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Case Report
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Use of radiofrequency ablation for controlling liver hemorrhage in the emergency setting; report of two cases and review of the literature

Acil ortamlarda karaciğer kanamasının kontrolünde radyofrekans ablasyonun kullanılması: İki olgu sunumu ve literatürün gözden geçirilmesi

Ioannis MAROULIS,[1] Charalambos SPYROPOULOS,[1]
Christina KALOGEROPOULOU,[2] Dimitrios KARAVIAS[1]

Active liver hemorrhage with hemodynamic instability is a serious situation often requiring surgical intervention. The most common causes of hepatic bleeding are trauma and tumors of the liver parenchyma: mainly hepatocellular carcinoma and adenoma. Liver hemorrhage from blunt trauma or spontaneous tumor rupture is sometimes difficult to control with traditional methods and postoperative complications are frequent. Recently, the radiofrequency ablation system (RF) has been used for obtaining haemostasis of ruptured hepatic tumors or for controlling hemorrhage due to liver trauma in experimental models. We report two cases where the radiofrequency ablation system (RF) has been efficiently used during emergency laparotomy in humans in order to control massive hemorrhage from spontaneous rupture of a liver metastatic testicular germ cell tumor and from a Grade IV blunt liver trauma. RF ablation system combined with traditional techniques was effective in controlling liver bleeding during laparotomy in both cases. No recurrence of the hemorrhage or any side effects associated with the RF system were recorded postoperatively. RF system is an effective strategy for achieving hemostasis in patients with active liver hemorrhage. In cases of bleeding liver tumors, RFA could also be helpful in synchronous tumor elimination, maximizing the chances of longer term survival.

Key Words: Hemorrhage; liver; radio frequency ablation.

Hemodinamik instabiliteyle birlikte aktif karaciğer kanaması sıklıkla cerrahi girişimi gerektiren ciddi bir durumdur. Karaciğer kanamasının en sık görülen nedenleri travma, başlıca hepatoselüler karsinom ve adenom olmak üzere karaciğer parankimi tümörleridir. Künt travma veya spontane tümör rüptürünü bazen klasik yöntemlerle kontrol altına almak zorlaşmakta ve sık sık ameliyat sonrası komplikasyonlar görülmektedir. Son zamanlarda rüptüre karaciğer tümörlerinde hemostazı sağlamak veya deneysel modellerde karaciğer travmasına bağlı kanamayı kontrol altına almak için radyofrekans ablasyon (RFA) sistemi kullanılmaktadır. İnsanlarda karaciğerde metastatik testis germ hücreli tümörün spontane rüptürüne ve grade IV künt karaciğer travmasına bağlı masif kanamanın kontrol altına alınması için acil laparatomi sırasında RFA sisteminin etkinlikle kullanılmış olduğu iki olgu sunuyoruz. Klasik tekniklerle kombine edilmiş RFA sistemi her iki olguda da laparotomi sırasında karaciğer kanamasını kontrol altına almada etkili olmuştur. Ameliyat sonrası dönemde RFA sistemiyle ilişkili herhangi bir kanama nüksü veya yan etki kaydedilmedi. Aktif karaciğer kanaması olan hastalarda hemostazı sağlama açısından RFA sistemi etkili bir stratejidir. Kanayan karaciğer tümörlerinde RFA aynı zamanda eş zamanlı olarak tümörün ortadan kaldırılmasına yardımcı olarak daha uzun sağkalım şansını en üst düzeye çıkartabilir.

Anahtar Sözcükler: Kanama; karaciğer; radyofrekans ablasyon.

Departments of [1]Surgery, [2]Radiology,
University Hospital of Patras Rion, Patras, Greece.

Patras Rion Üniversite Hastanesi [1]Cerrahi Kliniği, [2]Radyoloji Bölümü,
Patras, Yunanistan.

Correspondence *(İletişim)*: Charalambos Spyropoulos, M.D. 59, Vitsentzou Kornarou Street 26442 Patras, Greece.
Tel: +0030 - 2610 - 454958 e-mail *(e-posta)*: xspiropupatras@gmail.com

The liver is the most frequently injured abdominal organ. Management of liver injuries has evolved significantly over the last two decades, with significant improvement in outcomes. Road traffic accidents and antisocial, violent behavior account for the majority of liver injuries. In the absence of trauma or anticoagulant therapy, hepatic hemorrhage may be due to underlying liver disease. The most common causes of non-traumatic hepatic hemorrhage are hepatocellular carcinoma (HCC) and adenoma but such hemorrhage can also occur in patients with other liver tumors, such as focal nodular hyperplasia and hemangioma. In contrast, hemoperitoneum due to rupture of liver metastases is quite rare while the cases of bleeding metastatic testicular tumors are quite exceptional.[1-3] In the case of massive hemorrhage with hemodynamic destabilization, surgical intervention is required. There are a variety of methods to control liver bleeding; radiofrequency ablation (RFA) system has been recently used in the emergency setting for obtaining haemostasis of ruptured HCCs[4,5] or for controlling traumatic liver bleeding[6] at the experimental level.

In the present study, we report two cases where RFA was successfully applied during emergency laparotomy in humans in order to control hepatic hemorrhage, not managed by conventional techniques. The first case is a spontaneous rupture of a liver metastasis from a testicular germ cell tumor and the second case is a Grade IV liver trauma after blunt abdominal injury due to a traffic accident. We also report a review of the current literature as to our knowledge there is no current report on the efficacy of this technique in humans, when applied in the emergency setting.

CASE REPORTS

Case 1– A 30-year-old male patient was admitted to the emergency department of our hospital reporting fatigue, abdominal pain and vomiting. His medical record included reports of prior surgical operation for undescended testicle at the age of four and heroin use in the preceding six months. Clinical examination revealed sensitivity at the palpation of the abdomen with tenderness and presence of rebound, without any clinical signs of hemorrhagic shock. Laboratory examinations indicated a hemoglobin level of 6.8 g/dl without any coagulation disorders or associated thrombocytopenia, elevated liver enzymes with ALT=290 g/dl and AST=133 g/dl and moderate elevation of γGT, ALP and amylase levels. A computed tomography scan (CT) was undertaken revealing multiple hepatic metastases, free quantity of endoperitoneal blood and the presence of a blood clot in the left hepatic lobe, without any active contrast extravasation (Fig. 1). Considering the patient's medical history and the findings of the CT scan, the possibility of hepatic metastases from a testicular tumor was suspected. Ultrasound (US) scan of the testes was subsequently performed revealing the presence of a single lesion on the right testicle of 1.5 cm in diameter with multiple calcifications.

The patient was transferred to the clinic for hemodynamic monitoring and support, and planning was made to perform the selected embolization of the left hepatic artery afterwards. Upon transfer and despite rigorous resuscitation with crystalloid, colloid and blood transfusion, clinical signs of serious hemorrhagic shock emerged with hemodynamic destabilization. An emergency exploratory laparotomy was deemed necessary to perform liver packing and possibly subsequent embolization postoperatively.

During surgery, as would be expected, massive intrabdominal blood clots were found and multiple hepatic metastases were detected with the largest ranging about 4 cm in diameter, located in the left hepatic lobe. The rupture was visible on the surface of the metastatic lesions accompanied by both massive blood clots around them and active bleeding. Temporary packing of the hemorrhagic lesions was performed with successful temporary stabilization of the patient. Bearing in mind recent reports of hemorrhage control via RFA in experimental conditions, particularly in liver trauma, and estimating the extent of the underlying

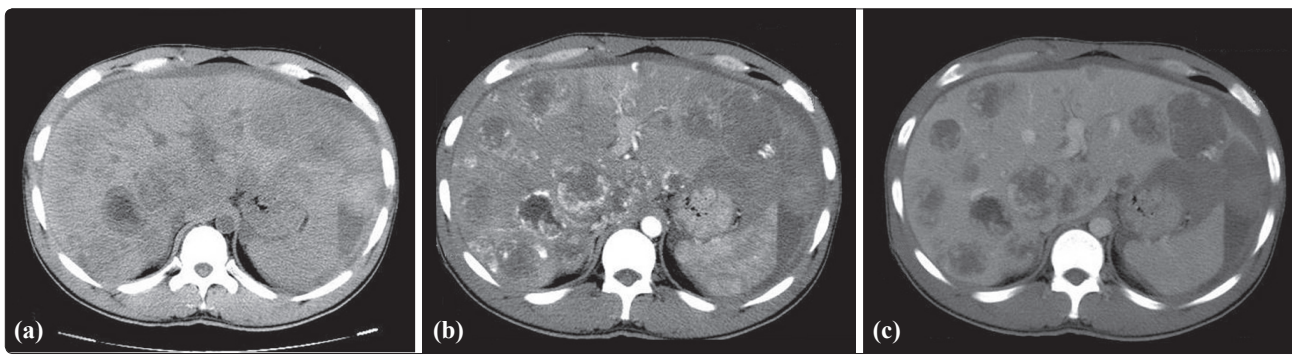

Fig. 1. Pre **(a)** and post contrast scans **(b, c)** reveal hemoperitoneum and multiple hypervascular liver metastases. A large metastasis in segment II is adjacent to the liver surface producing contour abnormality and discontinuity, surrounded by sentinel thrombus.

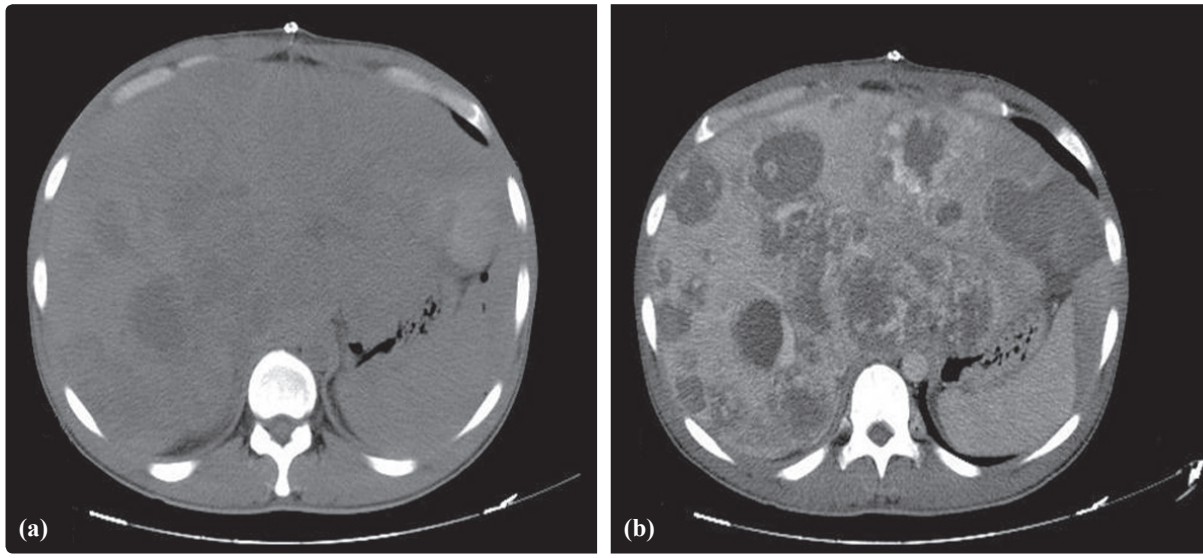

Fig. 2. Pre **(a)** and post contrast scan **(b)**, 10 days post surgery. There is marked hypovascularity of the ruptured metastasis in the left lobe and hyper dense material within it, corresponding to intralesional thrombus.

damage as well as our experience with RFA-assisted hepatic resection, it was decided that RFA was a viable alternative for the specific patient. To this end we employed the Cool-tipTM RF system (Valley Lab, Boulder, CO®) utilizing the system's "manual mode". Operating at a generator power output of 180-200W and using a single probe, we performed various applications directly inside the rupture as well as to the surrounding area, effectively creating an occlusive barrier of dried tissue within the liver parenchyma, ranging ~3 cm in diameter. The time length of each application varied between 3-5 minutes and it was carried out at every site until the impedance readings exceeded 300 Ω and the tissue had assumed a characteristic dehydrated, brownish appearance. After completion of the RFA sessions, hemorrhage was completely controlled with hemodynamic stabilization of the patient and he was admitted to the intensive care unit for 48 hours.

Lesion biopsy was indicative of metastatic testicular choriocarcinoma. The diagnosis was also supported by the pre-operative values of chorionic gonadotropin which were 25.000 mIU/mL. The patient remained hospitalized for a period of 12 days (two days in the intensive care unit) without any postoperative complications, as indicated by a new CT scan during follow-up (Fig. 2), before being transferred to the oncology department for commencing chemotherapy sessions. The patient is still alive at present and doing well.

Case 2– A 28-year-old male patient, victim of a road traffic accident, who had been initially managed in a secondary general hospital, was transferred intubated to the emergency department of our hospital for further evaluation and management. His medical record included heroin use and chronic hepatitis C. The patient had initially undergone an exploratory damage control laparotomy due to hemodynamic instability where a Grade IV hepatic trauma was revealed with right lobar destruction and active bleeding. Furthermore there was a rupture in the prepyloric area of the stomach and also a laceration at the body of the pancreas with the presence of extended peripancreatic hematoma. Damage control management consisted of peri-hepatic packing, partial suturing of the prepyloric injury and positioning of a drainage tube throughout the gastric rupture. During initial assessment at our hospital the patient was hemodynamically stable and he was transferred to the radiology department where a CT scan was performed (Fig. 3). Computed tomography findings indicated additional thoracic injuries (right pneumothorax) and minor injuries at the right kidney. The patient was admitted to the ICU where he remained hemodynamically stable receiving transfusions of concentrated red blood cells and fresh frozen plasma. After 24 hours, he was transferred to the angiography suite where selective embolization of the right hepatic artery was performed due to continuous low volume bleeding from branches of the right hepatic artery.

Forty-eight hours after the accident, a second-look laparotomy was performed where unpacking revealed extended injuries at the right hepatic lobe (segments IV, V, VI and VIII) with areas of active bleeding. Bearing in mind recent effective hemorrhage control via RFA in our patient of case 1, recent reports of hemorrhage control via RFA in experimental conditions for liver trauma, and estimating the extent of the damage it was decided to use the RFA system as an adjunct for achieving liver haemostasis. The Cool-tipTM RF system (Valley Lab, Boulder, CO®) was applied performing ablative applications at maximum power (180-200 W) and for time-lengths/periods long enough to de-

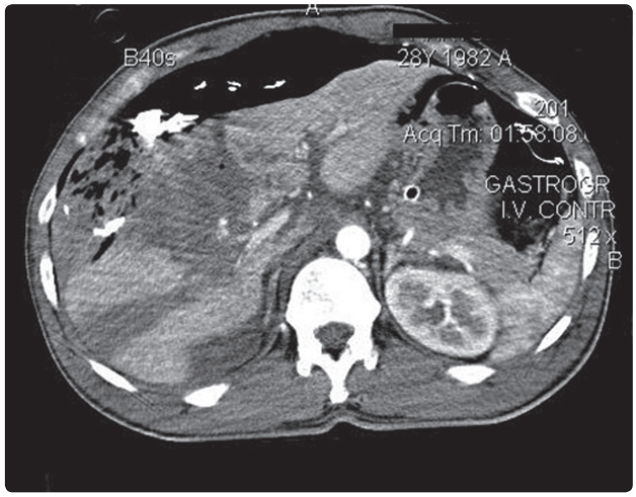

Fig. 3. Grade IV hepatic injury. Contrast-enhanced CT scan shows multiple hepatic lacerations in the right hepatic lobe, resulting in parenchymal disruption of about 50% of the lobe. Pneumoperitoneum and gauze pads in the liver surface are also present, due to prior laparotomy (packing).

hydrate/cauterize thick pieces of liver tissue to cease hemorrhage at all sites, as described above (Fig. 4a). Applications again did not exceed 3 minutes at every site, while the 300 Ω impedance reading and tissue discoloration criteria were applied once more for every hemorrhagic site. The application of RFA was effective and prevented any further blood loss (Fig. 4b). All other intra-abdominal injuries were systematically reviewed and were properly managed. Drainage tubes were positioned at the site of the liver injury and the peripancreatic hematoma. The patient was transferred to the intensive care unit for 24 days. On the second postoperative day, minor pancreatic leakage was detected leading to the formation of a low-volume pancreatic fistula. The patient also developed abstinence syndrome and central venous catheter related infections, all managed successfully.

On the 22nd postoperative day he was transferred to our clinic where he remained for a period of 39 days without any further complications, as confirmed in repetitive CT scans (Fig. 5).

DISCUSSION

Spontaneous rupture of liver tumors is infrequent and it is usually caused by HCCs while rupture of hepatic metastasis is quite exceptional.[7] In a series of 70 cases of spontaneous liver hemorrhage reported by Chen et al, the cause was HCC rupture in 60 patients, cirrhosis without underlying tumor existence in three, hemangioma in two, hepatocellular adenoma in four and a bleeding metastatic lesion in only one patient.[8] These hypervascular tumors can usually be revealed after accidents which involve liver trauma and thus about 10% of HCC would present in such a way, responsible for the deaths of 3% of patients with HCC in a large Swedish series.[9] Massive hemorrhage related to ruptured liver metastases is quite exceptional and less than 50 cases are reported in the literature.[7] Spontaneous rupture of an HCC may be explained by bleeding disorders, the intense vascularity of the tumor, the rapid tumor growth and probably by the coexistence of peritumoral venous dilatation due to portal hypertension. In the context of metastatic disease several factors may be invoked to explain sudden rupture such as rapid tumor growth, the peripheral vascularity and the intense central necrosis. Metastatic tumors are usually fibrotic, less vascular and invasive, and penetrate the liver capsule less frequently than HCC.

The usual treatment of hemoperitoneum caused by ruptured benign or malignant liver lesions is based on hepatic artery embolization which in most cases is highly effective.[10] Surgical intervention is deemed

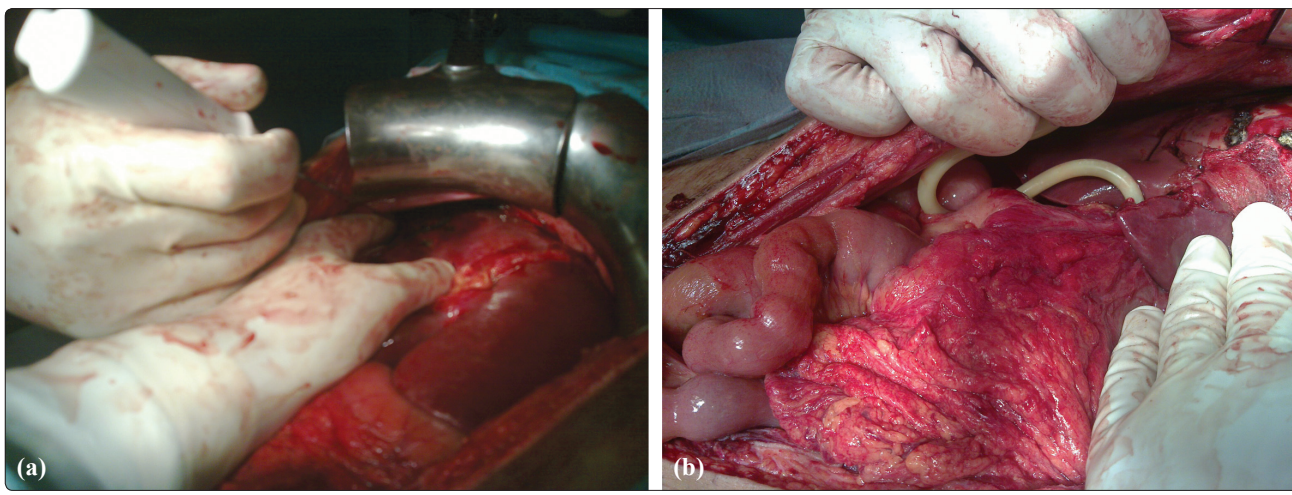

Fig. 4. The application of the RF system on major hepatic injury **(a)** prevented any further blood loss **(b)**.

(Color figures can be viewed in the online issue, which is available at www.tjtes.org).

necessary only in cases of hemodynamic instability despite conservative treatment with main goals to attain hemostasis and to preserve enough functional liver parenchyma. Various surgical procedures, including perihepatic packing, suture application of ruptured tumors, injection of alcohol, ligation of the hepatic artery and rarely emergency liver resection, have been reported to be effective in achieving hemostasis but they are associated with extremely high morbidity and mortality rates.[10]

The liver is also the most commonly injured organ in patients with blunt abdominal trauma. Non-operative management of grade I and II hepatic injuries is state of the art but this technique has also been supported for high-grade injuries;[11] nonetheless, embolization through digital selective angiography offers an effective way to control hepatic hemorrhage in these cases, although 24% of patients managed non-operatively are expected to require additional treatment secondary to complications.[12,13]

In the case of uncontrolled hepatic bleeding despite conservative techniques, surgical intervention is necessary. During emergency laparotomy, wide exposure of the injured liver is essential and temporary perihepatic packing with swabs and sponges is particularly useful. Packing can be freed gradually in theater 48 to 72 hours later, according to the patient's condition. Hepatic resection is indicated only in patients with severe multiple contusions and injuries in bile ducts, hepatic veins, and the inferior vena cava in combination with extensive parenchymal damage.[14] RFA is a therapeutic approach exhibiting substantial progress in the last decade.[4] In recent years, the effectiveness of this method for achieving hepatic hemostasis has become greatly appreciated in the treatment of liver trauma, as shown in animal models, as well as in cases of ruptured liver tumors.[4,6]

RFA system uses pulsed radiofrequency current to quickly heat and ablate large volumes of tissue[15] and is mainly used for thermal destruction of unrespectable liver tumors. Alternating current through the tissue creates friction on a molecular level. Increased intracellular temperature generates localized interstitial heating. At temperatures above 60 °C, cellular proteins rapidly denature and coagulate.[15] The unique ability of radiofrequency to irreversibly denature sub-cellular protein structures and to coagulate tissues leaving them dry and essentially free of any circulating blood is in fact responsible for its hemostatic effect. The dried tissue, which can be several millimeters thick, acts as a permanent occlusive barrier on the endings of severed and ruptured vessels thereby rendering subsequent bleeding from the coagulated site impossible.

In cases of emergency surgical planning, the application of RFA provides valuable time for determining final surgical manipulations, an alternative to perihepatic packing and subsequent unpacking operations. The application of this system should always be evaluated in the operating room, and if deemed commendable it should be performed in the appropriate cases. Based on successful results from the use of RFA in hepatic resections, this technique could be extremely helpful as an efficient alternative in cases of emergency laparotomic exploration for liver bleeding, when other traditional methods cannot be applied due to specific conditions and underlying limitations.

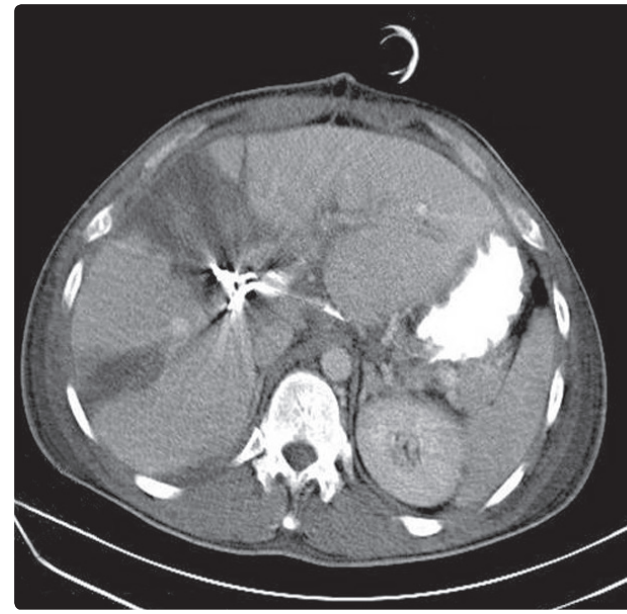

Fig. 5. Post contrast follow up scan. Haemostatic elements have been removed from the liver surface. Embolic agents (coils) are present in the RT hepatic artery.

In both cases reported in the current study, the RFA protocol involved our system's manual mode of function. In this mode, no inherent algorithm is at work and the result is more dependent on the operator's experience. By applying the single Cool-tipTM probe (Valley Lab, Boulder, CO) at the site of hemorrhage and monitoring the system's impedance readings, it is possible to control blood loss at that site by dehydrating the parenchyma as well as by forming occlusive blood clots within small nearby vessels. The occlusive barrier is essentially formed in columns of 1 cm in diameter and 3 cm in length (the length of the probe's active tip), which can be created within 1-2 mins at a generator output of 200 W. Then, by applying the probe at successive sites, the occlusive barrier can be shaped according to the operator's needs. The barrier can be concentrated at one site to terminate blood loss or spread along a path forming a dehydrated wall within the parenchyma that can be cut bloodlessly. Throughout every application, the impedance elevation above the 300 Ω threshold, the characteristic discoloration

of the tissue and of course blood leakage cessation are the criteria that dictate the system's operation.

RFA is an effective strategy for achieving hemostasis in patients with liver hemorrhage in the emergency setting when the appropriate infrastructure is present. In addition to controlling active liver bleeding caused by ruptured tumors, RFA could also be helpful in synchronous tumor elimination, maximizing survival.

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