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Subcapsular renal haematoma after ureteroscopic lithotripsy: a single-centre, retrospective study in China

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ABSTRACT

Objectives To investigate the incidence, predisposing factors, diagnosis and management of subcapsular renal haematoma (SRH) after ureteroscopic lithotripsy (URSL).

Design Retrospective observational study.

Setting Shandong Provincial Hospital, a 4500-bed tertiary hospital in China.

Participants The data from 1535 consecutive patients treated with URSL (including rigid URSL and flexible URSL) between January 2015 and October 2020 were retrospectively analysed.

Main outcome measures SRH after URSL confirmed via CT. The characteristics, operative data and outcomes of these patients were documented and compared.

Results Six patients were confirmed to have an SRH after URSL on CT. The total incidence of SRH after URSL was 0.39%. The incidences of SRH after rigid URSL and flexible URSL were 0.38% and 0.41%, respectively. Unendurable ipsilateral flank pain and a significant decrease in haemoglobin after surgery were the characteristics of SRH after URSL. There were no significant differences in age, sex, history of diabetes mellitus, preoperative hypertension, body mass index, stone laterality or perfusion pressure (p>0.05). However, SRH was significantly associated with the stone size, stone location, degree of hydronephrosis and operative duration (p<0.01). One patient was managed conservatively without further intervention, percutaneous drainage was performed in four patients and one patient underwent emergency angiography. No patients died of SRH.

Conclusions SRH is a rare but potentially serious complication of URSL. Severe hydronephrosis and a thin renal cortex preoperatively and prolonged operative duration are strong predisposing factors for SRH. Laparoscopic ureterolithotomy should be considered as an alternative surgery for patients with severe ureteral tortuosity. SRH is treated based on patients’ clinical manifestations. Most patients can be managed with conservative treatment or percutaneous drainage alone.

INTRODUCTION

With advances in equipment and technology over the last few decades, ureteroscopic lithotripsy (URSL) has played a dominant role in the treatment of ureteral calculi. The European Association of Urology guidelines now recommend ureteroscopy (URS) as one of the first-line treatment options for proximal ureteric stones >10 mm.1 Furthermore, the learning curve for URS is relatively flat; thus, endourologists can more confidently manage complex urolithiasis with URSL.

Currently, URSL with a holmium:yttrium-aluminium-garnet (Ho:YAG) laser is considered an effective and safe method for managing ureteral stones.2 The complication rates for this procedure are low, and possible complications include infection, bleeding, colic, ureteric stricture and urinary retention; major complications occur in less than 0.1% of cases.3 Subcapsular renal haematoma (SRH) is an uncommon complication after URSL. Whitehurst and Somani recently reviewed 210 articles reporting on post-URS SRH from 1980 to September 2016; only seven studies met the inclusion criteria, and 8929 URSLs were evaluated, with a reported incidence of post-URS SRH of 0.45% (40 patients, range: 0.15%–8.9% per study).4

In the present study, we investigated the incidence of SRH after URSL for urolithiasis, identified the predisposing factors and reported the management and outcomes of SRH.
METHODS

Study design and participants
We retrospectively reviewed the medical records of patients who underwent URSL (including rigid URSL and flexible URSL) for urolithiasis between January 2015 and October 2020 at Shandong Provincial Hospital. In all, 1591 patients in our departmental database underwent URSL. Fifty-six patients were excluded from the present study because concomitant percutaneous nephrolithotomy (PCNL) was performed. Ultimately, 1535 patients who underwent URSL performed by three surgeons were enrolled in this study. A total of 1043 patients with ureteral stones were managed with a rigid 8/9.8F ureteroscope (Richard Wolf, Knittlingen, Germany) by flexible URSL (7.5F, Olympus, Tokyo, Japan), and holmium laser lithotripsy (flexible URSL) was performed in 341 patients with renal calculi and 151 patients with proximal ureteral stones alone or with proximal ureteral stones and renal calculi.

Data extraction
Patient demographics, such as age, sex, body mass index (BMI) and preoperative hypertension; stone characteristics, such as stone laterality, stone location and the degree of hydronephrosis; intraoperative data; renal haematoma manifestations; and the management of each patient were documented and compared.

The endoscopic procedure was performed under general anaesthesia with the patient in a dorsal lithotomy position. Continuous saline irrigation (Karl Storz & Co, Tuttinglen, Germany) was used to maintain clear operative visibility with an irrigation pressure of 50–100 mm Hg. A 600 µm Ho:YAG laser fibre was used for lithotripsy with a rigid ureteroscope, and the energy setting was set at 0.8–1.5 J with a frequency of 6–12 Hz. A 230 µm Ho:YAG laser fibre was used for lithotripsy with a flexible ureteroscope, with the laser energy of 0.6–1.0 J and a frequency of 6–10 Hz. Ureteral access sheaths were used routinely during flexible URSL. The aim of lithotripsy was to fragment the stones to a size of less than 1 mm in diameter. After the procedure, a 5F double-J stent (Cook Medical, Bloomington, Indiana, USA) was inserted in each patient. The double-J stent was removed 4 weeks postoperatively.

Unendurable ipsilateral flank pain and significant decreases in haemoglobin postoperatively with no other identifiable causes were strong indicators of SRH formation. Ultrasonography (US) or CT was used to diagnose SRH.

Statistical analysis
The X² test or Fisher’s exact test was used for categorical variables (gender, laterality, preoperative comorbidities), and Student’s t-test was used for continuous variables (age, BMI and operative duration). Predisposing factors were compared using bivariate analysis between patients with and without SRH. Stone location was analysed using Pearson’s X² test. All tests were two sided, and a p value of less than 0.05 was considered statistically significant.

RESULTS
Six patients were confirmed to have an SRH after URSL with CT. The total incidence of SRH after URSL was 0.39% (6 of 1535). The incidence of SRH after rigid URSL and flexible URSL was 0.38% (4 of 1043) and 0.41% (2 of 492), respectively. The six patients included three men and three women between 33 and 65 years of age. The patients’ preoperative serum creatinine levels were normal, except in one patient with a mildly impaired preoperative serum creatinine level (161 µmol/L). None of these six patients were anticoagulated at the time of the procedure. The mean (range) stone size was 1.4 (0.8–2.3) cm. One patient with a right distal ureteral stone and a left proximal ureteral stone underwent bilateral URSL. SRH was identified on both sides with a postoperative CT (Figure 1). This patient was counted as one case of SRH for the statistical analysis. The stone location was proximal in six patients; only one patient had a distal ureteral stone.

Table 1 shows the patient demographics (age, sex, BMI and preoperative comorbidities), stone characteristics (stone laterality, stone size, stone location and degree of hydronephrosis), and intraoperative data (operative duration and perfusion pressure) between patients with and without SRH after URSL. There were no significant differences in age, sex, history of diabetes mellitus, preoperative hypertension, BMI, stone laterality or perfusion pressure (p>0.05). However, SRH was significantly associated with the stone size, stone location, degree of hydronephrosis and operative duration (p<0.01).

Unendurable ipsilateral flank pain, fever and significant decreases in haemoglobin after surgery were the typical clinical manifestations of SRH after URSL. Four patients developed SRH within 24 hours after surgery. All of these

four patients reported flank pain and experienced significant decreases in haemoglobin levels (30–80 g/L), and three of them became febrile. The remaining two patients had a delayed presentation of persistent fever that developed on days 7 and 23 after surgery, respectively. The management of SRH was performed according to the patient’s vital signs and response to medical therapy. One patient was managed conservatively without any further interventions. Emergency angiography was performed in one patient. The haemoglobin level of this patient decreased from 140 g/L to 60 g/L within 8 hours after surgery and symptoms of shock occurred. Interestingly, no active haemorrhage was found during angiography, and this patient’s vital signs stabilised after angiography. Four patients required postoperative blood transfusions. Four patients were treated with percutaneous drainage; one of these patients underwent simultaneous percutaneous nephrostomy because of the formation of large clots in the renal pelvis (figure 2). No patients required conversion to open surgery, and the SRH was resolved in all patients at 6 months of follow-up. Table 2 shows the clinical manifestations, management and outcomes of those patients who presented with an SRH after URSL.

**DISCUSSION**

SRH usually occurs in patients after extracorporeal short-wave lithotripsy and PCNL. There are few cases reported in the literature about SRH after URSL. Bansal et al first reported a case that was confirmed as SRH after pneumatic URSL in 2010. A 35-year-old male patient with a right ureteric stone developed an 11×12×10 cm SRH after pneumatic URSL, and the haematoma was managed by percutaneous drainage and percutaneous nephrostomy. Bai et al reported 11 patients with SRH after rigid URSL, which is the largest number of patients with SRH after URSL reported in the literature. However, Bai et al documented only patients who developed an SRH after rigid URSL; those patients who developed an SRH after flexible URSL were not mentioned. To our knowledge,

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**Table 1** Comparison between patients with and without SRH after URSL in terms of patient demographics, stone characteristics and intraoperative data

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Non-haematoma, N=1529</th>
<th>SRH, N=6</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean, SD), years</td>
<td>51.3 (9.2)</td>
<td>52.0 (11.1)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Gender (% male)</td>
<td>48.3</td>
<td>50</td>
<td>0.74</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>28.6</td>
<td>66.7</td>
<td>0.11</td>
</tr>
<tr>
<td>Diabetes mellitus (%)</td>
<td>19.3</td>
<td>16.7</td>
<td>0.72</td>
</tr>
<tr>
<td>Mean BMI, kg/m²</td>
<td>27.6</td>
<td>26.9</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Stone laterality (% left)</td>
<td>51.3</td>
<td>50</td>
<td>0.73</td>
</tr>
<tr>
<td>Stone location, n (%)</td>
<td>Proximal</td>
<td>569 (37.2)</td>
<td>6 (85.7)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>422 (27.6)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Distal</td>
<td>538 (35.2)</td>
<td>1 (14.3)</td>
</tr>
<tr>
<td>Mean stone size (range), cm</td>
<td>0.8 (0.5–1.6)</td>
<td>1.4 (0.8–2.3)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hydronephrosis, n (%)</td>
<td>No</td>
<td>128 (8.4)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>624 (40.8)</td>
<td>1 (16.7)</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>436 (28.5)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>341 (22.3)</td>
<td>5 (83.3)</td>
</tr>
<tr>
<td>Perfusion pressure, mean (SD), mm Hg</td>
<td>65.2 (3.6)</td>
<td>66.8 (3.8)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Operation duration, mean (range), min</td>
<td>28 (15–63)</td>
<td>57 (21–170)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

BMI, body mass index; SRH, subcapsular renal haematoma; URSL, ureteroscopic lithotripsy.

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**Figure 2** A patient who underwent ultrasonography-guided drainage of haematoma and nephrostomy.
have been reported in previously published studies. The typical clinical manifestations of SRH after URSL, which may not undergo imaging examination to identify these haematomas, and those patients who reported flank pain without a significant decrease in haemoglobin may be considered to have ‘stent pain’. Therefore, some haematomas may not be diagnosed. Although the incidence of SRH after URSL was relatively low, we still consider that SRH is a potentially life-threatening complication. One patient in this study developed shock, and there was a report about mortality due to SRH. Endourologists should be aware of the incidence of SRH after URSL.

Unendurable ipsilateral flank pain, fever and a significant decrease in haemoglobin after surgery were the typical clinical manifestations of SRH after URSL, which have been reported in previously published studies. Four patients in the present study developed acute onset flank pain and rapid decreases in haemoglobin within 24 hours after surgery, and five patients became febrile. There are some reports about delayed haematoma diagnosis during evaluations for nausea, weight loss or a palpable renal mass.

There is no standardised treatment for SRH after URSL. SRH is treated based on patients’ clinical manifestations. The majority of published reports have concluded that conservative treatment is the best initial management for SRH, but there are still some debates about the treatment of SRH. Kozinski et al reported that seven patients developed subcapsular haematomas or perinephric haematomas after URSL; no patients required surgery to drain the haematomas, only two patients required blood transfusions and only one patient was taken to surgery for an incorrectly positioned ureteral stent. The latest systematic review about perirenal haematoma formation after URS reported by Whitehurst and Somani reported that 55% of the perirenal haematomas were managed conservatively, and 27.5% required percutaneous drainage, while only 17.5% patients required surgical interventions. In our opinion, every patient should be managed individually according to their vital signs and the volume of blood loss. Patients with small subcapsular haematomas can be treated conservatively, but percutaneous drainage is needed in patients with symptoms caused by haematomas, such as fever, flank pain, nausea or weight loss. If conservative therapy fails, emergency angiography and transcatheter arterial embolisation should be considered as the best choice for controlling renal haemorrhage, followed by open surgery or laparoscopic surgery for the removal of haematomas and inevitable nephrectomy.

The aetiology of SRH formation after URSL is still unclear. Bai et al first proposed a mechanism of SRH formation after URSL. They suggested that ureteric recanalisation induces rupture of the renal parenchyma and/or capsular vessels; thus, blood and fluid accumulate in the subcapsular space of the kidney, separating the capsule from parenchyma and resulting in haematoma formation. They suggested that the stone size, degree of hydronephrosis, operative duration and perfusion pressure should be considered risk factors for SRH formation after URSL. We agree with these points, as five patients in the present study had severe hydronephrosis and a thin renal cortex preoperatively. Compared with those of patients in the control group, the stone size and operative duration of patients with haematoma formation were significantly different. Larger stones increase the operative duration, leading to longer perfusion duration.

### Table 2 Clinical manifestations and management of patients with SRH after URSL

<table>
<thead>
<tr>
<th>No</th>
<th>Gender</th>
<th>Stone position</th>
<th>Stone size (cm)</th>
<th>Hydronephrosis</th>
<th>Operation duration (min)</th>
<th>Symptoms</th>
<th>Blood transfusion</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Female</td>
<td>Left, proximal</td>
<td>1.6</td>
<td>Severe</td>
<td>45</td>
<td>Flank pain</td>
<td>Yes</td>
<td>Percutaneous drainage</td>
</tr>
<tr>
<td>2</td>
<td>Male</td>
<td>Left, proximal</td>
<td>2.3</td>
<td>Severe</td>
<td>35</td>
<td>Flank pain, fever</td>
<td>Yes</td>
<td>Emergency angiography</td>
</tr>
<tr>
<td>3</td>
<td>Female</td>
<td>Right, proximal</td>
<td>1.3</td>
<td>Severe</td>
<td>170</td>
<td>Flank pain, fever</td>
<td>Yes</td>
<td>Percutaneous drainage Percutaneous nephrostomy</td>
</tr>
<tr>
<td>4</td>
<td>Female</td>
<td>Right, proximal</td>
<td>0.8</td>
<td>Mild</td>
<td>21</td>
<td>Fever, 7 days after operation</td>
<td>No</td>
<td>Percutaneous drainage</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>Left, proximal</td>
<td>1.2</td>
<td>Severe</td>
<td>25</td>
<td>Fever, 23 days after operation</td>
<td>No</td>
<td>Conservative therapy</td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>Left, proximal</td>
<td>1.5</td>
<td>Severe</td>
<td>46</td>
<td>Flank pain, fever</td>
<td>Yes</td>
<td>Percutaneous drainage</td>
</tr>
</tbody>
</table>

SRH, subcapsular renal haematoma; URSL, ureteroscopic lithotripsy.
increasing the risk of haematoma formation. We suggest that operative duration should be considered the most important predisposing factor for haematoma formation. The operative duration of one patient with severe ureteral tortuosity (figure 3) in our study was 170 min, and we spent a considerable amount of time inserting a double-J stent. Compared with URSL, laparoscopic ureterolithotomy might be more appropriate for this patient. Xu and Li\textsuperscript{14} reported that urinary tract infections (UTIs) may play a role in haematoma formation. They suggested that UTIs can cause damage to the renal parenchyma through neutrophilic infiltration, making the parenchyma more susceptible to pronounced bleeding. Chiu et al reported that patients with a higher BMI were more at risk of SRH formation\textsuperscript{9}; however, similar results were not found in our study. Meng et al\textsuperscript{10} and Kozmins\textit{k}i et al\textsuperscript{11} suggested that hypertension is a predisposing factor that is associated with an increased risk of SRH. Kozminski et al\textsuperscript{11} proposed that patients with hypertension may be more prone to bleeding following a URSL-induced injury. However, similar results were not found in our study either.

Did the incidence of SRH relate to learning curve? Campobasso et al reported one retrospective series of 2497 consecutive URSS for urolithiasis performed by eight skilled endourologists (>200 procedures in the last 5 years); an SRH occurred in four cases (0.12%).\textsuperscript{14} The interesting thing was that the total four SRHs occurred in patients treated by highly experienced endourological surgeons (>500 procedures). They explained this may be caused by the self-confidence of these surgeons in treating larger stones or in their confidence in treating more rapidly small stones without ureteral access sheath application. In our study, the three doctors are endourological-experienced surgeons with the same level of experience (YJ reported two cases of SRH, BXJ reported one case of SRH and JJZ reported three cases of SRH), so it seemed that the onset of SRH may be not related to the learning curve.

To reduce the incidence of SRH, we suggest that endourologists should pay attention to the following principles: (1) strictly control the operative duration; (2) maintain a low perfusion pressure during surgery; (3) insert a 3 Fr ureteral stent with suction during lithotripsy to provide better visualisation and reduce the pressure in the pelvic-calyceal system; (4) perform preoperative nephrostomy in patients in whom the operative duration is expected to be long, especially in patients with severe hydronephrosis, a thin renal cortex or completely impacted ureteral stones; (5) consider laparoscopic ureterolithotomy as an alternative surgery for patients with severe ureteral tortuosity; and (6) treat hypertension and UTIs preoperatively.

Our study has some limitations. This study is a retrospective study, and bias may have occurred due to the relatively small number of cases. The single-centre setting is also an important concern that limits the generalisability of any associations reported. US and CT are not performed routinely in patients after URSL; thus, it is possible that subclinical or asymptomatic haematomas were not detected, so the true incidence of SRH may have been underestimated. Moreover, ureteral access sheaths were used routinely in the present study, which limited the assessment of the clinical association between ureteral access sheath placement and haematoma formation.

**CONCLUSION**

SRH is a rare but potentially serious complication of URSL. Severe hydronephrosis, a thin renal cortex preoperatively and prolonged operative duration are strong predisposing factors for SRH. Laparoscopic ureterolithotomy should be considered as an alternative operation for patients with severe ureteral tortuosity. SRH is treated based on patients’ clinical manifestations. Most patients can be managed with conservative treatment or percutaneous drainage alone.

**Contributors** JJZ designed the study protocol and performed study operations and acted as guarantor of this article. JY wrote the manuscript and performed study operations. BL was in charge of data analysis. NYZ and BXJ were responsible for data acquisition. BXJ performed study operations and revised the manuscript.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not required.

**Ethics approval** This study involves human participants and was approved by the Institutional Review Board of Shandong Provincial Hospital Affiliated to Shandong 1st Medical University (No. 2020000185). The data are anonymous, thus, the requirement for informed consent was waived.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data sharing not applicable as no datasets generated and/or analysed for this study.

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*Figure 3* Retrograde pyelography suggestive of severe tortuosity of the right ureter where a ureteral stone was located (red arrow).
REFERENCES