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Application of Percutaneous Methylene Blue Marking in Laparoscopic Partial Nephrectomy for the Treatment of Completely Endogenic Renal Tumors: Three Case Reports

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1. Abstract

1.1. Background: The difficulty of laparoscopic partial nephrectomy mainly depends on the size and location of the tumor. Complete endogenic renal tumors are very difficult to identify and remove during surgery. Therefore, localization assistance techniques are usually required during surgery.

1.2. Case Presentation: We report three patients with a completely endogenous renal tumor who underwent retroperitoneal laparoscopic partial nephrectomy using percutaneous methylene blue labeling localization. The first patient had a right endogenous renal mass identified by CT examination. A postoperative pathological examination revealed renal angiomyolipoma. The second patient had a right endogenous renal mass identified by CT examination. A postoperative pathological examination revealed renal clear cell carcinoma. The third patient had an endogenous renal mass due to abdominal distension identified by CT examination. A postoperative pathological examination revealed a renal cyst.

1.3. Conclusions: We describe a new technique based on percutaneous methylene blue labeling for locating completely endogenic renal tumors during laparoscopic partial nephrectomy, which has the advantages of being radiation free, easy to operate, and requiring low instruments. This technology provides new ideas and methods for the intraoperative localization of completely endogenous renal tumors.

2. Background

Endogenous renal tumors are surrounded by normal renal parenchyma. The location and edge of the tumor cannot be observed or touched by the surgeon on the surface of the kidney [1]. Compared with exogenous kidney tumors, endogenous kidney tumors are often deeper and therefore are closely related to the renal collecting system and blood vessels. Thus, the depth of resection for this type of kidney tumor is not easy to control during surgery, which can increase the difficulty of surgical techniques and the risk of complications [2]. A study showed that the location of renal tumors was related to surgical complications and the degree of malignancy of the tumor, and compared to exogenous kidney tumors, Laparoscopic Partial Nephrectomy (LPN) treated patients with endogenous kidney tumors had a longer warm ischemia time, higher risk of complications, and relatively higher degree of tumor malignancy [3, 4]. Most endogenic renal tumors, with precise localization of the tumor location during surgery, are as difficult to treat as conventional renal tumors [5]. If the LPN treatment for endogenic renal tumors is not designed properly, it may lead to postoperative urinary leakage, positive margins, vascular damage, and even require radical surgery [6].

To address the above issues, the localization technology of endogenic renal tumors in LPN surgery is particularly important. We propose a new technique for locating renal masses using percutaneous methylene blue marking. During surgery, Methylene Blue

(MB) was injected into the fat layer of the renal surface projected by the renal mass through an ultrasound guided puncture needle. The projection position of the renal mass on the renal surface was marked. During LPN surgery, MB markers can be intuitively and easily detected allowing the quick and accurate location of endogenous renal masses during surgery.

3. Case Presentation

3.1. Case Report 1

A 54-year-old woman was found to have a right renal mass during CT examination. She had always been in good health. Her CT scan showed the presence of an endogenic space occupying lesions in the right kidney, with a size of 3.0 cm × 2.3 cm × 2.2 cm, indicating a high likelihood of a tumor (Figure 1). The patient's R.E.N.A.L. score was 10 points. After excluding surgical contraindications, we applied retroperitoneal laparoscopic partial nephrectomy. During the surgery, we used percutaneous methylene blue marking for localization. The surgical steps are as follows.

The patient was placed in a healthy lateral position, exposing the puncture area of the waist. The ultrasound probe was wrapped with a sterile cover and placed tightly on the surface of the skin to ensure that the renal mass is located at the center of the ultrasound image. After determining the puncture path by ultrasound examination, an 18G puncture needle was used for puncture. Under ultrasound guidance, the tip of the puncture needle reached the surface of the renal fat layer of the completely endogenous renal tumor. The marking point was the central position of the renal surface projection of a completely endogenous renal tumor (Figure 2). Then, we pulled out the core of the puncture needle, and used a 2 ml syringe to inject 0.1-0.2 ml of MB solution through the puncture needle, and removed the puncture needle while maintaining the negative pressure of the syringe.

Under retroperitoneal laparoscopic technology, we used an ultrasound knife to free and remove extraperitoneal fat, and then cut through the perirenal fascia and perirenal fat, in order to fully expose the kidneys. We found blue staining markers under laparoscopic vision (Figure 3). Below the mark was the central location of the projection of the completely endogenous renal tumor on the renal surface. After using Bulldog to block the renal artery, we used tissue scissors to cut the renal parenchyma to expose the pseudocapsule of the tumor, then we used separation forceps and tissue scissors to separate the tumor bluntly and sharply, while maintaining the integrity of the tumor. Due to the absence of a pseudocapsule in the renal tumor of this patient, we used resection of the margin to normal renal tissue as a standard procedure. Unipolar electric hooks were used for coagulation (60-80w) treatment of suspected positive surgical margins during surgery.

The localization and surgery of the patient's endogenous tumor were successfully completed. The patient's percutaneous methylene blue marking time was 6 minutes. The surgical time was 62 minutes. The warm ischemic time was 17 minutes and the estimated intraoperative bleeding volume was 20 ml. Her renal tumor histology indicated renal angiomyolipoma. She had a drainage tube for 4 days after surgery and was hospitalized for 5 days after surgery. The patient did not experience any complications during the perioperative period. The patient underwent a CT examination in the second month after surgery, which showed no tumor recurrence or metastasis (Figure 4).

Figure 1: CT scan showed the presence of an endogenic space occupying lesions in the right kidney of case 1, with a size of 3.0 cm × 2.3 cm × 2.2 cm. The yellow arrow points to the renal tumor.

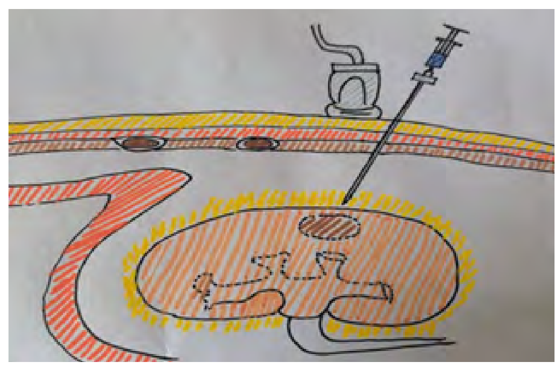

Figure 2: Under ultrasound guidance, the tip of the puncture needle reached the surface of the renal fat layer of the completely endogenous renal tumor. The marking point was the central position of the renal surface projection of a completely endogenous renal tumor. The black arrow points to the renal tumor.

Figure 3: We found blue staining markers under laparoscopic vision. Below the mark was the central location of the projection of the completely endogenous renal tumor on the renal surface. The black arrow points to the renal tumor.

Figure 4: Case 1 underwent a CT examination in the second month after surgery.

3.2. Case Report 2

A 41-year-old man underwent CT examination due to abdominal distension and a right kidney mass was found. He had hypertension in the past. His CT showed the presence of an endogenic space occupying lesions in the right kidney, with a size of 2.2 cm × 2.2 cm × 2.0 cm, indicating the high likelihood of a tumor (Figure 5). The R.E.N.A.L. score was 6 points. We applied the same surgical and localization methods as in case 1. A difference was that we replaced the stain with a mixture of methylene blue and tetracaine mucilage.

The localization and surgery of the patient's endogenous tumor were successfully completed. The percutaneous methylene blue marking time was 8 minutes. The surgical time was 80 minutes. The warm ischemic time was 12 minutes and the estimated intraoperative bleeding volume was 20 ml. The histological diagnosis of his renal mass was a renal cyst. In the seventh month after surgery, the patient underwent a CT examination, which showed no tumor recurrence or metastasis (Figure 6).

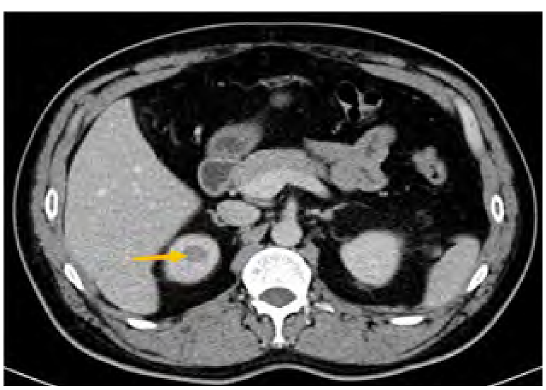

Figure 5: CT showed the presence of an endogenic space occupying lesions in the right kidney of case 2, with a size of 2.2 cm × 2.2 cm × 2.0 cm. The yellow arrow points to the renal tumor.

Figure 6: In the seventh month after surgery, the case 2 underwent a CT examination.

3.3. Case Report 3

A 60-year-old man was found to have a left renal mass during CT examination. The CT showed the presence of an endogenic space occupying lesions in the left kidney, with a size of 1.9 cm × 2.0 cm × 2.0 cm, indicating a high likelihood of a tumor (Figure 7). He had no other illnesses before. His R.E.N.A.L. score was 9 points. We applied the same surgical and localization methods as in case 1. A difference was that we replaced the stain with a mixture of methylene blue and absorbable gelatin sponge fragments.

The localization and surgery of the patient's endogenous tumor were successfully completed. The percutaneous methylene blue marking time was 5 minutes. The surgical time was 150 minutes. The warm ischemic time was 25 minutes and the estimated intraoperative bleeding volume was 30 ml. The histological diagnosis of his renal mass was a renal clear cell carcinoma. This patient has not been followed up due to the surgery being performed recently.

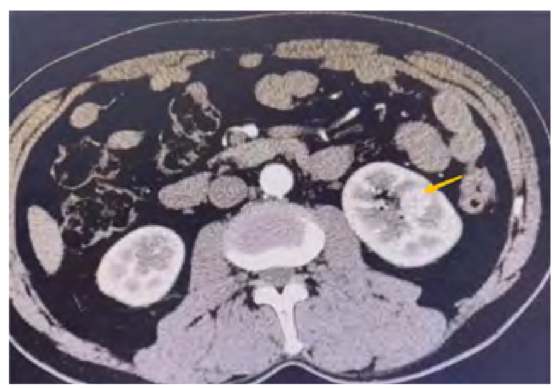

Figure 7: CT showed the presence of an endogenic space occupying lesions in the left kidney of case 3, with a size of 1.9 cm × 2.0 cm × 2.0 cm. The yellow arrow points to the renal tumor.

4. Discussion and conclusions

The auxiliary techniques for locating a completely endogenous renal tumor during LPN surgery include intraoperative ultrasound, 3D printing, 3D reconstruction, near-infrared fluorescence imaging [2,7,8,9]. However, these techniques are complex to perform and require relevant instruments, resulting in high application costs. In response to the limitations of existing techniques for locating completely endogenous renal tumors during LPN surgery, this study proposes a new technique: percutaneous methylene blue marking.

Ultrasound has advantages such as low cost, no radiation exposure, and good imaging results. It is useful for guiding the percutaneous microwave ablation treatment of T1a renal tumor patients and percutaneous renal puncture treatment of renal stones [10,11]. Our proposed positioning technology also relies on ultrasound guidance for percutaneous puncture. Ultrasound can effectively display the anatomical features of the kidney and its surroundings, which improves the accuracy of the puncture and makes percutaneous MB marking technology safer and more reliable. MB is a tricyclic phenothiazine drug. It has non-toxic biological staining properties and is widely used as a tracer in gastrointestinal, thyroid, and lymph node dissection in breast surgery [12,13]. MB, as a staining agent, is widely used in clinical practice due to its advantages of simple operation, short color development time, high safety, and low cost [14].

We injected 0.5 ml of MB solution using a 5 ml syringe for the first patient who underwent percutaneous MB marking localization. During the surgery, we found that MB diffused along the injection site and had a large labeling range. In subsequent surgeries, the injected MB dose was changed to 0.1-0.2 ml to avoid the excessive range of the blue staining marker. To better control the amount of dye injected, we changed the 5 ml syringe to a 2 ml syringe. Then, we used a mixture of tetracaine mucilage and MB to increase the viscosity of the stain, so that the stain injected into the fat layer on the kidney surface was concentrated in one place without much diffusion. During the second patient's surgery, we found that the staining range of this mixture in the fat layer was smaller than in the first patient, but it still had a certain range of dispersion. We believe that the ideal staining agent should have a diffusion range of 5-10 mm within the fat layer of the kidney surface. If the diffusion range of staining is too large, the staining agent may not accurately mark the location of the renal mass and if the diffusion range is too small, it is difficult to find markers during LPN surgery. During the third patient's surgery, we improved the staining agent by cutting an absorbable gelatin sponge into small pieces and mixing them with MB to form a mixture. Compared with the other cases, we found that the intraoperative labeling range was reduced and the marking effect was better. Because gelatin sponge is solid and insoluble in MB solution, there may be a blockage sensation when injected through the puncture needle, which makes it difficult to control the injection dose. We believe that the use of smaller diameter gelatin particles or a type of staining agent that coagulates in contact with a tissue can achieve precise positioning. This may require further research.

The percutaneous MB marking method also has some limitations [1]. This localization technique cannot display the size and margin of a completely endogenous renal tumor during surgery. The solution to this type of problem is to completely remove renal tumors using a pseudocapsule. If there is no pseudocapsule in the renal tumor, we can use unipolar electrocoagulation to ensure a negative cutting edge [2]. When the patient's renal tumor is located inside the ventral or dorsal side, posture deviation can be used to expose the renal tumor. If ineffective, Doppler ultrasound can be used to guide the puncture needle through the intestines or kidneys and then label and locate it [3]. This method may not be applicable to patients with endogenous renal masses with obstructed puncture pathways, such as the spleen.

In conclusion, we propose a percutaneous methylene blue marking localization method for the localization of a completely endogenous renal tumor in LPN. This positioning method has advantages including no radioactivity, easy operation, and low requirements for equipment. During surgery, we can accurately, quickly, and easily locate a completely endogenous renal tumor. This localization method might provide new ideas for the intraoperative localization of a completely endogenous renal tumor.

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