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FULL PAPER

Safety and efficacy of percutaneous microwave ablation for post-procedural haemostasis: a bi-central retrospective study focusing on safety and efficacy

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Objective: To review safety and efficacy of percutaneous microwave ablation (MWA) for post-procedural haemostasis.

Methods: Institutional databases retrospective research identified 10 cases of iatrogenic bleeding who underwent percutaneous MWA for post-procedural haemostasis. Ultrasound examination with Doppler and contrast enhancement identified a source of active bleeding prior to ablation; additionally they were used as guiding modality for antenna insertion whilst, post-ablation, assessed the lack of active extravasation. Target locations included liver intercostal space spleen and thyroid gland. Technical success was defined as positioning of the antenna on the desired location. Treatment end point was considered the disappearance of active extravasation in both Doppler imaging and contrast-enhanced ultrasound.

Results: Technical success (*i.e.* positioning of the antenna on the desired location) was achieved in all cases. No complications were noted. All patients post MWA remained haemodynamically stable with no need for transfusion and were discharged from the hospital the next morning. Imaging and clinical follow-up in all patients before exiting the hospital did not depict any sign of active extravasation or bleeding.

Conclusion: Our limited experience reports preliminary data showing that MWA could be added in the armamentarium of percutaneous therapies for iatrogenic bleeding. More prospective studies with larger patient samples are necessary for verification of this technique as well as for drawing broader conclusions in order to evaluate the place of percutaneous ablation in the treatment algorithm of haemorrhage.

Advances in knowledge: Percutaneous ablation might have a role in haemostasis in well-selected cases

INTRODUCTION

Percutaneous image-guided ablation constitutes a minimally invasive therapeutic option for local tumour control of oncologic lesions.^{1–4} The technique has been also indicated as a palliative therapy aiming in pain reduction as well as tumour debulking and decompression.⁴ In selected cases, percutaneous ablation has been proposed as a palliative therapy for haemobilia, haemoptysis or haematuria caused by inoperable cancer; in these case reports radiofrequency energy was the ablation method of choice.^{5–9} Microwave ablation (MWA) as opposed to radiofrequency is governed by the ability to achieve temperatures over 100°C with resultant larger ablation volumes in shorter time with less procedural pain; additionally, the technique is less affected by “heat-sink” effect and any kind of impedance-driven performance.¹⁰

According to the bleeding risk, lesions to be biopsied can be classified into three categories (1–3; low, moderate and high risk) taking account the location of the lesion and the patient's pre-procedural laboratory testing.^{11,12} The suggested threshold for clinical significant bleeding post-percutaneous biopsy, drainage as well as transhepatic biliary drainage and cholecystostomy are below 2.5%.^{13–15} Therapeutic techniques for iatrogenic haemorrhage post-biopsy or drainage include supportive care (volume replacement, transfusions etc), transarterial embolisation, percutaneous techniques such as gelfoam or thrombin injections or surgical options (with haemostasis strategies such as compression, suture and ligation or electrocoagulation). Surgical techniques result in parenchymal destruction; additionally, concerning surgical excision, patients with co-morbidities or advanced metastatic disease are

at higher risk.⁶ Transarterial embolisation can acutely stabilise patient's general condition and provide at the same time long-term haemorrhage/bleeding resolution.^{16,17} Selective embolisation, although technically more challenging, can preserve some of the organ's function; less selective embolisation could jeopardise function and parenchyma.⁶ Thermal ablation has been used to effectively cauterise tissue with minimal effects upon the function of a specific organ.^{18–20} For decades, radiofrequency ablation has been used for haemostasis and decreased blood loss in the surgical setting based on the fact that with coagulation necrosis, tissues do not bleed.

The objective of this retrospective, bicentral study is to review feasibility, safety, and efficacy of percutaneous MWA for bleeding control and haemostasis in a series of consecutive patients.

METHODS AND MATERIALS

Institutional databases retrospective research identified 10 patients with symptomatic haemorrhage (patients presented with tachycardia, hypotension and decrease of haemoglobin) as an iatrogenic post-biopsy/drainage complication who underwent

percutaneous MWA using a high power microwave system in order to achieve haemostasis. Patients were informed about the technique itself as well as potential complications (types and rates) and provided written informed consent. This study was approved by the review boards of both institutions. The principles of national legislation and the Declaration of Helsinki were followed. The mean patient age was 57.71 years (range 22–85 years; male/female ratio: 6/4).

Each patient underwent laboratory (including coagulation) tests at least 24 h prior to the percutaneous biopsy or drainage session. Details concerning type of procedures, materials used and haemodynamic status of the patients are illustrated in Table 1. Once contrast-enhanced ultrasound (CEUS) illustrated the bleeding point, percutaneous ablation was immediately performed. In the present study, the target location was liver ($n = 5$ cases), intercostal space ($n = 3$ cases), spleen ($n = 1$ case) and thyroid gland ($n = 1$ case). A 16-Gauge microwave antenna was used in 6/10 cases (in the liver and spleen); a 17-Gauge microwave antenna was used in the case of bleeding post-thyroid nodal biopsy and in all intercostal space cases (4/10 cases).

Table 1. Details of the procedure types prior to haemostasis ablation

CASE	AGE	GENDER	PROCEDURE	IMAGING GUIDANCE	CLINICAL PICTURE
1	18	Male	Spleen biopsy (18G semi-automatic biopsy needle)	Ultrasound	24 h post-biopsy CT scan illustrated perisplenic haematoma and haemoperitoneum
2	60	Female	RFA of HCC (17G RF electrode)	Ultrasound	Post-ablation there is a perihepatic effusion—patient was hospitalised and monitored for 3 days along with blood (5 units) and fluid transfusion—haemoglobin decrease on the fourth day
3	69	Female	Pleural effusion drainage (8F drainage catheter)	Ultrasound	6 h later patient presented with tachycardia, hypotension and decrease of haemoglobin
4	45	Male	Subdiaphragmatic effusion drainage (8F drainage catheter)	Ultrasound	The next day patient presented with tachycardia, hypotension and decrease of haemoglobin
5	63	Male	Liver cyst puncture and drainage (8F drainage catheter)	Ultrasound	48 h later patient presented with abdominal wall subcutaneous haematoma
6	47	Female	Pleural effusion drainage (8F drainage catheter)	Ultrasound	The next day haemorrhagic fluid was drained from the chest tube, and patient complained nausea whilst lab test showed haemoglobin decreased
7	22	Male	Liver biopsy (18G semi-automatic biopsy needle)	Ultrasound	10 h later patient presented with hypotension and decrease of haemoglobin
8	70	Female	Percutaneous Transhepatic Cholangio Drain	Ultrasound + Fluoroscopy	After 4 days, patient presented with tachycardia and hypotension.
9	58	Female	Thyroid node biopsy (18G semi-automatic biopsy needle)	Ultrasound	4 h post-biopsy ultrasound showed the effusion around the thyroid and cervical vessels.
10	84	Female	Liver biopsy (18G semi-automatic biopsy needle)	CT	4 h post-biopsy patient presented with tachycardia and hypotension

HCC, hepatocellular carcinoma; RFA, radiofrequency ablation.

Figure 1. A 70-year-old female patient underwent PTCD. After 4 days, patient presented with tachycardia and hypotension. (a) CEUS illustrated the bleeding point (white arrow). (b) Under ultrasound guidance a 16G MW antenna was placed at the specific location and ablation session was performed (80 W $\times$ 3 min)—white arrow illustrates the resultant gasification during the ablation. (c) After the treatment CEUS showed the ablation zone (white arrow) and haemostasis. CEUS, contrast-enhanced ultrasound; MW, microwave; PTCD, percutaneous transhepaticbiliary drainage.

Ultrasound examination with Doppler and contrast enhancement (CEUS) techniques were used in all patients to determine the site and presence of active bleeding pre-treatment; similarly, Doppler imaging and CEUS were used for planning, targeting and intraprocedural modification during the ablation session. In all cases, active extravasation was the only finding depicted by CEUS and Doppler imaging; there was no case of pseudoaneurysm depicted by the pre-ablation imaging evaluation. At the time of ablation, the target was the site of active extravasation as illustrated by the ultrasound imaging. Technical success was defined as positioning the antenna on the desired location as well as bleeding control post-ablation in the target area. Treatment end point was considered the disappearance of active extravasation in both Doppler imaging and CEUS. Specifically, CEUS was performed 5–10 min post-ablation in order to give enough time for gasification to be weakened.

MWA was always performed in an in-patient setting. A combination of local anaesthesia (performed by the Interventional Radiologist) and conscious sedation with fentanyl (employed by the anaesthesiologist) was used to treat intraprocedural pain. Under extended local sterility, microwave antenna (Microwave High Power Antenna, ECO Medical, Binjiang Plaza Jiangdong, North Road, Nanjing, China) was inserted under either real-time CEUS (Figures 1–3). In all cases, the microwave antenna was inserted through normal tissue to the bleeding point. Once in the correct location (*i.e.* site of active extravasation), ablation session was performed until the gasification area on ultrasound was covering all the bleeding point. The ablation protocol (watts

$\times$ minutes) used was 60 $\times$ 5 in the liver, 40 $\times$ 5 in intercostal space, 100 $\times$ 5 in spleen and 40 $\times$ 2 in the thyroid gland. Track ablation was performed in all cases for haemostasis purposes. Ultrasound with colour Doppler was used to confirm haemostasis. If no flow was detected, CEUS was used for confirmation. If colour Doppler or CEUS illustrated any sign of bleeding an extra minute of ablation was performed followed once again by control with colour Doppler and CEUS.

Outcome measures—statistical analysis

Ultrasound examination with Doppler and contrast enhancement assessed lack of bleeding and the immediate efficacy at the end of the ablation treatment. We evaluated technical success, treatment success and complication rates. Complications were classified and graded according the CIRSE classification system.²¹ Data were summarised using mean value and standard deviation (mean $\pm$ standard deviation). Statistical analyses were performed with SPSS Statistics 22 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, v. 22.0. Armonk, NY: IBM Corp).

RESULTS

Technical success (*i.e.* positioning of the antenna on the desired location as well as bleeding control post-ablation in the target area) was obtained in all cases. Location of antenna placement and the ablation protocol for each therapeutic session are illustrated in Table 2. An extra minute of ablation (beyond the standard 5 min) was necessary in 3/10 cases (2 in the liver and 1 in the intercostal space) whilst in the thyroid gland ablation was

Figure 2. A 69-year-old female patient underwent percutaneous drainage of thoracic effusion. Later in the evening, patient presented with tachycardia, hypotension and decrease of haemoglobin. (a) CEUS showed pleural effusion and the site of bleeding. (b) Under ultrasound guidance a 16G MW antenna was placed at the specific location and ablation session was performed (35 W $\times$ 35 s). (c) After the treatment CEUS showed the ablation zone and haemostasis. CEUS, contrast-enhanced ultrasound; MW, microwave.

Figure 3. (a) A 22-year-old male patient underwent liver biopsy; later in the evening patient presented with hypotension and decrease of haemoglobin. (b) Ultrasound demonstrated abdominal effusion. (c) CEUS illustrated ascites and the site of bleeding (white arrow). (d) After the treatment CEUS showed the ablation zone (white arrow) and haemostasis. CEUS, contrast-enhanced ultrasound.

interrupted after 2 min because the gasification area in ultrasound had covered the bleeding site. In all patients included in the present study, both Doppler imaging and CEUS immediately post the ablation session illustrated disappearance of active extravasation. After MWA session, enhancement post-ultrasound contrast medium intravenous injection was not detected in the ablation zone. No complications were noted. All patients post -MWA remained haemodynamically stable with no need for transfusion and were discharged from the hospital the next morning. Imaging follow-up with colour Doppler and CEUS in all patients before exiting the hospital did not depict any sign of active extravasation or bleeding.

DISCUSSION

Since the beginning of their use radiofrequency energy devices have been used in the surgical setting for tissue cauterisation and decreased blood loss by creating a coagulative necrosis plane along the surgical margins.^{18–20} In the surgical setting, the use of cautery devices is done under direct visualisation; ultrasound with Doppler imaging and contrast enhancement can provide real-time imaging of the bleeding source.²² Zhou et al have applied microwave energy in three cases aiming to control intraoperative life-threatening tumour haemorrhage during hepatic surgeries.²³ Percutaneous ablation has been reported as a palliative therapy for controlling haemorrhagic

Table 2. Diameter, location of antenna placement and the ablation protocol for each therapeutic session

PATIENT	ANTENNA DIAMETER (G)	ANTENNA LOCATION	ABLATION PROTOCOL (Watts × minutes)
1	16	Spleen	100 × 5
2	16	Liver	60 × 5
3	17	Intercostal space	40 × 5
4	16	Liver	60 × 5
5	16	Liver	60 × 5
6	17	Intercostal space	40 × 5
7	16	Liver	60 × 5
8	16	Liver	60 × 5
9	17	Thyroid	40 × 2
10	17	Intercostal space	40 × 5

symptoms. Neeman *et al* have applied radiofrequency ablation for tumour-related massive haematuria (transfusion-dependent) in four patients with gross haematuria resolution within 24–48 h in all cases.⁶ In selected cases, radiofrequency ablation has been applied for treating haematuria, haemobilia and haemoptysis of oncologic patients.^{5–9} MWA has been used in selected cases of massive bleeding post-liver biopsy and in transfusion-dependent patient with haemorrhaging angiosarcoma of the pleura.^{24,25} Guo *et al* in a prospective trial have applied MWA under ultrasound (with Doppler and CEUS) guidance reporting successful and fast haemostasis in seven patients with iatrogenic bleeding post-biopsy or drainage.²⁶ The results of the present study concerning efficacy and safety of percutaneous thermal ablation are in accordance to those of the aforementioned studies and case reports. The common substrate in that kind of use is that tissues do not bleed with coagulation necrosis.

The choice of MWA over other percutaneous techniques such as gelfoam or thrombin injection was based both on operator's preference and on technical reasons. As illustrated by the ultrasound examination including Doppler and CEUS techniques, bleeding source in all the cases included in the present study was in small arteries; thrombin injection works well in small venules or capillaries as long as it is injected in the exact bleeding site. In the present cases, it was feared that arterial velocity of the bleeding could work against the efficacy of the thrombin injection. On the other hand, MWA could coagulate the area at and around the bleeding point, is easier to perform, effective, with lower risks whilst the ablation zone can be monitored by ultrasound. Super-selective arterial embolisation is the treatment of choice for the cases included in the present study; MWA was preferred due to the need for higher technical requirement, the longer preparation time and to avoid radiation of both patient and medical staff. At the moment, it is not clear which factors could make a bleeding patient candidate for percutaneous ablation over transarterial embolisation. According to the literature, when transcatheter embolisation is necessary for the treatment of iatrogenic bleeding, both technical and clinical success rates are >95% with clinically

significant complications being extremely rare whilst insertion of gelfoam torpedos, although commonly used has not been evaluated by well-controlled studies reporting any actual benefit.²⁷ In an experimental study on a dog model, Choi *et al* compared post-biopsy radiofrequency ablation, transarterial embolisation with an absorbable gelatin sponge and plugging with Histoacryl–Lipiodol mixture reporting percutaneous ablation as the most useful postbiopsy bleeding reduction method in terms of the amount of bleeding and procedure time.²⁸

In the present study, all ablation sessions were performed with a 16 or 17G microwave probe with internal water cooling to avoid shaft overheating. Ultrasound (with Doppler and contrast medium application) was used as the guiding modality of choice in all the cases included in the present study. CEUS has been shown sensitive for the detection of traumatic abdominal organ injuries.^{29,30} Fusion imaging systems allowing the acquisition of CT images and real-time fusion with ultrasound could provide improved identification of the target and real-time control of needle insertion.³¹

Limitations of the present study include the small patient sample, the lack of long-term follow-up and its retrospective character, all of which render it difficult to draw broad conclusions. Another limitation is the lack of comparison to other percutaneous (such as gelfoam or thrombin injections) or endovascular techniques. Furthermore, at the moment there are no data upon the proposed technique for coagulation using microwave. There was no standard ablation protocol in the present study; different ablation protocols were applied with the selection based mostly upon operator's experience. Last but not least, generalisation of the aforementioned results may be hinder due to lack of CEUS in some countries.

Our experience shows that MWA could be added in the armamentarium of therapies for haemorrhage complicating cancerous masses or percutaneous techniques such as biopsy and drainage. More prospective studies with larger patient samples are necessary for verification of this technique as well

as for drawing broader conclusions in order to evaluate the place of percutaneous ablation in the treatment algorithm of haemorrhage.

ETHICAL APPROVAL

All procedures performed in studies involving human participants were in accordance with the ethical standards of the insti-

tutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study.

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