

Spontaneous renal rupture due to renal calculi: A case report and literature review

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Abstract. Spontaneous renal parenchymal rupture is a rare clinical emergency. The formation of benign and malignant tumors is the most common underlying cause of spontaneous rupture of renal parenchyma. To the best of our knowledge, 15 cases of renal parenchymal rupture have been reported to date. This report describes a rare case of renal parenchyma rupture in the lower left kidney caused by kidney calculi. Furthermore, previously published cases and articles were reviewed. The patient underwent four extracorporeal shockwave lithotripsy procedures within 2 years. The renal parenchyma rupture caused by the stones was successfully treated by removing the stones and repairing the kidney. However, a large hematoma was discovered around the lower pole of the left kidney, suggesting the possibility of a renal tumor. Therefore, radical nephrectomy was performed. Postoperative pathology revealed the lesion to be consistent with an intrarenal stone, where no malignancy, infection or vascular disease was observed. The present case highlights the requirement to also take into account the patient's clinical history in cases where imaging cannot completely identify the underlying cause of renal parenchymal rupture. Accurate identification of the underlying etiology of spontaneous renal rupture may determine the best treatment for the patient. The purpose of the present report is to facilitate the identification of the disease and reduce the rate of clinical misdiagnosis.

Introduction

Spontaneous rupture of the kidney is a rare but clinically critical event (1). According to its location, spontaneous rupture of the kidney may be categorized as renal parenchyma rupture, renal collecting system rupture or mixed rupture (2). Spontaneous rupture of the renal parenchyma is uncommon and its incidence is lower compared with that of renal pelvis rupture (3). The main causes of renal parenchyma rupture are malignancies, tuberculosis, abscesses, calculi, hemophilia and polycystic kidneys (4-6). Formation of benign and malignant tumors appear to be the most common cause of spontaneous rupture of the renal parenchyma (7). However, selective incidences of renal parenchyma rupture caused by kidney stones have been reported (1,8). The present report describes a rare case of renal parenchyma rupture caused by stones, where a large hematoma was discovered on the affected side of the patient and subsequently misdiagnosed as a malignancy for treatment. The present report discusses the diagnosis and treatment of this case. It was emphasized that: i) Spontaneous renal rupture may occur in patients with long-term kidney calculi with a history of extracorporeal shockwave lithotripsy (ESWL); and ii) in an emergency with a ruptured kidney, rapid and accurate preoperative diagnosis is important for the selection of treatment and surgical protocol for patients.

Case report

In November 2020, a 67-year-old male presented to the Affiliated Hospital of Yangzhou University (Yangzhou, China) with pain on the left flank and oliguria. Apart from this, the patient had no other symptoms or complaints. The patient had a history of left kidney calculi for more than ten years, he had undergone ESWL twice a year for kidney calculi in 2018 and 2019. The patient's blood pressure on admission was 133/71 mmHg. Physical examination revealed pain on percussion in the left renal area but no palpation on the mass.

The routine blood test and coagulation function test were conducted using the XN-3000 automatic blood cell analyzer and automatic coagulation analyzer, respectively (Sysmex Corporation). A Roche moduladp was used for other biochemical tests. Laboratory analysis revealed a hemoglobin of 89 g/l (normal, 115-150 g/l), elevated

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creatinine of 163.8 $\mu\text{mol/l}$ (normal, 41-81 $\mu\text{mol/l}$), potassium of 5.42 mmol/l (normal, 3.5-5.3 mmol/l), leukocyte count of $13.95 \times 10^9/l$ (normal, $3.5-9.5 \times 10^9/l$) and blood glucose of 6.77 mmol/l (normal, 3.89-6.11 mmol/l).

The patient underwent ultrasound examination with a Philips IU Elite (Philips Healthcare). The kidney was detected using a convex curved probe at 33.5 MHz. Ultrasonography revealed heterogeneous echo area in lower pole of left kidney, which suggested the possibility of renal cell carcinoma rupture. Subsequently, a plain and enhanced CT scan was performed with a SOMATOM Definition AS 64-slice spiral CT machine (Siemens Healthineers). The scan range was from the upper kidney to the lower kidney. The scanning parameters were set as follows: Pitch, 0.9375:1; layer thickness, 5 mm; layer spacing, 5 mm; tube voltage, 120 kV; and tube current, 160 mA. The CT enhancement scan was performed using iohexol (Cytiva) 1.5 ml/kg at an injection rate of 4.0 ml/sec. The arterial phase was scanned 25 to 30 sec after contrast medium injection, the venous phase was scanned 60 to 70 sec and the renal pelvis filling phase was scanned 120 to 180 sec. The results revealed that a strip of high-density shadow with a width of ~ 0.9 cm could be seen in the left ventral ureter and the upper urinary tract was dilated with effusion (Fig. 1A). An abnormally large mass in the left renal area measured $\sim 9.4 \times 8.9 \times 11.5$ cm in size (Fig. 1B). Multiple nodular high-density shadows were also observed in the left renal pelvis and calyces (Fig. 1B). The enhancement was uneven in the arterial phase according to contrast-enhanced CT, similar to that in the renal parenchyma, but less intense in the venous phase (Fig. 1C). According to the ultrasound, CT imaging findings and clinical manifestations, the preoperative diagnosis was as follows: i) Hemorrhage of the left renal cell carcinoma with hematoma formation; and ii) calculus of the left ureter, renal pelvis and calyceal, accompanied by dilation and hydronephrosis of the urinary system.

After admission, the patient was given fluid resuscitation and empirical anti-infection treatment. Subsequently, the patient underwent radical nephrectomy, with resection of the left kidney, surrounding fat tissues and a substantial proportion of the ureter. To verify the preoperative diagnosis of spontaneous rupture of the kidney caused by a tumor, the surgically removed kidney was examined pathologically. There was a large hematoma in the lower pole of the left kidney and the left renal cortex was thin (Fig. 2A). In addition, prominent stones were present in the stellate fracture of the dorsal renal parenchyma. It was also observed that numerous yellow stones were mixed with perirenal blood clots outside the renal capsule (Fig. 2B). The renal tissues were stained with H&E after operation. The specific steps were as follows: i) The fixation solution was 10% formalin solution, 20 volumes of the sample, and fixing was performed at room temperature for 24 h; ii) dehydration was carried out by using an alcohol sample with low concentration to high concentration, then the tissue block was placed in a xylene clearing agent, and the alcohol was replaced; iii) the tissue was placed in the melted paraffin and blocks were automatically formed after the paraffin was cooled; iv) 5-mm slices were cut with a microtome; v) dyeing: H staining for 5 min and E staining for 3 min at room temperature; vi) repeated alcohol dehydration as in step ii; and vii) sealing. The sections were examined using a light microscope. Postoperative pathology indicated

that the lesions were consistent with intrarenal stones, where giant cell reaction to stones, renal interstitial atrophy (Fig. 3A) and degeneration were observed (Fig. 3B). However, tumor, infection and vascular disease could not be observed.

After the operation, the patient's vital signs were stable and he returned to the general ward. The surgical drain was removed on day 5, while intravenous antibiotics were continued until day 7. The patient also received symptomatic treatment such as analgesia, fluid replacement and cough relief. The patient was discharged from hospital 10 days after the operation. We conducted regular follow-up visits were performed and the last follow-up visit was in April 2022. The patient recovered well and no other diseases occurred during the follow-up visit.

Discussion

Non-traumatic spontaneous renal rupture is a rare but critical clinical event that frequently leads to dilemmas regarding diagnosis and treatment (9). The incidence of spontaneous renal parenchyma rupture is lower compared with that of renal pelvic rupture (8). The key words 'spontaneous renal parenchymal rupture' and 'case report' were searched in PubMed and Google Scholar for published case reports. The inclusion criteria were as follows: i) Case reports; ii) renal parenchyma rupture was required to be mentioned in the abstract; iii) detailed clinical information of patients was included. Finally, 10 articles were included in the study. A total of 15 cases of renal parenchyma rupture were reported in these 10 articles (Table I) (1,6,8,10-16). Among them, Durak *et al* (6) reported an autopsy case in an elderly Turkish male. Among the previously reported patients, males appeared to be at a slightly higher risk, with the male to female ratio of 8:7 and a mean age of 49 ± 23 years. In these previous reports, infection was the main cause of spontaneous renal rupture in female patients. Spontaneous rupture of the kidney occurs indirectly or directly as a result of kidney atrophy and abscess formation caused by inflammation (10,13). By contrast, renal tumors were the cause of rupture in $>50\%$ of the male patients (5). In addition, renal parenchyma rupture caused by renal cancer may lead to fatal hemorrhage (1,6,10). Abdominal pain is a common feature in all patients with ruptured renal parenchyma due to irritation of the retroperitoneal nerve plexus and emesis in certain patients (17). Hematuria may also occur, but it is not a characteristic symptom of non-traumatic renal rupture and its appearance is mainly dependent on potential diseases (10). These symptoms are similar to acute abdominal pain and require differentiation from other gastrointestinal diseases (14). The appearance of shock symptoms is a risk signal for spontaneous renal rupture (18). Even if prompt surgery is performed, the patient may finally succumb to this condition due to organ failure (1). CT examination of the retroperitoneal space is currently the most important means for diagnosing spontaneous renal rupture (17). Typical CT findings include high-density masses within the renal capsule with exudation into the perirenal space (19). Strip-like and high-density infiltration of perinephric fat is a common manifestation of renal hemorrhage (20). The CT findings in 10 of the 15 cases revealed perirenal hematomas, suggesting the possibility of renal rupture. However, it remains difficult to accurately make an etiological diagnosis, since an accurate

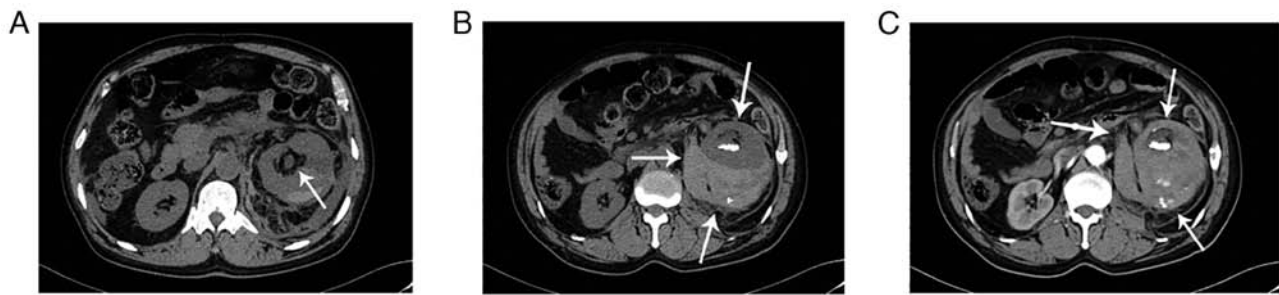


Figure 1. Preoperative CT. (A) Plain CT image. Left upper urinary tract was dilated with effusion (white arrow). (B) Plain CT image. A huge mass (white arrows) was observed in the left kidney area with a size of $\sim 9.4 \times 8.9 \times 11.5$ cm, in which multiple calcifications and patchy low-density shadows appeared. (C) Contrast-enhanced CT image. The mass (white arrows) was enhanced unevenly in the arterial phase, which was similar to the density of renal parenchyma.

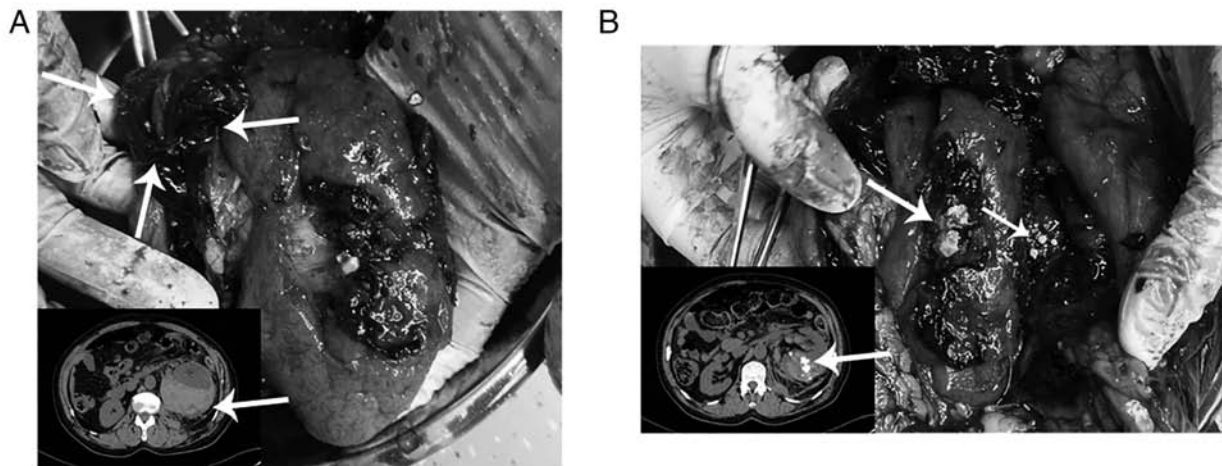


Figure 2. Postoperative images indicating the locations of the calculi and atrophy. (A) Hematoma (white arrows) surrounded the lower pole of the ruptured kidney. (B) Stones (white arrows) protruded from the left renal cortex.

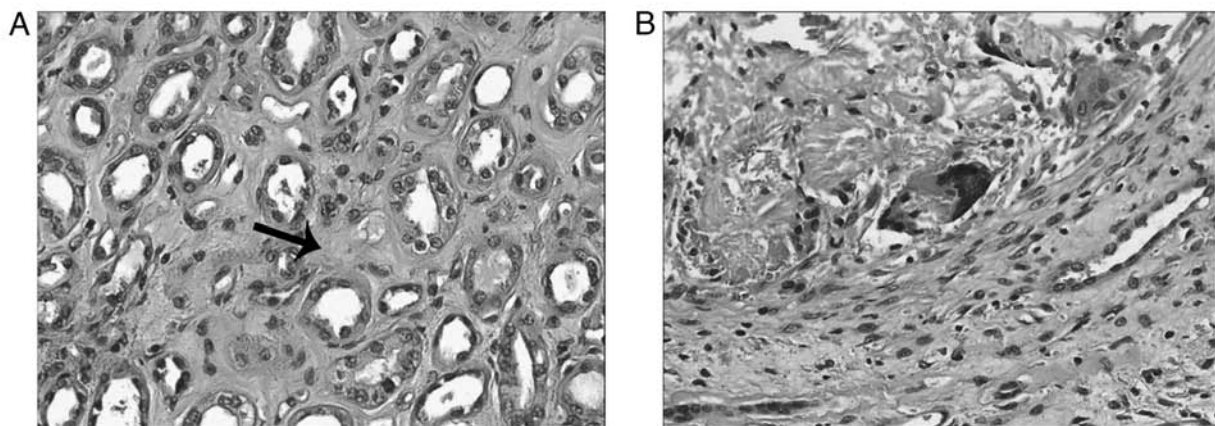


Figure 3. Histological features indicated by H&E staining. (A) Long-term stimulation of calculi had resulted in renal interstitial atrophy (black arrow). (B) Giant cell reaction of foreign bodies caused by calculi (magnification, x200).

diagnosis prior to surgery was only made in two cases (10,15). Faced with this situation, clinicians first consider the possibility of a tumor, which is the most common etiology found during histological evaluation after spontaneous renal rupture surgery (3,17). A plain and enhanced CT examination of the patient was performed in the present report. A CT scan is able to detect, quantify the extent of and locate perirenal hemorrhage (21). In the present report, CT suggested a possible renal

tumor. A preoperative diagnosis of renal cancer-associated hemorrhage can be readily detected using CT, which requires urgent surgery due to the immediate risk of mortality (14).

It should be noted that a diagnosis made based on imaging examination alone should not be regarded as sufficient. The particularity of the present case was identified by comparing the medical records with other reported cases of renal parenchyma rupture (1,6,8). Renal parenchymal rupture is a

Table I. Reported cases of spontaneous rupture of renal parenchyma.

Author (year)	Age, years/sex	Clinical symptoms	CT description	Therapeutic method	Causes of rupture	(Refs.)
Councill WA and Councill WA Jr (1950)	48/F	Right lumbago with vomiting	Not performed	Pyelotomy and lithotomy	Incarcerated calculi in lower segment of large calyx of kidney	(8)
Miyamoto H and Usuda K (1994)	3/M	Left abdominal pain	Left hydronephrosis with perirenal uroma	Left pyeloplasty	Renal rupture caused by elevated renal pelvis pressure	(11)
Szentgyorgyi E <i>et al</i> (1994)	67/F	Abdominal pain and fever	Extracapsular hematoma of left kidney	Nephrectomy	Aposthematous pyelonephritis without obstruction	(10)
Szentgyorgyi E <i>et al</i> (1994)	69/F	Abdominal pain and fever	Not performed	Nephrectomy	Acute purulent pyelonephritis	(10)
Szentgyorgyi E <i>et al</i> (1994)	80/F	Pain in the left lower abdomen	Heterogeneous infiltration around kidney	Nephrectomy	Chronic pyelonephritis and a cortical cyst	(10)
Szentgyorgyi E <i>et al</i> (1994)	70/M	Left renal colic	Not performed	Radical nephrectomy	Adenopapillary cancer with ecchymosis and necrosis	(10)
Szentgyorgyi E <i>et al</i> (1994)	41/M	Abdominalgia	Suspected renal tumor	Radical nephrectomy	Renal cancer with hemorrhage	(10)
Wakasugi E <i>et al</i> (1996)	47/F	Abdominalgia	Left renal hemorrhage with hematoma	Nephrectomy	The formation of renal abscess	(12)
Altinoluk <i>et al</i> (2012)	25/F	Abdominal pain and fever	Low-density mass around left kidney	Nephrectomy	Xanthogranulomatous pyelonephritis	(13)
Durak <i>et al</i> (2014)	79/M	-	Not performed	-	Renal-cell carcinoma	(6)
Sudusinghe <i>et al</i> (2018)	48/M	Left lumbar colic	Left perirenal hematoma	Nephrectomy	Acquired renal cystic disease	(14)
Zhang <i>et al</i> (2019)	57/F	Fever with edema	Bilateral perirenal hematoma	Methylprednisolone pulse therapy	Microscopic polyangiitis	(15)
Chiancone <i>et al</i> (2021)	64/M	Acute left flank pain and massive haematuria	Left kidney rupture and a left pelvic ureteral stone	Nephrectomy	Intrarenal hypertension aft ureteral calculi obstruction	(1)
Yavuzsan <i>et al</i> (2021)	20/M	Abdominalgia	Mesenteric vascular injury	Nephrectomy	Hydronephrosis and increased abdominal pressure	(16)
Yavuzsan <i>et al</i> (2021)	38/M	Abdominalgia	Perirenal hematoma formation	Radical nephrectomy	Multiple renal cysts, adenomas and small renal cancers	(16)

M, male; F, female.

life-threatening emergency, where the most common symptoms are intense sharp pain, hemorrhagic shock and a palpable abdominal mass (17). In the present report, the patient exhibited no symptoms other than left lower back pain and oliguria. The first suspicion may be upper urinary tract obstruction caused by urinary calculi. However, CT suggested a perirenal

hematoma most likely caused by the rupture of renal cancer, which is the most common condition clinically. An important feature that was overlooked in the present case was that the patient had developed multiple stones in his left kidney over several years and had undergone four ESWL procedures within 2 years. Therefore, in the present case, the risk of spontaneous

rupture of the renal parenchyma was high. No significant lumbago or hematuria were detected in the patient prior to the first ESWL in 2018. The long-term presence of calculi during this period may lead to hematuria that cannot be recognized by naked eyes or compensated mild hydronephrosis, although the patient has no obvious symptoms (14). In addition, infection may occur (17). Since these aforementioned symptoms resolved, the patient ignored the stones that caused them. According to his description, no tumor was found in the left kidney at the last preoperative examination of ESWL in 2019. We cannot rule out tumorigenesis after 2019. Tumors may arise due to irritation caused by the stones or spontaneously in the absence of precipitating factors. Among all cases reported, renal parenchyma rupture was caused by kidney stones in two cases. In one case, severe hydronephrosis was caused by the obstruction of ureteral calculi in the pelvic region, where the patient delayed medical treatment for 4 months due to the coronavirus disease 2019 outbreak (6). This delay may have induced chronic tubulointerstitial nephritis or rupture of the collecting system (1). Sudden increases in the renal venous pressure are most likely to be the physiological cause of parenchymal rupture. The characteristics in the other case was similar to those in the patient in the present report (8). Comparison of the two cases indicated that both patients had kidney calculi for several years, such that the stones grew to >2 cm in size. Long-term friction and adverse reactions to stones rendered the renal cortex thinner and weaker. Upper urinary tract obstruction caused by ureteral calculi and ureteropelvic junction stenosis may have led to increased renal pressure, changes in the normal renal morphological structure and weakening of the renal parenchyma, undoubtedly increasing the risk of renal parenchyma rupture (22). A medical history review revealed that the patient in the present report had undergone ESWL twice a year for kidney calculi in 2018 and 2019. The patient's ESWL surgeries were performed at an external hospital, which means that a series of patient examination reports before and after each ESWL were not available. It is a limitation of this report. In a follow-up phone call to the patient, he stated that no tumor was found during the routine pre-operative examination of the stones and that he was discharged from the hospital after the symptoms had resolved post-operatively. After ESWL, the patient's lower back pain was markedly alleviated and no bleeding or urinary system infection occurred. Hematuria occurred every time after surgery and the hematuria disappeared at an average of 3 days. Re-examination using B ultrasonography indicated that the stones were well cleared after ESWL. Acute renal rupture has been previously reported to occasionally occur after ESWL (23,24). The renal tissue can be damaged when a kidney calculus is broken by a clinical dose of shockwaves. One of the initial signs of tissue damage is hematuria (25). This type of early stage typically occurs in the renal medulla. With increases in energy, the vascular lesions extend to the kidney surface and then into the cortex, producing lesions and intraparenchymal hemorrhage in the kidney (26). Fibrous scar tissue formation after segmental kidney injury in the hemorrhagic lesion area may induce ischemia, leading to increased tissue fragility (27-29). This type of injury was reported to be markedly associated with the number of ESWL admissions (29). Renal pathology, such as intraoperative renal

mucosal injury, continuous high-pressure reperfusion after lithotripsy and possible renal tumors, are also risk factors for renal rupture (30). In conclusion, the patient's left kidney was already at risk prior to rupture. When the posture was altered, stones in his left kidney may have protruded from the renal parenchyma, leading to renal rupture.

Management of patients with spontaneous renal rupture is based on the underlying etiology and the hemodynamic state of the patient (14). In the majority of cases, severe bleeding requires open surgical intervention to prevent patient mortality. When CT confirms the existence of perirenal hemorrhage, immediate surgical exploration should be performed (16). Based on the exploratory results, nephrectomy is almost always required for patients with renal tumors, renal carbuncles, hydronephrosis or severe cicatricial nephrosclerosis (10,13,16). Conservative non-surgical management has also been described in patients with hemodynamic stability and no evidence of continuous blood loss. This method is mainly used for patients with chronic hemodialysis and the possible pathology is acquired renal cystic disease (14). Due to the present patient's potential for renal tumors and poor preoperative imaging sensitivity to confirm the presence of a tumor within the hematoma, this patient required frequent CT monitoring every 3-6 months post-operatively to exclude the possibility of a potential renal malignancy. Although conservative treatment could have been attempted to remove the stone and repair the kidney, due to the erroneous diagnosis, the patient's left kidney was removed as a precaution. It was emphasized that pre-operative diagnosis served a decisive role in the selection of surgical methods in the present case, which provides evidence for the spontaneous rupture of renal parenchyma caused by kidney calculi. In addition, the molecular clues of spontaneous renal rupture were explored, which revealed no common consensus and provides a niche for research in the future.

In conclusion, the present case was reported to draw attention to the possibility of spontaneous renal rupture caused by kidney calculi and avoid similar misdiagnoses. Particular attention should be paid to patients with long-term kidney calculi who have a history of ESWL. In such cases, the possibility of renal parenchyma rupture should be evaluated. In addition, it would be suggested that benign urinary system diseases be considered during early diagnosis and treatment.

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Availability of data and materials

Data sharing is not applicable to this article, as no datasets were generated or analyzed during the present report.

Authors' contributions

GY and XP contributed to the conception of the study, collected, analyzed and interpreted data from the literature and the data corresponding to the patient, and critically revised the manuscript. YL, LQ, HT, ZZ, JL, XW, QF and FT contributed to the conception of the study, performed the literature research and drafted the manuscript. All authors have read and approved the final manuscript. GY and XP confirm the authenticity of all the raw data.

Ethics approval and consent to participate

The present study was approved by the Ethics Committee of The Affiliated Hospital of Yangzhou University (Yangzhou, China).

Patient consent for publication

Written informed consent was obtained from the patient for publication of the details of his medical case and any accompanying images.

Competing interests

The authors declare that they have no competing interests.

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