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Application of microwave ablation in the emergent control of intraoperative life threatening tumor hemorrhage during hepatic surgeries

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Author contributions: Wei Ling, Deming Zhu and Ling Lu collected the patient clinical data; Haoming Zhou and Jindao Wu wrote the manuscript; and Xuehao Wang, Liyong Pu and Lianbao Kong designed the report and revised the manuscript.

Informed consent statement: The patients were not required to provide informed consent for this study because the study used clinical data that were obtained after the patients agreed to treatment and before the initiation of treatment.

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Abstract

Purpose: This study was designed to evaluate the efficacy and safety of microwave ablation (MWA) in the treatment of intraoperative life-threatening tumor hemorrhage during hepatic surgeries.

Methods: Three cases of MWA application in the emergent control of life-threatening hepatic tumor hemorrhage were analyzed and reported.

Results: Satisfactory hemostasis for hepatic tumor rupture was achieved by MWA in all three cases. No major complications, such as post-operative hemorrhage, bile duct injury, liver abscess, colon perforation, skin burns, tumor seeding or renal dysfunction, were identified.

Conclusions: MWA may be a feasible, effective and simple strategy for the emergent control of intraoperative hepatic tumor bleeding. To the best of our knowledge, this study represents the first reported cases of this novel application of MWA.

Key words: Microwave ablation; Hepatic tumor hemorrhage; Hepatic surgeries

Introduction

Hepatocellular carcinoma (HCC) is one of the leading causes of cancer death worldwide. Surgical approaches, including tumor resection and liver transplantation, have been the traditional potentially curative treatments. However, intraoperative hemorrhage is a major concern, as it may cause hemodynamic instability or tumor recurrence[1] and can be life-threatening. Aside from surgical resection, microwave ablation (MWA) has emerged as an effective and safe therapy for small liver tumors over the previous decade[2-4]. However, limited reports are available regarding the use of MWA for hemostasis in hepatic surgeries. Here, we report a case series of MWA for the emergent control of life-threatening tumor hemorrhage in patients undergoing hepatic surgeries.

Case reports

Case #1

A 68-year-old woman presenting with abdominal pain was admitted to our hospital in July 2014. The patient had persistent dull abdominal pain in the right upper quadrant for over 1 year without receiving medical evaluation or treatment. She had no evidence of hepatitis B or hepatitis C, and her initial vital signs were stable. The alpha-fetoprotein (AFP) was greater than 1210 ng/mL. A liver computed tomography (CT) indicated a large, 11.1 × 7.5 × 9.0 cm hepatic mass in liver segment VIII, which featured external protrusion. It also showed low-density signaling at the center of the lesion (Fig. 1A and B).

A partial hepatectomy was considered and scheduled after routine preoperative preparation. A reverse "L" shape incision was made for laparotomy. Mild fatty liver-like changes were observed, but no liver cirrhosis was noted. The lesion was exophytic, and the diaphragm was invaded. Continuous hemorrhage occurred during the separation of the peritumor adhesions. The bleeding continued despite the application of multiple conventional hemostasis strategies, such as compression, suture and ligation, electrocoagulation and hepatic portal occlusion. A total volume of 500 mL blood was lost within 5 min, accompanied by hemodynamic compromise. WMA with the ECO system (ECO-100E, Nanjing, China) was subsequently applied to stop the bleeding from the ruptured tumor. After satisfactory hemostasis was achieved, WMA was further used to assist in partial liver resection. The microwave needle was inserted into the peripheral hepatic parenchyma around the tumor base, followed by adequate ablation with 55 W for 10-15 s at each site, as shown in Fig. 2A and B. The hepatic portal triad was subsequently occluded (the Pringle maneuver), and the conventional clamp crushing method was used for tumor removal (Fig. 2C). The hemorrhage at the base of the wound was further treated with MWA (Fig. 2D and E). The intermittent clamping

strategy was also applied to protect the liver from prolonged ischemic injury. Finally, areas of the diaphragm invaded by the hepatic tumor were treated by MWA (Fig. 2F). The total surgical time was 210 min, and the intraoperative blood loss was approximately 600 mL. The patient received 3 units of red blood cells (RBCs) and 320 mL of fresh frozen plasma. The patient recovered well and was discharged on postoperative day 14.

Hepatocellular carcinoma was identified via pathological analysis. Unfortunately, the patient presented with multiple metastases within the liver at 3 months after surgery (Fig. 1 C and D). She subsequently received radiotherapy at another medical center and died of multiple organ failure at 16 months after surgery.

Case #2

A 40-year-old man presenting with recurrent upper abdominal pain for more than one month was admitted to our center in February 2016. He had been diagnosed with hepatitis B at birth and received anti-viral therapy for more than ten years. A CT scan showed multiple liver masses with no indication for surgical resection.

The man received liver transplantation from donation-after-circulatory-death donors (DCD). However, during the resection of the recipient's diseased liver, uncontrollable hemorrhage occurred as a result of the isolation of local adhesions of the tumor located at the liver surface. The bleeding was so vigorous and frustrating that no successful hemostasis was achieved by electrocoagulation or suture and ligation until MMA was applied (55 W at multiple sites for 6 min). The subsequent liver transplantation and postoperative recovery is going well. He is alive and well as of the latest follow-up in November 2016.

Case #3

A 53-year-old woman presented with right upper abdominal pain for one day and was admitted in December 2015. Rupture of a hepatic tumor was indicated by a CT scan

performed at a local hospital. Hemorrhagic shock was corrected by fluid and blood infusion. The patient was transferred to our center for further treatment.

An abdominal laparotomy was scheduled, and 1700 mL of dark blood were noted in the peritoneal cavity. A 10-cm-diameter hematoma was identified in liver segment VI, which had previously ruptured and adhered to the lateral abdominal wall. After removal of the hematoma, active bleeding continued and could not be stopped by conventional hemostasis strategies. Subsequent hemorrhagic shock occurred, and enhanced fluid and blood infusion was applied. WMA was then used for hemostasis. After coagulation at multiple sites in the base of the hematoma for 10 min, the bleeding was stopped. The total volume of blood loss was approximately 2500 mL; 15.7 units of RBCs and 1000 mL of plasma were infused. Liver hemangioma was identified via postoperative pathological analysis. The patient recovered well, and no liver mass was identified by ultrasound or CT scan during the 1-year follow-up.

Discussion

We have shown that MWA is safe and effective in (1) the control of intraoperative hemorrhage due to liver tumor rupture, (2) assisting in the resection of large liver tumors and (3) treating local liver metastases.

HCC is a major health problem worldwide and a leading cause of cancer-related death. Surgical resection or liver transplantation is the gold standard for HCC treatment. However, thermal ablations, such as radiofrequency ablation (RFA), cryoablation and high-intensity focused ultrasound (HIFU) ablation, are becoming increasingly utilized in the treatment of primary and secondary liver tumors[2]. RFA is the most common type of thermal ablation worldwide. However, as a result of the high tissue perfusion and large blood vessels in the liver[5], also referred to as “heat sinks”, adequate treatment is difficult. The heat sinks may also lead to sub-lethal temperatures and an increased likelihood of local tumor progression[6]. In contrast, MWA does not present

this problem, as microwaves propagate readily through charred and desiccated tissues, thus leading to larger ablation zones than RFA. The MWA device we employed is equipped with a water cooling system, which enables a longer ablation time with higher power production[7]. The new generation of multiple microwave antennas enables more efficient heat delivery and larger ablation zones than a single antenna[8]. Although these devices with multiple microwave antennas were not used in our hospital, we placed the single antenna at multiple sites around the tumor to achieve a substantially larger ablation area. These factors and techniques enabled us to achieve adequate ablation zones both in the tumor and peritumor liver parenchyma.

Although many studies have shown the role of MWA in the treatment of solid tumors, limited papers are available on its application in hemorrhage treatment. Thermal ablation was reported to successfully control solid-organ hemorrhage and uterine bleeding in patients who were poor surgical candidates[9, 10]. Ophelia *et al*. reported a case of post-biopsy liver hemorrhage that could not be controlled by transarterial embolization; however, it was successfully stopped by ultrasound-guided percutaneous microwave ablation[11]. In another case, transcatheter hepatic arterial embolization followed by WMA was reported as a useful treatment for HCC with portal and biliary tumor thrombi that rupture into the biliary system[12]. Consistent with these findings, satisfactory hemostasis for hepatic tumor rupture was achieved by MWA in all three cases, which indicates that MWA may be a feasible, effective and simple strategy for the emergent control of intraoperative hepatic tumor bleeding.

Resection of large liver tumors is typically associated with a longer hepatic portal occlusion time and more blood loss. Thus, in the third case, we pretreated the peritumor margin with MWA for “tumor isolation and devascularization”, expecting to reduce ischemic liver injury and intraoperative bleeding. However, further controlled clinical

trials are required to confirm the superiority of MWA in the treatment of large liver tumors.

Furthermore, intraoperative bleeding and blood transfusion are associated with an increased likelihood of tumor recurrence after liver surgery for HCC[13, 14]. The patient in the first case showed tumor recurrence at 3 months after surgery. However, late-stage HCC, as demonstrated by a large tumor size and diaphragm invasion, was identified during the surgery. Thus, in this single case, whether the intraoperative blood loss was associated with the early HCC recurrence remains uncertain.

MWA has a good safety profile with low rates of complications, such as hemorrhage, bile duct injury, liver abscess, colon perforation, skin burns and tumor seeding[15]. Fever and post-procedural malaise occur after ablation in some cases. Low-grade fever, discomfort and dull abdominal pain in the right upper quadrant occurred in cases 1 and 3 and improved after symptomatic treatment. No other major complications were identified. The patient in the third case died of tumor metastasis 18 months after surgery. In addition, prolonged administration of microwaves may cause hemoglobinuria or acute kidney failure[16]. In all 3 cases, 125 mL of NaHCO3 solution was prophylactically used to prevent renal insult during the operation and post-operatively. No hemoglobinuria or renal dysfunction was identified by urine testing and serum renal function examination.

Conclusions

In summary, this study is the first reported case series of MWA application in the emergent control of life-threatening hepatic tumor hemorrhage. However, additional studies are required to further determine its efficiency and safety.

Disclosure statement

The authors report no conflicts of interest.

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Figures:

Fig. 1

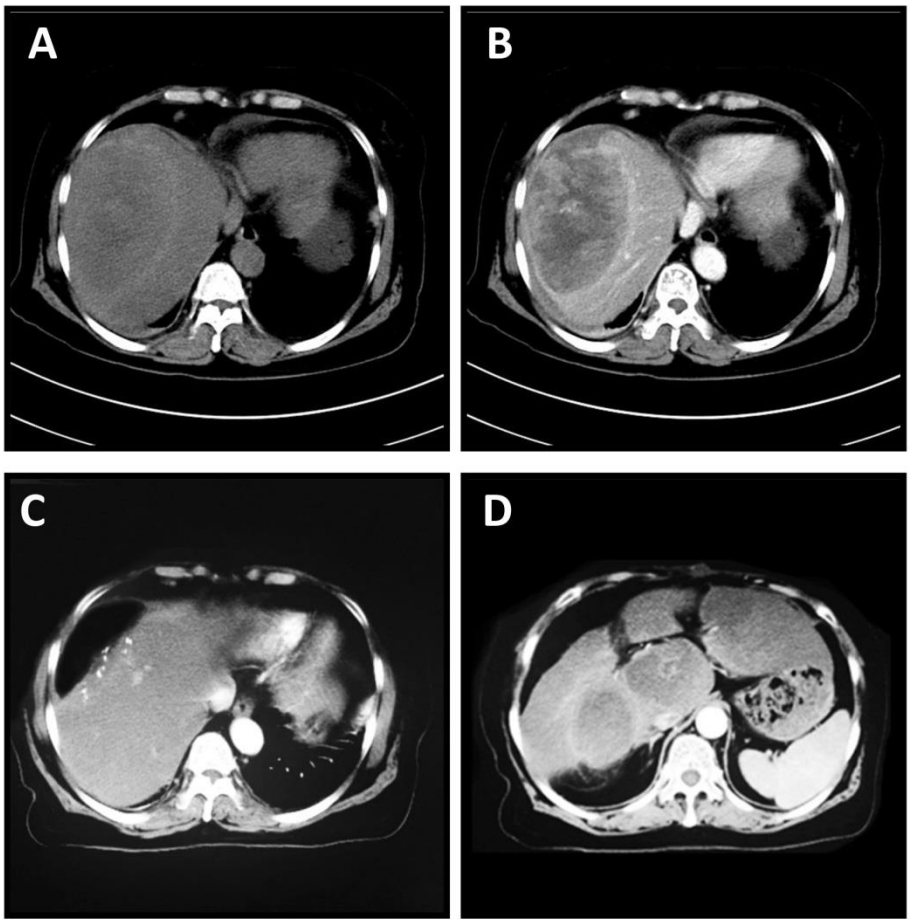

Figure 1. CT scan of the liver in case #1. A huge 11.1 × 7.5 × 9.0 cm mass was identified in segment VIII. It showed a rich blood supply within the tumor (A and B, plain scan and arterial phase, respectively). Enhanced CT scan was performed at 3 months after surgery. Post-operative image of the liver after partial resection (C). Multiple metastases were identified in the liver (D).

Fig. 2

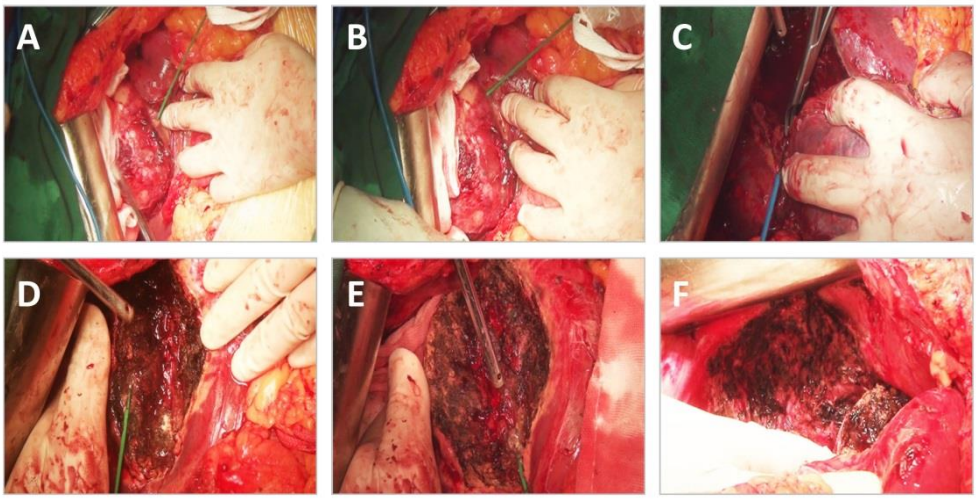

Figure 2. Pictures indicating the multiple steps of the surgery in case #1. The microwave needle was inserted into the liver parenchyma at different sites around the tumor, and microwave ablation was subsequently conducted (A and B). Tumor resection by the conventional clamp crushing method (C). MWA at the wound base for hemostasis (D and E). MWA of the invaded diaphragm (F).

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