




Original Article

Impact of COVID-19 on the management and outcomes of ureteric stones in the UK: a multicentre retrospective study

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Objectives

To determine if management of ureteric stones in the UK changed during the coronavirus disease 2019 (COVID-19) pandemic and whether this affected patient outcomes.

Patients and methods

We conducted a multicentre retrospective study of adults with computed tomography-confirmed ureteric stone disease at 39 UK hospitals during a pre-pandemic period (23/3/2019–22/6/2019) and a period during the pandemic (the 3-month period after the first severe acute respiratory syndrome coronavirus-2 case at individual sites). The primary outcome was success of primary treatment modality, defined as no further treatment required for the index ureteric stone. Our study protocol was published prior to data collection.

Results

A total of 3735 patients were included (pre-pandemic 1956 patients; pandemic 1779 patients). Stone size was similar between groups ($P > 0.05$). During the pandemic, patients had lower hospital admission rates (pre-pandemic 54.0% vs pandemic 46.5%, $P < 0.001$), shorter mean length of stay (4.1 vs 3.3 days, $P = 0.02$), and higher rates of use of medical expulsive therapy (17.4% vs 25.4%, $P < 0.001$). In patients who received interventional management (pre-pandemic 787 vs pandemic 685), rates of extracorporeal shockwave lithotripsy (22.7% vs 34.1%, $P < 0.001$) and nephrostomy were higher (7.1% vs 10.5%, $P = 0.03$); and rates of ureteroscopy (57.2% vs 47.5%, $P < 0.001$), stent insertion (68.4% vs 54.6%, $P < 0.001$), and general anaesthetic (92.2% vs 76.2%, $P < 0.001$) were lower. There was no difference in success of primary treatment modality between patient cohorts (pre-pandemic 73.8% vs pandemic 76.1%, $P = 0.11$), nor when patients were stratified by treatment modality or stone size. Rates of operative complications, 30-day mortality, and re-admission and renal function at 6 months did not differ between the data collection periods.

Conclusions

During the COVID-19 pandemic, there were lower admission rates and fewer invasive procedures performed. Despite this, there were no differences in treatment success or outcomes. Our findings indicate that clinicians can safely adopt management strategies developed during the pandemic to treat more patients conservatively and in the community.

Keywords

urolithiasis, ureteric stone, ureteral stone, COVID-19, patient outcomes, management, conservative management, ESWL, ureteroscopy, nephrostomy

Introduction

Nephrolithiasis is a major clinical and economic health challenge. Up to 20% of men and 10% of women are affected by stone disease [1,2]. It is responsible for >85 000 hospital episodes in the UK and costs the UK NHS an estimated £190–324 million/year [3].

The management of ureteric stones can be conservative, as most stones <5 mm pass spontaneously [4]. However, interventions such as ESWL or ureteroscopic (URS) laser lithotripsy may be required. Untreated stone disease can result in refractory pain, sepsis, renal failure, and death [5]. The UK National Institute for Health and Care Excellence (NICE) guidelines published in 2019 recommend that adults with ureteric stones measuring <10 mm should be treated with ESWL, and URS is recommended as a second-line alternative. For ureteric stones measuring between 10 and 20 mm, URS should be offered as first-line treatment, and ESWL can be considered if local facilities will allow stone clearance to be achieved within 4 weeks [6]. Similarly, when active management is required, European Association of Urology (EAU) guidelines recommend ESWL or URS for stones <10 mm, URS as first-line and ESWL as second-line treatment for stones >10 mm [7].

In March 2020, coronavirus disease 2019 (COVID-19) was declared a pandemic by the WHO, and measures were introduced across the world to mitigate the spread of infection [8]. There was worldwide disruption to healthcare provision, including increased pressures on healthcare services and the cancellation of elective procedures [9]. The multicentre, international COVIDSurg study demonstrated that perioperative infection with the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) virus was associated with an unadjusted 30-day mortality of 23.8% [10]. In light of this, and as a result of reduced access to operating theatres, recommendations were made to favour non-operative management strategies [9,11–13]. Furthermore, during the peak of the pandemic in the UK, non-COVID-19-related Emergency Department attendances fell dramatically as patients delayed or avoided presentation to hospital due to fear of infection [14].

The existing body of literature around COVID-19 and endourology discusses alterations required of clinical care to accommodate the widespread disruption to healthcare services due to COVID-19. However, these articles were written at the start of the COVID-19 pandemic and do not discuss whether these suggested changes to treatment algorithms manifested during the pandemic or what their impact on outcomes were [12,13,15].

We hypothesised that during COVID-19 there were delays in patient presentation resulting in higher rates of acute kidney injury (AKI) and sepsis, and that non-invasive management

options such as observation, ESWL, and alternatives to general anaesthesia were used more frequently, resulting in higher rates of failed index management and subsequent change in treatment modality and/or re-presentation to hospital. We sought to test this hypothesis by undertaking a multicentre, retrospective study to determine how management of ureteric stones changed during the COVID-19 pandemic in the UK and define how changes in management affected patient outcomes.

Patients and Methods

Study Design

We conducted a multicentre, retrospective cohort study of the management and outcomes of patients presenting with ureteric stones before and during the COVID-19 pandemic at 39 hospitals in the UK.

Our protocol was published prior to data collection [16]. We followed principles of the trainee-led collaborative research model [17], coordinated by the COVID Stones Collaborative; and the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines [18] (Appendix S1). NHS Health Research Authority guidance was followed, and each participating site obtained local audit approval.

Patients aged ≥ 18 years with ureteric stone disease confirmed on contrast or non-contrast CT imaging were identified via retrospective review of all abdominal CT scans undertaken during relevant data collection periods. Patients with non-ureteric stone disease were excluded.

Data Collection

Data were collected during two time periods: a pre-pandemic period from 23/3/2019 to 22/6/2019; and a period during the pandemic, which was defined as the 3-month period after the first SARS-CoV-2 case at each individual site. This time point was approximately equivalent to the start of the first UK lockdown due to COVID-19 on 23/3/2020. Data were collected by local collaborators and entered and stored on the Research Electronic Data Capture (REDCap) server managed and hosted by the University of Oxford, UK [19,20]. Data collected included demographics, management, and outcomes at 6 months follow-up.

Outcomes

Our primary objective was to assess success of primary treatment modality, defined as no additional treatment required for the index ureteric stone. Our secondary objectives were to assess rates of non-operative management, ESWL, stent insertion, URS, and nephrostomy insertion; type of anaesthesia for operative management options; operative complications; hospital admission and length of stay; 30-day

and 6-month mortality; re-admission; and impact of stone on renal function.

Statistical Analysis

Statistical analysis was performed using R (version 4.1.0) [21]. Patients in the pre-pandemic cohort were compared to patients in the pandemic cohort. Two-sided unpaired *t*-tests and chi-squared tests were used to analyse the data. Data are presented as mean \pm standard deviation (SD) or as raw number and percentage. A $P < 0.05$ was deemed statistically significant.

Results

Demographics

Data were collected from a total of 3735 patients from 39 centres. In the pre-pandemic period data were entered for 1956 patients and in pandemic period data were entered for 1779 patients. Baseline patient characteristics were broadly similar (Table 1). Although, there was a significant difference in age between cohorts, the median age group for both cohorts was 50–59 years.

Stone site and size were similar between cohorts (Table 1). Unexpectedly, patients from the pre-pandemic cohort were reported to have significantly higher rates of active infection and AKI on admission, and fever at any point during index admission. However, mean C-reactive protein (CRP), white cell count, positive microbiology cultures (urine or blood), and creatinine were not significantly different (Table 1).

Management

Overall, patients in the pandemic period had significantly lower rates of admission to hospital (pre-pandemic 54.0% vs pandemic 46.5%, $P < 0.001$) and shorter length of stay in hospital compared to the pre-pandemic period, at a mean (SD) of 3.3 (5.9) vs 4.1 (8.0) days ($P = 0.02$). The use of α -blockers was significantly higher during the pandemic (pre-pandemic 17.4% vs pandemic 25.4%, $P < 0.001$). Despite the higher rates of active infection and fever, antibiotic usage was similar between cohorts (Table 2).

Interventional Management

There were no differences in rates of interventional management between the cohorts (pre-pandemic 787 [40.2%] vs pandemic 685 [38.5%], $P = 0.30$), or American Society of Anesthesiologists (ASA) Grade ($P = 0.50$) and WHO/Eastern Cooperative Oncology Group (ECOG) Performance Status ($P = 0.21$) in patients who received operative management (Table S1). However, there were significantly higher rates of ESWL and nephrostomy insertion, and significantly lower

Table 1 Baseline characteristics between the pre-pandemic patient cohort and the pandemic patient cohort.

Characteristic	Pre-pandemic period (N = 1956)	Pandemic period (N = 1779)	P
Age group, n (%)			
18–19 years	11 (0.6)	17 (1.0)	0.02
20–29 years	198 (10.1)	164 (9.2)	
30–39 years	340 (17.4)	346 (19.4)	
40–49 years	361 (18.5)	359 (20.2)	
50–59 years	409 (20.9)	405 (22.8)	
60–69 years	336 (17.2)	267 (15.0)	
70–79 years	210 (10.7)	149 (8.4)	
≥ 80 years	90 (4.6)	72 (4.1)	
Gender, n (%)			
Female	576 (29.4)	517 (29.1)	0.823
Male	1380 (70.6)	1262 (70.9)	
Body mass index, kg/m²			
Mean (SD)	28.8 (6.3)	29.6 (7.4)	0.074
Median (IQR)	28.0 (24.4–32.1)	28.7 (24.7–32.9)	
Non-urological comorbidities, n (%)			
Yes	538 (36.2)	453 (32.9)	0.075
No	950 (63.8)	923 (67.1)	
Urological comorbidities, n (%)			
Yes	56 (3.8)	46 (3.4)	0.662
No	1429 (96.2)	1309 (96.6)	
Ureteric stone location, n (%)			
Left	1014 (51.8)	929 (52.2)	0.52
Right	873 (44.6)	799 (44.9)	
Bilateral	69 (3.53)	51 (2.87)	
Maximum stone size, n (%)			
≤ 5 mm	1026 (57.5)	926 (56.9)	0.687
6–10 mm	633 (35.5)	598 (36.8)	
11–19 mm	108 (6.1)	85 (5.2)	
≥ 20 mm	18 (1.0)	17 (1.1)	
Active infection at time of presentation, n (%)			
Yes	258 (13.2)	193 (10.8)	0.032
No	1697 (86.8)	1586 (89.2)	
Fever (>38 °C) at any stage in index admission, n (%)			
Yes	151 (9.3)	107 (7.1)	0.031
No	1482 (90.8)	1406 (92.9)	
Admission blood tests CRP, mg/L			
Mean (SD)	27.7 (64.6)	26.4 (68.7)	0.562
Median (IQR)	4.0 (1.0–17.0)	3.0 (1.0–13.0)	
Admission blood tests WCC, $\times 10^9/L$			
Mean (SD)	11.0 (6.2)	11.0 (4.2)	0.725
Median (IQR)	10.3 (8.1–12.9)	10.7 (8.1–13.1)	
Positive blood culture, n (%)			
Yes	51 (38.1)	41 (41.0)	0.749
No	83 (61.9)	59 (59.0)	
Positive urine culture with $>10^5$ CFU, n (%)			
Yes	97 (21.8)	78 (20.9)	0.796
No	347 (78.2)	296 (79.1)	
Admission blood tests creatinine, $\mu\text{mol/L}$			
Mean (SD)	105 (70.8)	106 (75.9)	0.765
Median (IQR)	94.0 (77.0–113.0)	93.0 (78.0–113.0)	
AKI, n (%)			
Yes	340 (21.9)	290 (18.9)	0.041
No	1211 (78.1)	1245 (81.1)	
AKI grade (KDIGO)			
Grade 1	226 (74.1%)	202 (74.8%)	
Grade 2	55 (18.0%)	44 (16.3%)	
Grade 3	24 (7.9%)	24 (8.9%)	

CFU, colony forming units; KDIGO, Kidney Disease: Improving Global Outcomes; IQR, interquartile range; WCC, white cell count.

Table 2 Management and complications.

	Pre-pandemic period (N = 1956)	Pandemic period (N = 1779)	P
Admitted to hospital, n (%)			
Yes	1057 (54.0)	827 (46.5)	<0.001
No	899 (46.0)	952 (53.5)	
Length of stay, days			
Mean (SD)	4.08 (8.04)	3.29 (5.94)	0.021
α-blocker, n (%)			
Yes	316 (17.4)	414 (25.4)	<0.001
No	1501 (82.6)	1219 (74.6)	
Antibiotics, n (%)			
Yes, oral	171 (8.74)	148 (8.32)	0.251
Yes, intravenous	304 (15.5)	245 (13.8)	
No	1481 (75.7)	1386 (77.9)	
Interventional management, n (%)			
Yes	787 (40.2)	685 (38.5)	0.295
No	1169 (59.8)	1094 (61.5)	

	Pre-pandemic period (N = 787)	Pandemic period (N = 685)	P
Anaesthetic, n (%)			
General	390 (92.2)	173 (76.2)	<0.001
Non-general	33 (7.80)	54 (23.8)	
ESWL for index stone, n (%)			
Yes	179 (22.7)	233 (34.1)	<0.001
No	608 (77.3)	451 (65.9)	
URS for index stone, n (%)			
Yes	450 (57.2)	325 (47.5)	<0.001
No	337 (42.8)	359 (52.5)	
Stent insertion for index stone (alone or as part of URS), n (%)			
Yes	538 (68.4)	374 (54.6)	<0.001
No	249 (31.6)	311 (45.4)	
Emergency nephrostomy insertion for index stone, n (%)			
Yes	56 (7.1)	72 (10.5)	0.027
No	731 (92.9)	613 (89.5)	
Operative complication, n (%)			
Yes	87 (11.5)	68 (10.5)	0.616
No	671 (88.5)	580 (89.5)	
30-day highest Clavien–Dindo grade, n (%)			
None	671 (88.5)	580 (89.5)	
I	44 (5.8)	28 (4.3)	
II	29 (3.8)	15 (2.3)	
III-A	1 (0.1)	8 (1.2)	
III-B	9 (1.2)	12 (1.9)	
IV-A	2 (0.3)	0 (0.0)	
IV-B	1 (0.1)	2 (0.3)	
V (death)	1 (0.1)	3 (0.5)	

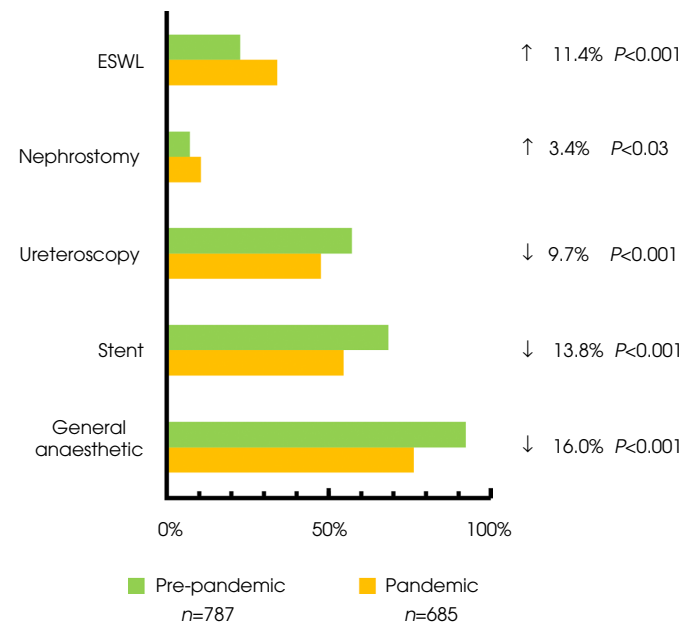
rates of general anaesthetic, URS and stent insertion during the pandemic compared to pre-pandemic (Fig. 1, Table 2). During the pandemic, planned interventions were delayed due to COVID-19 status in 63 of 1580 patients (4.0%).

Outcomes

At 30 days

The 30-day operative complication rate among those who received operative management was similar between the pre-pandemic and pandemic cohorts (Table 2), as was the 30-day mortality rate (any cause) across the whole of each cohort

Fig. 1 Change in interventional management during the pandemic.



(pre-pandemic eight of 1800 [0.4%] vs pandemic nine of 1637 [0.6%], P = 0.85).

At 6 months

The success rate of primary treatment (i.e., no further treatment required for the index stone after primary treatment modality) was similar between cohorts (pre-pandemic 73.8% vs pandemic 76.1%, P = 0.11). There was no significant difference in success of primary treatment modality when stratified by treatment modality or stone size.

In patients who did require further intervention, the rates of ESWL, URS, retrograde stent insertion, and nephrostomy were similar between each cohort (Table 3).

The mean (SD) number of unplanned admissions (pre-pandemic 0.17 (0.52) vs pandemic 0.18 (0.50), P = 0.83), mean (SD) creatinine (pre-pandemic 87.3 (36.9) vs pandemic 89. (51.9) μmol/L, P = 0.31), and chronic kidney disease Stage 1–5 (pre-pandemic 17.1% vs pandemic 17.9%, P = 0.99) were similar between the cohorts. There was a higher mortality rate in the pre-pandemic cohort group, at 42 of 1871 (2.3%) pre-pandemic vs 21 of 1719 (1.2%) pandemic (P = 0.02).

Discussion

In response to the COVID-19 pandemic, strategies to prioritise and triage patients with urological pathology were developed [13]. These included conservative treatment whenever possible [13], and use of local anaesthesia to minimise ventilator use and reduce risk of COVID-19

Table 3 Outcomes and additional operative management required at the 6-month follow-up.

	Pre-pandemic period (N = 1956)	Pandemic period (N = 1779)	P
Primary treatment success, n (%)			
Yes	1379 (73.8)	1308 (76.1)	0.113
No	490 (26.2)	410 (23.9)	
Unplanned re-admission for ureteric stone disease			
Mean (sd)	0.173 (0.520)	0.176 (0.500)	0.826
Creatinine, $\mu\text{mol/L}$			
Mean (sd)	87.3 (36.9)	89.4 (51.9)	0.305
Chronic kidney disease, n (%)			
Yes	230 (17.2)	213 (17.1)	0.989
No	1111 (82.8)	1036 (82.9)	
Death, n (%)			
Yes	43 (2.30)	21 (1.22)	0.021
No	1828 (97.7)	1698 (99.0)	
Additional interventions, n (%)			
ESWL			
Yes	87 (4.9)	95 (5.8)	0.231
No	1689 (95.1)	1519 (94.1)	
URS \pm laser lithotripsy \pm stent insertion, n (%)			
Yes	358 (19.5)	288 (17.1)	0.072
No	1481 (80.5)	1400 (82.9)	
Stent insertion retrograde, n (%)			
Yes	84 (4.8)	69 (4.3)	0.62
No	1685 (95.3)	1524 (95.7)	
Nephrostomy insertion, n (%)			
Yes	17 (1.0)	13 (0.8)	0.782
No	1767 (99.0)	1602 (99.2)	

exposure [12,13,15]. If operative management was deemed necessary, recommendations were made to select patients according to surgical priority using patient factors (symptoms, comorbidities, and renal tract abnormalities) and stone factors (obstruction, infection, and conservative management failure) [12,13]. In cases where there was an infected, obstructed system, multiple sources recommended insertion of a ureteric stent under local anaesthetic as first-line treatment, with nephrostomy as the second-line option [13,15].

In this study, we demonstrate that the management of ureteric stones changed across the UK during at the onset of the COVID-19 pandemic, with fewer invasive procedures and increased rates of ESWL and medical expulsive management. We also found that rates of nephrostomy were higher, despite lower rates of AKI and active infection.

Other studies have reported a decrease in urological presentations during the COVID-19 pandemic [22–25]. We therefore predicted that during the pandemic patients with ureteric colic would have delayed presenting to hospital and therefore have been a more unwell cohort. However, in our data, rates of AKI and active infection were lower in the pandemic patient cohort suggesting that these patients did not delay their presentation long enough to impact their clinical condition. These findings contrast with other urolithiasis datasets. Castellani *et al.* [26] compared ureteric stone disease outcomes of 298 patients prior to the pandemic

with 218 patients during the pandemic, reporting reduced admissions and higher rates of infected-obstructed systems, hospitalisation, and intervention during the COVID-19 pandemic. Furthermore, Flammia *et al.* [27] found that serum creatinine was significantly higher in 36 patients with urinary stone emergencies during the pandemic compared to 44 patients with urinary stone emergencies prior to the pandemic, which the authors' posited was due to delayed presentation. Similarly, Gul *et al.* [28] demonstrated an increase in creatinine, white cell count, hospital admissions, antibiotic treatment, and emergency nephrostomy insertion in 35 patients with urolithiasis during the pandemic compared to 114 patients with urolithiasis prior to the pandemic.

Our findings are consistent with those reported by Anderson *et al.* [29] and Nourian *et al.* [30] who identified no difference in markers of infection or AKI between pre- and post-pandemic cohorts of patients presenting with urolithiasis. Our study represents the largest cohort to date investigating ureteric stone outcomes during the pandemic, has a multicentre design and had a pre-defined protocol. Thus, we predict our findings are representative of true outcomes in the UK during the COVID-19 pandemic.

Steinberg *et al.* [31] suggested that we can use the COVID-19 pandemic as an opportunity to re-assess ureteric stone management strategies and establish whether conservative management strategies have been under used. Our study is the first to evaluate the impact of changes in the management of ureteric stones during the COVID-19 pandemic on patient outcomes at long-term follow-up [27,29,30,32,33].

We demonstrate that increased use of conservative management strategies did not have a detrimental effect on primary treatment success or patient outcomes at 6-month follow-up. Our data supports increased use of less-invasive options recommended by NICE and EAU guidance [6,7], including watchful waiting with medical expulsive therapy and ESWL as first line; there was an ~10% shift from URS to ESWL during the pandemic with non-inferior outcomes. Our data also support a reduction in admission rates and earlier discharge. It is unclear whether these changes will revert once the pandemic stabilises, and patient backlog is tackled or if practice will change permanently. Evidence such as this should drive a more permanent change to less-invasive management, as the change in practice during the pandemic has shown that this is safe and as effective.

This study is the first of its kind to be conducted across multiple sites with a 6-month follow-up. However, the study is limited by its retrospective design and missing data. Our study was conducted across 39 centres and the number of cases entered by each centre varied considerably. This may be due to differences in local patient populations; however, it may be that not all patients within each time period were captured. This increases the risk of selection bias within our

study and therefore no comment can be made on whether there was a change in the number of presentations with ureteric stone disease during each time period. Unexpectedly, we found there was a significant decrease in the mortality during the pandemic. It is difficult to explain this, particularly when demographic data such as age and other comorbidities was broadly similar. We hypothesise that some patients may have died due to COVID-19 before their stone disease was symptomatic enough to present to hospital, and this may have caused a sampling bias. While we demonstrated no difference in clinical outcomes, we did not collect data on quality-of-life outcomes, and this is a limitation. We made the assumption that if a patient's quality of life deteriorated significantly they would re-present to hospital for additional management. We did not collect data on location of ureteric stone, as we felt these data would not have been accurate due to heterogeneity in subjective location between different radiologists. Therefore, there may be differences in the ureteric stone locations between our cohort that we were unable to detect. As parts of the UK were affected by COVID-19 at different times, we sought to mitigate local differences by defining the start of the pandemic period as the first SARS-CoV-2 case at each individual site. We assumed that changes to urological care occurred at each site around this time, although these may have occurred later. As such, there may have been a difference in response over time at each site and this may have underestimated the difference in treatment change during the pandemic period.

Conclusions

As a result of the COVID-19 pandemic patients in the UK with ureteric stones were less likely to be treated invasively and more likely to be managed without admission. However, this change in practice did not result in inferior outcomes for patients. The pandemic has given the urological community an opportunity to re-evaluate management of ureteric stones; our findings indicate that a greater proportion of ureteric stones can be managed safely and effectively with non-invasive ambulatory options.

Acknowledgements

None.

Author Contributions

Matthew H.V. Byrne and Fanourios Georgiades were responsible for conceptualisation. All authors were responsible for writing the first draft and revisions. Alexander Light, Catherine Dominic, Josephine Rahman, Rajeev Kumar, and Members of the COVID Stone Collaborative were responsible for data collection. Matthew H.V. Byrne was responsible for data analysis. Sarah Howles, Grant D. Stewart, Ben Turney, and Oliver Wiseman were responsible for supervision. Ben

Turney and Oliver Wiseman are the guarantors. All authors have seen and approved the final version.

Disclosure of Interests

Grant D. Stewart: educational grants from Pfizer, AstraZeneca and Intuitive Surgical; consultancy fees from Pfizer, Merck, EUSA Pharma and CMR Surgical; Speaker fees from Pfizer; Trustee The Urology Foundation and Kidney Cancer UK; Travel expenses from Pfizer. Oliver Wiseman: consulting fees: Boston Scientific, EMS, Coloplast, Ambu, Astellas. Speaker fees: Education Boston Scientific, EMS, Coloplast, Ambu. Research grants Coloplast, EMS; Trustee BAUS, Treasurer BAUS. Ben Turney: consulting fees: Boston Scientific; Speaker fees: Boston Scientific, Devicare; *BJUI* (subeditor); Data safety monitoring/advisory board: Boston Scientific.

Ethical Approval

We followed NHS Health Research Authority guidance, and the study did not require ethical approval. Each participating site obtained local audit approval.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Appendix

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Abbreviations: AKI, acute kidney injury; ASA, American Society of Anesthesiologists; COVID-19, coronavirus disease 2019; CRP, C-reactive protein; EAU, European Association of Urology; ECOG, Eastern Cooperative Oncology Group; NICE, National Institute for Health and Care Excellence; SARS-CoV-2, severe acute respiratory syndrome coronavirus-2; STROBE, STrengthening the Reporting of OBServational studies in Epidemiology; URS, ureteroscopy/ureteroscopic.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. STROBE statement: checklist of items that should be included in reports of observational studies.

Table S1. ASA grade and WHO/ECOG performance status.