



Original research

Massive hemorrhage after percutaneous nephrolithotomy: Saving the kidney when angioembolization has failed or is unavailable

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H I G H L I G H T S

- Partial nephrectomy/renorrhaphy can efficiently control massive bleeding after PCNL.
- The principles of such surgery resemble renorrhaphy in the setting of renal trauma.
- Renal vessel control during the surgery provides a bloodless field for kidney repair.
- This procedure is quite effective in saving the kidney function.
- As a demanding procedure, adequate surgical experience in the setting of renal trauma is essential.

A R T I C L E I N F O

Article history:

Received 23 February 2014

Received in revised form

30 June 2014

Accepted 8 July 2014

Available online 11 July 2014

Keywords:

Angioembolization

Bleeding

Renal calculi

Percutaneous nephrolithotomy (PCNL)

A B S T R A C T

Objectives: To describe the management protocol in cases with massive hemorrhage after percutaneous nephrolithotomy (PCNL) with a failed angioembolization or when angioembolization is not available.

Patients and methods: Between October 2006 and December 2012, the charts of patients who had undergone PCNL and were complicated with massive post procedural bleeding unresponsive to conservative management were reviewed. Those cases in whom angioembolization had failed, or was unavailable, or could not be afforded by the patient were selected and studied. These patients underwent open surgical exploration through a midline transperitoneal or a flank retroperitoneal approach. In both approaches, kidney mobilization outside the Gerota's fascia, temporal renal pedicle clamping and partial nephrectomy or renorrhaphy were done in a stepwise manner.

Results: During the study period, we had 8 patients for whom angioembolization had failed ($n = 4$), was not available ($n = 2$) or the patient could not afford it ($n = 2$). Median patients' age was 31 years (range 16–59 years). We did a partial nephrectomy in 2 and renorrhaphy in 6 of patients with a successful outcome. Median operative time was 2.25 h and median warm ischemia time was 26 min (range 24–42 min). After a median follow up period of 21 months, the involved renal unit, in all cases, remained functional in the postoperative intravenous urography.

Conclusion: Massive hemorrhage after PCNL when angioembolization failed or was not feasible due to any reason could be controlled by partial nephrectomy or renorrhaphy with the same principles as that used for surgical exploration in patients with high grade renal trauma.

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1. Introduction

With great advancements in minimally invasive techniques during the past two decades, the need for open stone surgery has

been markedly reduced. Percutaneous nephrolithotomy (PCNL) is now the standard of care for patients with large renal stones. Although, in general, PCNL is a low morbidity procedure, as many as one in four patients may have complications after PCNL [1,2]. Intraoperative/postoperative hemorrhage is one of the most important complication of PCNL. While the surgeon's experience plays a crucial role in reducing complications after PCNL, the rate of bleeding complications is also related to the patient's age, stone characteristics (stone burden and configuration) and to the

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characteristics of the PCNL procedure (i.e. operative duration, method of dilatation, sites and number of accesses) [2,3]. Intrarenal or perinephric hematoma would be a frequent finding (90–100%) if computerized tomography was performed just after PCNL [2,4–5]. Most of these hematomas are clinically insignificant and they resolve spontaneously. Significant blood loss requiring blood transfusion during or after PCNL has been reported at a rate of 11–23% [1,2,5,6]. The most severe cases of hemorrhage after PCNL are those of intrarenal arterial origin. This complication usually presents a few weeks after PCNL and is a result of arteriovenous fistula (AVF), intrarenal pseudoaneurysm formation, or an injured segmental artery [2–5]. The incidence rate of this unpredictable complication is 1–2% in centers with a high turnover. The treatment of choice in this serious complication is superselective angioembolization which is highly successful and efficient in controlling bleeding [2,7]. Thanks to the high success rate of angioembolization, the rate of nephrectomy after PCNL is extremely low (0.2%) in contemporary series [2,3]. Despite this efficacy, little is known about the management protocol in cases with failed angioembolization. Moreover, in some settings, such as a patient in poor condition (i.e. hemodynamic instability), unavailability of angiography setting or the problems with the cost of this procedure, the patient must undergo emergency laparotomy for control of bleeding. In the current study, we present our experience in the emergency management of severe hemorrhage in these settings.

2. Patients and methods

2.1. Patients

Our institutional review board approved this study. Between October 2006 and December 2012, the charts of patients who had undergone PCNL and were complicated with massive post procedural bleeding unresponsive to conservative management were reviewed. By matching of our PCNL database with our renal angioembolization records and with partial nephrectomy/renorrhaphy database, we selected and studied those cases in whom angioembolization had failed, or was unavailable, or could not be afforded by the patient. These patients underwent renal exploration for control of bleeding. The benefits and risks of such an approach, including the possibility of nephrectomy, were explained prior to the operation.

2.2. Surgical technique

The patients were placed in supine or lateral decubitus position, supported by adequate padding. A midline transperitoneal approach or flank retroperitoneal approach (in patients with massive abdominal pannus; $n = 2$) was used for the operation. In both approaches, the colon (and duodenum on the right side) was medialized to expose the renal pedicle, aorta (on the left side) and inferior vena cava (on the right side). The renal pedicle was meticulously dissected.

Care was taken to keep the Gerota's fascia intact. The kidney was mobilized outside the Gerota's fascia. Then, the renal pedicle was temporarily clamped with a Satinsky clamp. Thirty minutes before renal pedicle clamping, 12.5 g of mannitol was infused and was repeated after release of the clamp. After controlling the renal pedicle, the Gerota's fascia was incised, the perinephric hematoma was drained and the kidney was completely mobilized within the Gerota's fascia. The site of access was found and the necrotic and inflamed renal tissue was debrided. If the access site was in the lower or upper pole, a polar partial nephrectomy was considered; otherwise the site of access was circumferentially sutured with chromic 2–0 running sutures (Fig. 1). In both cases the renorrhaphy was done with frequent running chromic 2–0 or 0 sutures on 37 mm needles. After the renal pedicle was released, the renal perfusion was observed and the site of repair was evaluated for any hemorrhage. Then the ureter was opened and a 6 Fr feeding tube was passed to the kidney to check the presence of any significant intrarenal hemorrhage. After fixing a ureteric stent, an 18 Fr catheter was put in the retroperitoneum as external drainage and the wound was closed in layers. During recovery phase, the patients had complete bed rest for 48 h and were closely monitored for any recurrence of bleeding.

2.2.1. Study outcomes

The demographic characteristics of all patients were recorded. Intraoperative data such as operative time, intraoperative difficulties and complications were also noted. To evaluate blood loss after PCNL and after open surgical exploration, preoperative and postoperative hemoglobin (Hb) levels were compared. The amount of blood transfusion that each patient was received and major perioperative complications (higher than grade 1 according to Clavien classification [8]) were recorded.

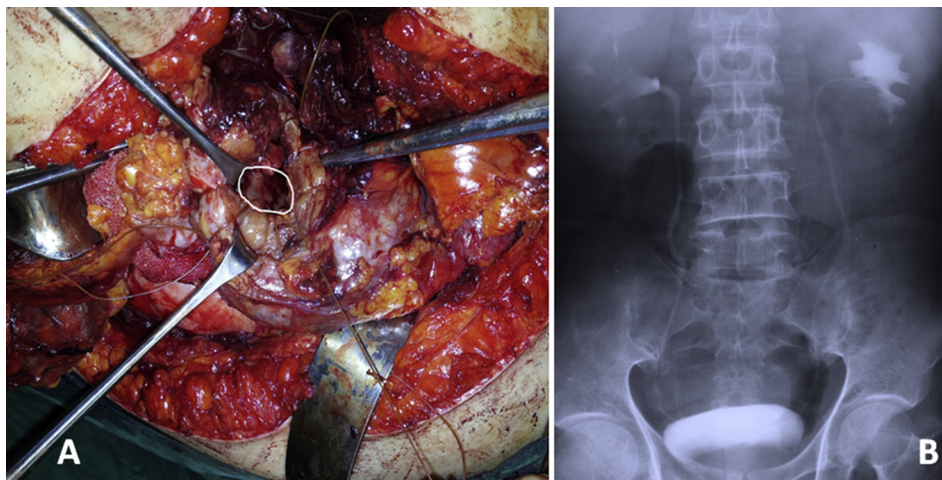


Fig. 1. A) The site of access in the mid part of the kidney was found and the necrotic and inflamed renal tissue was debrided (Encircled zone). The site of access was circumferentially sutured with chromic 2–0 running sutures to be prepared for renorrhaphy. B) Six month- postoperative IVU of the same patient showed completely functional left kidney.

3. Results

During the study period, 21 out of 4156 cases of PCNL underwent angioembolization due to post procedural massive hemorrhage. During the same period, we had 8 patients for whom angioembolization had failed ($n = 4$), was not available ($n = 2$) or the patient could not afford it ($n = 2$). We urgently operated 2 cases due to massive bleeding with associated hemodynamic instability. Initial angiographic finding in those who had a failed angioembolization was pseudoaneurysm (Fig. 2).

Median patients' age was 31 years (16–59) with median stone size of 27.5 mm. All patients had one access during their PCNL which was in the lower pole in 7 (87%) of them. Table 1 summarizes the patients' profiles and characteristics. On average, the patients received 2.6 units of packed cells after their PCNL. Median hemoglobin (Hb) decrease after PCNL and after open kidney exploration were 4.4 and 1.1 g/dL, respectively. Massive bleeding occurred 2–7 days after PCNL. We did partial nephrectomy in 2 and renorrhaphy in 6 of the patients with a successful outcome. No patients needed any additional procedures to control hemorrhage. Median operative time was 2.25 h and median warm ischemia time was 26 min (range 24–42 min). Creatinine levels remained stable in the perioperative period in all patients. No major perioperative complications were observed in this series. After a median follow-up period of 21 months, the involved renal unit, in all cases, was found to be functional in the postoperative intravenous urography.

4. Discussion

Hemorrhage is one of the most common complications of PCNL. Conservative management and blood transfusion are sufficient to control most bleeding complications. Significant arterial bleeding after PCNL is uncommon but is a challenging problem. Richstone et al. showed that 57 of their 4695 patients (1.2%) who had percutaneous renal surgery had complications with massive hemorrhage requiring angioembolization. This procedure was quite successful in controlling the bleeding in 95% of cases. They found

that in these circumstances, the most common pathology is arterial pseudoaneurysm (about 50%) followed by AVF (25%) and isolated arterial injury (25%). They also revealed that as many as 17.5% of these patients may have more than one angiographic finding on their initial assessment [7]. Alternative procedures such as endovascular placement of a covered stent to occlude the site of arterial injury without jeopardizing the patency of the feeding artery or percutaneous injection of thrombin into the pseudoaneurysm under guide of ultrasonography have been reported anecdotally. However, these techniques have not yet been standardized and needs specific experience and equipments [9,10].

The cause of pseudoaneurysm or AVF is the free drainage of the injured segmental artery into the renal parenchyma in the former or into an adjacent segmental renal vein in the latter. The pathology may occur during puncture, dilation or nephroscopy phase and its location is at the site of the parenchymal access. Intrarenal arterial injury may also occur with almost the same frequency in other procedures that invade the renal parenchyma such as partial nephrectomy or nephrolithotomy [11,12]. After analyzing 3878 PCNL procedures, El-nahas et al., found that beside the surgeon's experience, patients with solitary kidney or staghorn stones are at risk of massive hemorrhage after PCNL which needs angioembolization. Number of accesses and upper pole access also increase the odds of angioembolization [13]. In another study, the same group also indicated that the size of the infarcted area becomes significantly reduced after a long-term follow-up [14]. Using the National Trauma Data Bank, Hotaling et al analyzed the outcome of angiography and angioembolization for acute management of patients with high graderenal trauma. They found that the success rate of initial angiography was low and 88.3% of these patients required at least one secondary intervention including open surgery in 22% of them [15]. In their series, only 0.5% of blunt kidney injuries underwent repair and open surgery following blunt injuries almost exclusively led to nephrectomy. Therefore, the outcome of angioembolization is entirely different between patients with renal trauma and those with massive bleeding after PCNL (i.e. a "controlled" grade IV renal injury). While post-PCNL

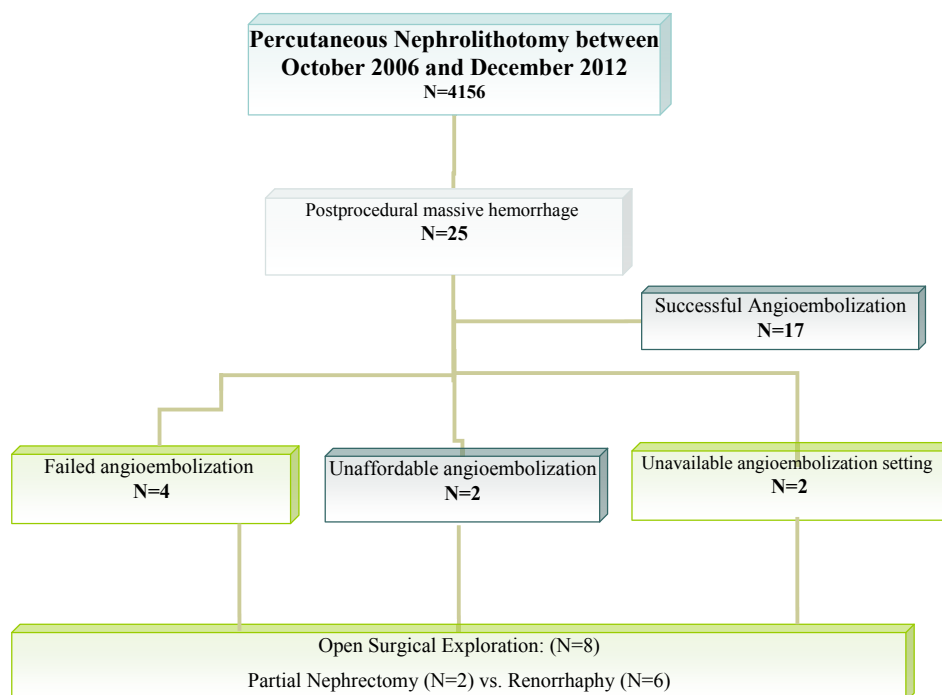


Fig. 2. Massive hemorrhage after percutaneous nephrolithotomy-Management algorithm.

Table 1
Patients' demographics and surgical details.

	Age (years)	Sex	Stone size (mm)/location	Site of access	Pre/post PCNL ^a Hb ^b (g/dL)	Procedure type after open kidney exploration	Operative time (h)	Warm ischemia time (min)	Stone composition
1	30	Male	20 mm/lower pole	Lower pole	14/8.5	Right partial nephrectomy	2.5	35	Calcium oxalate
2	55	Female	35 mm/renal pelvis	Lower pole	12/9.5	Right renorrhaphy	3	25	Calcium oxalate + uric acid
3	59	Male	20 mm/lower pole	Lower pole	17.7/8	Left renorrhaphy	2.5	31	Calcium oxalate
4	23	Female	40 mm/staghorn	Lower pole	11.5/9	Right renorrhaphy	3	42	Magnesium ammonium phosphate
5	16	Male	50 mm/staghorn	Lower pole	15.7/10.9	Left renorrhaphy	2	25	NA
6	45	Male	20 mm/lower pole	Lower pole	12/7	Left partial nephrectomy	2	25	Calcium oxalate
7	32	Female	45 mm/mid pole	Mid pole	12/8	Left renorrhaphy	2	27	NA
8	30	Male	20 mm/lower pole	Lower pole	14/10	Left renorrhaphy	2	24	Calcium oxalate

^a PCNL: Percutaneous nephrolithotomy.

^b Hb: Hemoglobin, NA: Not available.

angioembolization is generally a highly successful procedure, in up to 5% of cases, this procedure may fail to stop bleeding [7]. During selective angioembolization, there is always a risk of arterial dissection or perforation, migration of the embolization material and “nontarget” embolization [5,16]. Moreover, in certain situations, the facility of angioembolization is not available, or the patient's poor condition (hemodynamic instability) precludes any delay. The cost of angioembolization may also be considered as a limitation in some centers.

In the present series, we described in detail the procedure of renal exploration in these challenging cases. As shown, we used the same approach in these patients as that used for surgical cases of high grade renal trauma. We found extensive perinephric hematoma confined to the Gerota's fascia in these patients. To reduce the risk of nephrectomy, we carefully dissected the renal pedicle and abdominal great vessels. Then, only after controlling the renal pedicle, was the Gerota's fascia opened. This approach helped the surgeon to remove the injured pole (partial nephrectomy) or repair the site of access in bloodless fields and was quite effective in saving the kidney. The main concern during this approach was the inevitable warm ischemia that was imposed on the kidney. In our experience, the warm ischemia ranged between 24 and 42 min. Although it seems rather prolonged compared with what might be expected during partial nephrectomy in the setting of cancer in stable patients [17], we believe that this range of warm ischemia time counterbalances the possibility of nephrectomy. We showed that in the long-term follow-up intravenous urography, the involved renal unit remained functional. Nevertheless, determining the split renal function using a radionuclide scan would be a better modality to evaluate the functional loss of these renal units. Despite the fact that renal preservation is a general trend in the setting of trauma, population based studies showed that nephrectomy is still the most common renal surgery in high grade renal injuries [15, 18]. Recently, McClung et al evaluated the contemporary trends in surgical management of renal injuries. Using National Trauma Database, they found that 1183 out of a total of 9002 (13.1%) cases of renal injuries were operated. Most of them had grade IV or V renal injuries and overall nephrectomy rates were 54% and 83% for penetrating and blunt injuries, respectively. They indicated that in addition to the severity of the renal injury, concomitant other intraabdominal visceral injuries were an independent predictor of nephrectomy [18]. Our findings, however, confirm that it is worthwhile to make every effort to save the post-PCNL traumatized kidneys, especially in patients suffering from urolithiasis. Although our patients had a high grade kidney injury, the mechanism and nature of their injury, and in turn the chance for salvaging the kidney, seems completely different in comparison with classic high grade renal trauma. As shown, our 8 complicated cases are heterogeneous series with variable stone sizes and configurations. We

showed that even in “simple” cases, the surgeon may encounter such difficult circumstances.

As described, two of our patients were deprived of standard of care (i.e. angioembolization) due to procedural costs. We think that from ethical standpoint this would not be acceptable and our institution should take measures to support these exceptional situations.

These patients are definitely critical patients but fortunately in centers with adequate experience in PCNL and angioembolization, such critical circumstances occurs rarely. We admit that our sample size is too small to know to what extent the outcome of exploration are successful; perhaps a multicenter study may provide more precise conclusions.

5. Conclusion

Massive hemorrhage after PCNL when angioembolization failed or was not feasible for any reason could be controlled by partial nephrectomy or renorrhaphy. The principles of such surgery are the same as laparotomy for kidney repair in patients with high grade renal trauma. Due to renal pedicle control during such surgery, the operation could be done in a bloodless field. This procedure is quite effective in both controlling the hemorrhage and saving the kidney. However, it is a demanding procedure and needs adequate surgical experience in the setting of renal trauma.

Ethical approval

Our institutional review board approved this study.

Funding

N/A.

Author contribution

Alireza Aminsharifi: Study design, writing.

Darush Irani: Study design.

Ali Eslahi: Data collection.

Conflict of interest

The authors have no conflicts of interest or financial ties to disclose.

Acknowledgments

This work was supported by Shiraz University of Medical Sciences. We thank P Walzl (Author AID in the Eastern Mediterranean) for improving the use of English in the manuscript.

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