915 MHz microwave-assisted laparoscopic partial splenectomy: A case series

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INTRODUCTION

The main concern regarding total splenectomy is overwhelming post-splenectomy infection, a severe type of sepsis.[1] In addition, reactive thrombocytosis was shown to cause thrombosis of the portomesenteric trunk.[2] Alternatively, auto-transplantation of a splenic remnant has been shown to be poorly functional.[3] Partial splenectomy (PS) was reported as an ideal option because it removes splenic lesions and decreases splenic size, while preserving organ function. PS has been advocated for trauma, hereditary spherocytosis, resection of nonparasitic cysts, hamartomas and other splenic tumours and also for staging of Hodgkin’s lymphoma.[1,4]

Abstract

Background: Haemorrhage during the splenic parenchyma transection is a major threat for laparoscopic partial splenectomy (LPS). We here aim to evaluate the feasibility and safety of pre-coagulation of a 915 MHz microwave (MW) device during LPS.

Materials and Methods: Data of four patients admitted to our hospital between November 2016 and July 2018 were retrospectively analysed. The mean age was 24 years (range, 19–33); they all diagnosed with splenic unifocal lesion with a mean diameter of 4.6 cm (ranged from 3.7 to 6 cm) and underwent LPS with pre-coagulation of a 915 MHz MW.

Results: The LPS with pre-coagulation was successfully resulted in complete resection without microscopic residual tumour (R0 resection). The mean operative time was 205 min, and the minimum blood loss was at the range of 30–50 ml. No complication was observed, and the length of stay in hospital was varied from 5 to 10 days.

Conclusion: Based on our observation, pre-coagulation of a 915 MHz MW during LPS is a safe and efficient technique. More studies are required before applying extensively.

Keywords: Laparoscopic partial splenectomy, microwave, pre-coagulation

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Laparoscopic PS (LPS) was first conducted by Poulin et al. for a trauma patient with prior selective embolisation of the splenic artery for an active haemorrhage. Excessive uncontrolled intraoperative bleeding was a major risk of conversion to an open procedure, being necessity for a total splenectomy. It was more difficult to gain haemostasis through compression, sutures and other means in LPS than that in laparotomy. Mastering the skills of laparoscopic operations and adopting reliable haemostasis apparatus were the fundamental means for solving the problem mentioned above.

Some techniques were described for splenic parenchymal transection, including ultrasonic disectors, LigaSure (Covidien, USA), endovascular stapling and radiofrequency ablative. Each technique has its potential advantages, but there is no solid evidence that one technique is better than the other for LPS. The objective of the present study is to explore the feasibility and safety of pre-coagulation of a 915 MHz microwave (MW) in LPS.

MATERIALS AND METHODS

Patients

In this study, four patients who diagnosed with splenic unifocal lesion were observed for LPS between November 2016 and July 2018. These patients were admitted to the First Affiliated Hospital, School of Medicine, Zhejiang University (Hangzhou, Zhejiang province, China) and offered the technique of pre-coagulation of a 915 MHz MW assisted for LPS after written consent was obtained. All patients had no previous operation history. Medical records were collected on 31 August 2018.

Microwave thermal coagulation system

The MW ablation system was comprised of a KY-2100 portable, MW generator and a 915 B-type cooled-shaft MW antenna, of which the front end was flexible (Kangyou Medical Instrument Co., Ltd. Nanjing, China). The power output ranged from 5 to 100 W with a frequency of 915 MHz (±1%). The antenna shaft was coated with Teflon to prevent adhesion. There were dual channels inside the antenna shaft, and distilled water was circulated within the shaft by a peristaltic pump at a velocity of 40 rounds/min. The length of the antenna was 18 cm, the outside diameter was 1.9 mm, the width of the crack was 1.5 mm and the distance from the crack to the top of the antenna was 22 mm.

Surgical procedure

The patients were placed in a semi-lateral position with 15°–20° to the right side. Five regular ports were achieved. A 10-mm trocar was placed subumbilically for a 30° laparoscope. Two 12-mm trocars were placed at the middle point of the line between the xiphoid and the umbilicus and another parallel to the umbilicus in the left midlavelicular line, respectively. Two 5-mm ports were placed parallel to the umbilicus in the left mid-axillary line and parallel to the first 12-mm trocar in the right midlavelicular line. Lesions were located using the combination of intraoperative ultrasound guidance and pre-operative three-dimensional images were reconstructed by IQQA-Liver (EDDA Technology Inc., Princeton, NJ, USA) [Figure 1].

The procedure began with a full-scale search of the abdominal cavity. The gastrocolic ligament and the splenogastric ligament including the short gastric vessels were transected. The splenic flexure of the left colon and gastro-phrenic ligament were dissected and mobilised. Thus, the spleen was free to rotate on its vascular axis. The branches of the splenic artery and vein that supply the upper or the lower pole depending on the localisation of the lesions were separated and divided after ligation with a Hem-o-lok clip, resulting in an ischaemic demarcation line. The resection line, which was set 5 mm or more above the demarcation line for safety reasons, was marked on the spleen capsule with a monopolar electric coagulation hook to guide the insertion of MW antenna.

The flexible antenna was penetrated into the spleen through a 12-mm trocar. The pre-coagulation was performed at the site 1 cm away from one end of the marked line. The depth of puncture did not exceed the thickness of the parenchyma, the emission power of MW was 50 W and the duration of emission was 100 s. After completion of the first coagulation procedure, the antenna was pulled out 5 cm along the puncture tract to coagulate the next cylindrical parenchyma connected with the previous one, until the coagulation zone reached the capsule of the spleen. Then, the antenna was pierced into the parenchyma 2 cm away from the first site along the marked line, as measured by a curved separation clamp. The above-mentioned process was repeated until the parenchyma on the resection plane was completely coagulated. The parenchyma was dissected by a harmonic scalpel (Ethicon Inc., Bridgewater, NJ, USA) along with the coagulated plane. After transection, haemostasis was performed on the resection line with bipolar diathermy [Figure 2]. The specimen was placed in a bag, which was removed through a suprapubic incision. One intra-abdominal drain was placed next to the spleen.

Ethic statement

The study was approved by the Ethics Committee of the First Affiliated Hospital, School of Medicine, Zhejiang University.
University, and the study protocol conformed to the Ethical Guidelines of the 1975 Declaration of Helsinki as revised in 2000. Informed consent was obtained from patients before LPS.

RESULTS

We observed four patients including one male and three females who underwent pre-coagulation of a 915 MHz MW assisted for LPS. The mean age was 24 years (ranged from 19 to 33 years), and the mean tumour diameter for all patients was 4.6 cm (ranged from 3.7 to 6 cm). R0 resection was confirmed in all cases. The mean operation time was 205 min (range, 180–225 min), and the minimum blood loss was at the range of 30–50 ml. The patients’ post-operative course was unremarkable, and no complication was observed. The length of hospital stay varied from 5 to 10 days [Table 1]. A female patient with non-Hodgkin’s disease received chemotherapy (6 cycles of R-CHOP: Rituximab 375 mg/m² day 1, Cyclophosphamide 750 mg/m² day 1, Hydroxydaunorubicin 50 mg/m² day 1, Oncovin 1.4 mg/m² day 1, (P)rednisone 40 mg/m² day 1-5, every 3 weeks), after 1-year follow-up, and no recurrence was observed.

DISCUSSION

It is shown that the spleen is crucial not only for the development of the immune system during childhood but also for combating infections, in general, and bacterial infections, particularly in adulthood. The objective of PS is to remove a focal lesion or to retain the minimal functional splenic parenchyma in case of haematologic conditions and splenic tumour. A reduction in the volume of the spleen resulted in decrease of the level of haemolysis, while the immunologic function is preserved. It is reported that no immunological deficits or signs of abnormal splenic function were observed with long-term (1–20 years) follow-up after 86 sub-total splenectomies. Therefore,

| Case | 1 | 2 | 3 | 4 |
|------|---|---|---|---|
| Gender | Female | Female | Male | Female |
| Age (years) | 25 | 33 | 20 | 19 |
| Diagnosis | Haemangioma | Non-Hodgkin’s disease | Sclerosing angiomatoid nodular transformation of the spleen | Epidermoid cyst |
| Size of specimen (cm) | 4.5×4.5 | 4×3 | 3.7×3.2 | 6×5 |
| Segmentomy | Upper pole | Upper pole | Lower pole | Lower pole |
| Blood loss (ml) | 50 | 40 | 30 | 50 |
| Operative time (min) | 195 | 225 | 180 | 218 |
| Length of stay (days) | 5 | 8 | 6 | 10 |
| Complications | None | None | None | None |

Figure 1: Image findings. (a) Pre-operative three-dimensional reconstruction of the spleen, tumour (highlighted in yellow) and splenic artery and vein, and the simulated penetration plane of 915 MHz microwave antenna was conducted by IQQA-Liver. The tumour was located in the lower pole. (b) Computed tomography scan 1 month after surgery.

Figure 2: Laparoscopic technique and procedure. (a) The branches of the splenic artery and vein that supply the lower pole were divided. The flexible antenna of 915 MHz microwave was penetrated into the spleen 5 mm above the demarcation line. (b) The antenna was pierced into the parenchyma 2 cm away from the first site along the marked line, until the parenchyma on the resection plane was fully coagulated. (c) The parenchyma was dissected by a harmonic scalpel along the pre-coagulated plane. (d) The specimen (3.7 cm x 3.2 cm) was placed in a bag which was removed through a suprapubic incision.
a splenic tissue-saving technique should be implemented not only in children but also in adults whenever possible.

The present study demonstrates that pre-coagulation of a 915 MHz MW device for LPS is technically feasible and safe for the treatment of splenic tumours. This technique combines the immunological benefits of PS with the post-operative benefits of the minimally invasive approach. Minimal blood loss was achieved during the spleen dissection at the cost of mild injury of residual parenchyma. However, compared with laparoscopic total splenectomy, MW-assisted LPS was relatively associated with longer operation time and longer median post-operative length of stay (data are not shown).

The delivery of MW did not depend on tissue texture and impedance, and the efficacy of heat production and the heating rate were both higher with MW than that with radiofrequency. The frequencies of 915 and 2450 MHz are currently used for tumour therapy, and 915 MHz showed higher heat efficacy and larger range of coagulation under the same operational parameters. The ratio of transverse diameter/longitudinal diameter regarding the coagulation zone of 915 MHz MW was <2450 MHz; thus, a cylindrical coagulation zone was more easily achieved with a 915 MHz MW. Therefore, 915 MHz MW is an optimal instrument for creating a coagulated resection plane, resulting in coagulation necrosis of the splenic tissue and sealing of blood vessels before transection.

Targeted segmental devascularisation of the spleen is mandatory to avoid conversion from PS to total splenectomy. In cases of rupture of the spleen with an active haemorrhage, or large spleens with long and intrapedicular pancreatic tails, when mobilisation of vessels for each segment of the spleen is not feasible, thereby pre-coagulation application of a 915 MHz MW could make demarcation line more remarkable. The dissection of the spleen parenchyma by harmonic scalpel became more efficient after pre-coagulation. We did not observe any post-operative pain related to ischaemia of the remnant spleen, as one of the most frequent complications after LPS. De Pastena et al. fixed the remaining spleen by suturing the splenorenal ligament to the retroperitoneum and the abdominal wall to prevent splenic torsion and ischaemia.

In our study, we did not do the suturing because we thought it was not necessary. Instead, we asked the patients to lie on the bed for at least 24 h, and no torsion of the remnant spleen was observed.

CONCLUSION

LPS using harmonic scalpel assisted by pre-coagulation of a 915 MHz MW simplified the course of spleen parenchyma dissection and reduced the blood loss, showing a safe and promising technique. Further multicentre research with large sample size and long-term follow-up should be conducted.

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Conflicts of interest

There are no conflicts of interest.

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