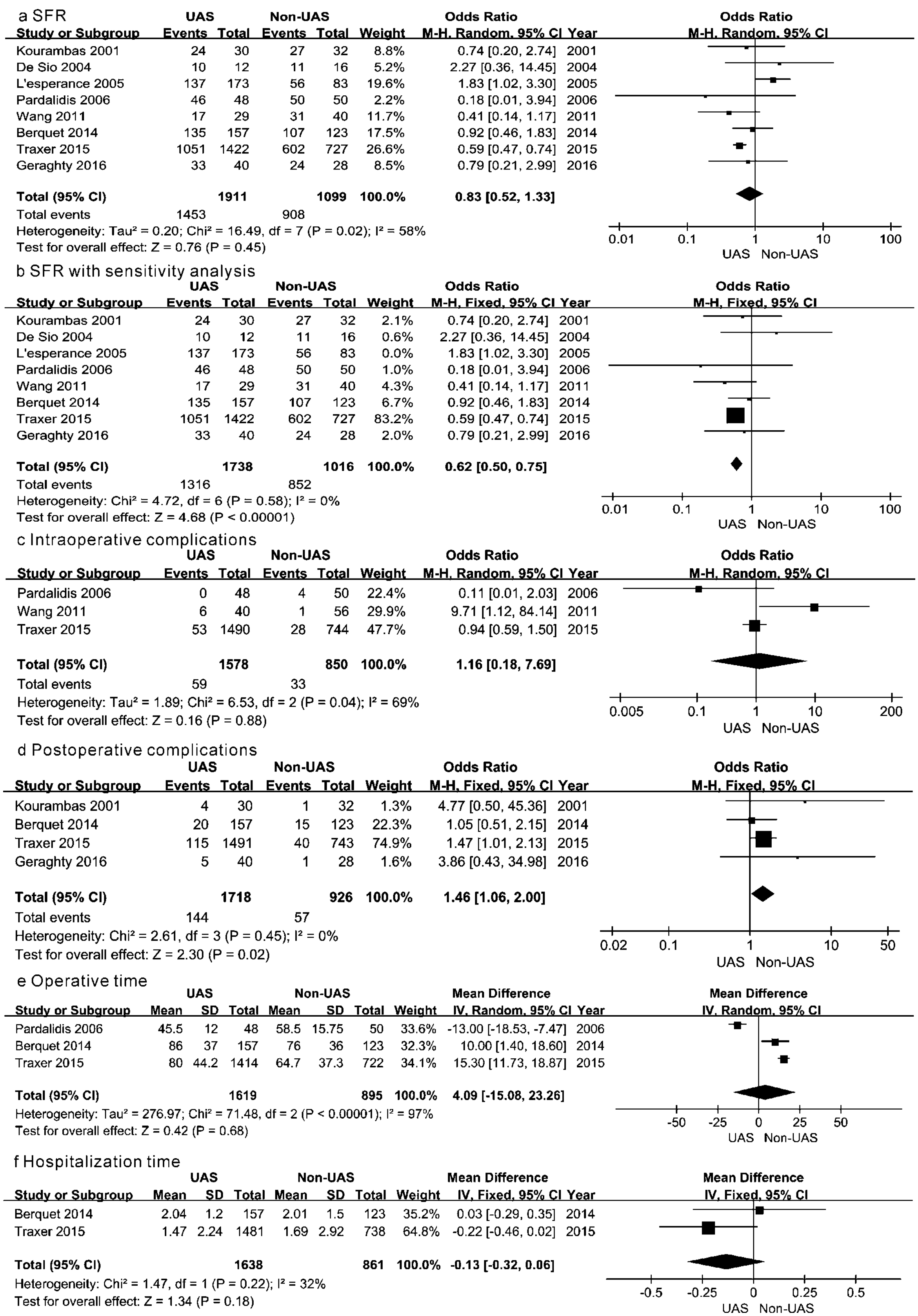
a SFR
UAS
Non-UAS
Odds Ratio
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Year
M-H, Random, 95% CI
Kourambas 2001 24 30 27 32 8.8% 0.74 [0.20, 2.74] 2001
De Sio 2004 10 12 11 16 5.2% 2.27 [0.36, 14.45] 2004
L'esperance 2005 137 173 56 83 19.6% 1.83 [1.02, 3.30] 2005
Pardalidis 2006 46 48 50 50 2.2% 0.18 [0.01, 3.94] 2006
Wang 2011 17 29 31 40 11.7% 0.41 [0.14, 1.17] 2011
Berquet 2014 135 157 107 123 17.5% 0.92 [0.46, 1.83] 2014
Traxer 2015 1051 1422 602 727 26.6% 0.59 [0.47, 0.74] 2015
Geraghty 2016 33 40 24 28 8.5% 0.79 [0.21, 2.99] 2016
Total (95% CI) 1911 1099 100.0% 0.83 [0.52, 1.33]
Total events 1453 908
Heterogeneity: Tau² = 0.20; Chi² = 16.49, df = 7 (P = 0.02); I² = 58%
Test for overall effect: Z = 0.76 (P = 0.45)
0.01 0.1 1 10 100
UAS Non-UAS
b SFR with sensitivity analysis
UAS
Non-UAS
Odds Ratio
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Fixed, 95% CI Year
M-H, Fixed, 95% CI
Kourambas 2001 24 30 27 32 2.1% 0.74 [0.20, 2.74] 2001
De Sio 2004 10 12 11 16 0.6% 2.27 [0.36, 14.45] 2004
L'esperance 2005 137 173 56 83 0.0% 1.83 [1.02, 3.30] 2005
Pardalidis 2006 46 48 50 50 1.0% 0.18 [0.01, 3.94] 2006
Wang 2011 17 29 31 40 4.3% 0.41 [0.14, 1.17] 2011
Berquet 2014 135 157 107 123 6.7% 0.92 [0.46, 1.83] 2014
Traxer 2015 1051 1422 602 727 83.2% 0.59 [0.47, 0.74] 2015
Geraghty 2016 33 40 24 28 2.0% 0.79 [0.21, 2.99] 2016
Total (95% CI) 1738 1016 100.0% 0.62 [0.50, 0.75]
Total events 1316 852
Heterogeneity: Chi² = 4.72, df = 6 (P = 0.58); I² = 0%
Test for overall effect: Z = 4.68 (P < 0.00001)
0.01 0.1 1 10 100
UAS Non-UAS
c Intraoperative complications
UAS
Non-UAS
Odds Ratio
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Year
M-H, Random, 95% CI
Pardalidis 2006 0 48 4 50 22.4% 0.11 [0.01, 2.03] 2006
Wang 2011 6 40 1 56 29.9% 9.71 [1.12, 84.14] 2011
Traxer 2015 53 1490 28 744 47.7% 0.94 [0.59, 1.50] 2015
Total (95% CI) 1578 850 100.0% 1.16 [0.18, 7.69]
Total events 59 33
Heterogeneity: Tau² = 1.89; Chi² = 6.53, df = 2 (P = 0.04); I² = 69%
Test for overall effect: Z = 0.16 (P = 0.88)
0.005 0.1 1 10 200
UAS Non-UAS
d Postoperative complications
UAS
Non-UAS
Odds Ratio
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Fixed, 95% CI Year
M-H, Fixed, 95% CI
Kourambas 2001 4 30 1 32 1.3% 4.77 [0.50, 45.36] 2001
Berquet 2014 20 157 15 123 22.3% 1.05 [0.51, 2.15] 2014
Traxer 2015 115 1491 40 743 74.9% 1.47 [1.01, 2.13] 2015
Geraghty 2016 5 40 1 28 1.6% 3.86 [0.43, 34.98] 2016
Total (95% CI) 1718 926 100.0% 1.46 [1.06, 2.00]
Total events 144 57
Heterogeneity: Chi² = 2.61, df = 3 (P = 0.45); I² = 0%
Test for overall effect: Z = 2.30 (P = 0.02)
0.02 0.1 1 10 50
UAS Non-UAS
e Operative time
UAS
Non-UAS
Mean Difference
Mean Difference
Study or Subgroup Mean SD Total Mean SD Total Weight IV, Random, 95% CI Year
IV, Random, 95% CI
Pardalidis 2006 45.5 12 48 58.5 15.75 50 33.6% -13.00 [-18.53, -7.47] 2006
Berquet 2014 86 37 157 76 36 123 32.3% 10.00 [1.40, 18.60] 2014
Traxer 2015 80 44.2 1414 64.7 37.3 722 34.1% 15.30 [11.73, 18.87] 2015
Total (95% CI) 1619 895 100.0% 4.09 [-15.08, 23.26]
Heterogeneity: Tau² = 276.97; Chi² = 71.48, df = 2 (P < 0.00001); I² = 97%
Test for overall effect: Z = 0.42 (P = 0.68)
-50 -25 0 25 50
UAS Non-UAS
f Hospitalization time
UAS
Non-UAS
Mean Difference
Mean Difference
Study or Subgroup Mean SD Total Mean SD Total Weight IV, Fixed, 95% CI Year
IV, Fixed, 95% CI
Berquet 2014 2.04 1.2 157 2.01 1.5 123 35.2% 0.03 [-0.29, 0.35] 2014
Traxer 2015 1.47 2.24 1481 1.69 2.92 738 64.8% -0.22 [-0.46, 0.02] 2015
Total (95% CI) 1638 861 100.0% -0.13 [-0.32, 0.06]
Heterogeneity: Chi² = 1.47, df = 1 (P = 0.22); I² = 32%
Test for overall effect: Z = 1.34 (P = 0.18)
-0.5 -0.25 0 0.25 0.5
UAS Non-UAS

**Fig 2. Forest plot in meta-analysis.** a SFR, b SFR with sensitivity analysis, c intraoperative complications, d postoperative complications, e operative time, f hospitalization time. UAS: ureteral access sheath; non-UAS: without an ureteral access sheath.

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groups in terms of intraoperative complications (OR = 1.16, 95% CI 0.81–7.69, P = 0.88, Fig 2C) with a moderate heterogeneity among trials (Q = 6.53, P = 0.04, $I^2$ = 69%, Fig 2C).

**Postoperative complications.** There were 6 articles [8,9,11,13–15] providing data with regard to postoperative complications such as bleeding, fever, urinary tract infection, bladder cramps, lung embolism, sepsis and so forth. However, two articles [9,11] with no events should be excluded because they didn't provide any indication of the direction and magnitude of the relative treatment effect. Combining the results of studies with a fixed-effects model produced an OR of 1.46 (95% CI 1.06–2.00, P = 0.02; Q = 2.61, P = 0.45, $I^2$ = 0%; Fig 2D), which comes into a conclusion that UAS group get a significant higher incidence of postoperative complications than non-UAS group.

**Operative time.** Six studies mentioned the operative time [8,9,11,13–15], whereas only 2 articles [13,14] provided the SD. Only half of articles with lacking data provided the value of range [9,11], which was essential to estimate SD with the theory of Hozo et al [19]. However, due to the limited sample size provided by De Sio et al [9], it was excluded from the meta-analysis on this endpoint. Finally, three studies [11,13,14] including 2514 procedures were obtained and showed no significant difference between arms (MD = 4.09, 95% CI -15.08–23.26, P = 0.68, Fig 2E) with a severe heterogeneity (Q = 71.48, P < 0.00001, $I^2$ = 97%, Fig 2E).

**Hospitalization duration.** There were only two articles that compared the difference between arms regarding hospitalization duration [13,14]. Berquet et al [13] demonstrated no significant difference between groups concerning this issue. Whereas, Traxer et al indicated that hospitalization periods were longer in cases treated without a UAS [14]. Pooling the data of these articles, meta-analysis for hospitalization duration showed no significant difference between groups (MD = -0.13, 95% CI -0.32–0.06, P = 0.18; Q = 1.47, P = 0.22, $I^2$ = 32%; Fig 2F).

**Table 3. Subgroup analysis.**

| subgroup | Studies, n | Heterogeneity | | | OR (95% CI) | P value |
|---|---|---|---|---|---|---|
| | | Q | P value | $I^2$, % | | |
| Age | | | | | | |
| Adult | 7 | 15.50 | 0.02 | 61 | 0.92 (0.55–1.54) | 0.74 |
| Children | 1 | - | - | - | 0.41 (0.14–1.17) | 0.10 |
| Diseased region | | | | | | |
| Proximal | 5 | 13.22 | 0.01 | 70 | 0.90 (0.52–1.56) | 0.72 |
| Distal | 3 | 3.04 | 0.22 | 34 | 0.62 (0.18–2.16) | 0.45 |
| Study design | | | | | | |
| RCT | 2 | 0.68 | 0.41 | 0 | 0.60 (0.18–1.99) | 0.40 |
| Prospective cohort study | 2 | 0.18 | 0.68 | 0 | 0.59 (0.47–0.74) | <0.00001 |
| Retrospective cohort study | 4 | 7.05 | 0.07 | 57 | 1.08 (0.54–2.14) | 0.84 |
| The control of stone burden | | | | | | |
| Control | 6 | 13.96 | 0.02 | 64 | 0.86 (0.51–1.47) | 0.59 |
| Uncontrolled | 2 | 2.49 | 0.11 | 60 | 0.81 (0.16–4.18) | 0.80 |
| Extract/shatter stone with flexible or semirigid Ureteroscopy | | | | | | |
| Flexible | 5 | 13.95 | 0.007 | 71 | 0.88 (0.48–1.61) | 0.68 |
| Semirigid | 3 | 2.53 | 0.28 | 21 | 0.70 (0.29–1.65) | 0.41 |

OR odds ratio, RCT randomized controlled trials.

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## Discussion

Several articles had examined the effect of using UAS during ureteroscopy. However, the results of these studies were contradictory, even proposed completely different recommendations [8–15]. To the best of our knowledge, this is the first meta-analysis to elaborate the relationship between those contradictions, which have pointed out an evidential orientation on this issue. Besides, it should be noted that a series of subgroup analyses such as age, diseased region, study design, the control of stone size and the use of semirigid ureteroscope have been conducted. Only the subgroup of study design revealed the different result with quondam one, which indicated the stability of this meta-analysis. Moreover, both of Egger test and trim-and-fill method indicated no publication bias in this meta-analysis.

The efficacy and safety of UAS during ureteroscopy with a systematic review and meta-analysis was evaluated. In general, 8 studies containing 3099 patients, a total of 3127 procedures were included. The results indicated the same effect on SFR, intraoperative complications, operative time and hospitalization duration but showed a significant increase in the incidence of postoperative complications in UAS arm.

Stone burden was no significant differences in 6 original documents [8,10,11,13–15]. Subgroup analysis of the control of stone burden showed the same with original result, which indicated the reliability of outcome of SFR. Proponents of UAS proposed that the use of UAS could serve to remove stone fragments with basket easily. Also, it provided a repeatable, safe and fast access to the upper urinary tract with improved vision [5]. Therefore, the potential superiority of UAS in the SFR has been advocated. However, Berquet et al [13] documented the number of stone, stone location and the use of UAS had no effect on SFR. The only predictive factor of SFR was stone burden. Traxer et al [14] explored the effect of UAS with a sizable population of prospective study indicated that the SFR was 73.9% in UAS group versus 82.8% in non-UAS group, and presented that UAS is not used to increase SFR.

Some of the advantage of UAS have been recommended, such as providing an access to the collecting system with the ability for multiple entrie and exits of the ureter, decreasing intrarenal pressure during pulse or continuous ureteroscopic irrigation, and also improving drainage around the scope and visibility, thus protecting the scope when performing lithotripsy and extracting stone fragments [3–6]. However, several articles have indicated that UAS could be responsible for postoperative complications such as persistent hematuria, ureteral stricture, urinary extravasation etc [13,14,26]. In this meta-analysis, the higher postoperative complication was observed in UAS group. Ureteral injury with UAS insertion resulting in more postoperative persistent hematuria, use of ureteral stents, post-operative pain, and even contributing to ureteral strictures [26,27]. Lallas et al [28] observed that nadir ureteral blood flow was 25%, 70%, and 80% below baseline when 10/12F, 12/14F, and 14/16F UAS were used during ureteroscopy, while the bigger size of UAS need more time to recover. Traxer et al [7] indicated that severe injury of ureteral smooth muscle layers is common even after a 12/14Fr UAS was inserted. Other studies [5,29] also have shown that the insertion of the UAS could harm the ureteral mucosa and induce ischemia of the ureter. Furthermore, up-regulation of pro-inflammatory mediators, COX-2 and TNF-alpha were observed in the ureteral wall after the use of UAS, which might indicate another reason for postoperative pain and complications [30].

Among the studies for operative time, the synthesis of meta-analysis revealed the same effect between groups. Of note, with the estimation of SD from Pardalidis et al [11], it showed an inescapable deviation. Also, Kourambas et al [8] preferred the UAS group as they showed an advantage in operative time. On the other hand, Geraghty et al [15] and De Sio et al [9] demonstrated no significant difference between both arms. These results should not be neglected.

The following limitations were deserved mention in this meta-analysis. Firstly, this study was based on non-RCTs which meant the risk of bias from inappropriate random sequence generation and blinding was unavoidable. Secondly, several parameters indicated heterogeneity because of the discrepancy in study design, surgeon's experience and some unmeasured confounders across studies. Finally, lack of the unified standard and the value of SD in some studies also prevented a more accurate analysis.

## Conclusions

To sum up, this is the first meta-analysis to evaluate the efficacy and safety of UAS during ureteroscopy and provides evidence that using a UAS in ureteroscopy neither has an effect on SFR, operative time, hospitalization time, nor intraoperative complications but significantly increases the incidence of postoperative complications. Current study didn't manifest an obvious advantage for using a UAS during ureteroscopy, which indicated the use of UAS should not be a routine in all cases. However, given intrinsic restrictions of included studies, more RCTs are warranted to confirm and update the findings of this study.

## Supporting information

**S1 Fig. Egger test.**
(TIF)

**S2 Fig. Trim-and-fill method.**
(TIF)

**S1 Table. PRISMA 2009 checklist.**
(DOC)

**S1 File. The protocol from PROSPERO.** (CRD42017052327).
(PDF)

**S1 Text. The search strategy for PubMed.**
(DOCX)

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