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Case Report

Transchondral access for irreversible electroporation of hepatocellular carcinoma

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ABSTRACT

Ablative treatment for hepatocellular carcinoma is standard of care in selected settings and is endorsed by international societal guidelines. Centrally located hepatocellular carcinoma are difficult to treat due to their proximity to vasculature and central bile ducts. Irreversible electroporation is a nonthermal ablation modality that has been shown to preserve the extracellular matrix and is less likely to damage structures such as bile ducts and is not susceptible to vascular heat sink. Successful irreversible electroporation requires the parallel placement of probes which can be prevented by ribs or the sternum. This case report describes the use of the coaxial bone biopsy system to enable transchondral access and facilitate parallel placement of probes during irreversible electroporation IRE for the treatment of hepatocellular carcinoma.

Introduction

Ablative treatment for hepatocellular carcinoma (HCC) has advanced as the standard of care in selected settings and is now endorsed by national and international societal guidelines [1–3]. Multiple ablation modalities and adjunctive techniques are available for the treatment of HCC which enables individualization of treatment based on hepatic reserve, tumor biology, and local anatomic factors. Challenging intra- and extrahepatic anatomy can add complexity to and increase the risks of an ablation. Centrally located tumors are particularly difficult to treat due to their proximity to the hepatic and portal veins which serve as heat sinks as well as the bile ducts and arteries which are prone to injury [4–6]. Transarterial therapies can overcome these challenges but may be limited by the quality of vascular conduit supplying the tumor and the at-risk margin. Irreversible electroporation (IRE) is a nonthermal ablation modality that generates nanoscale cellular membrane defects resulting in apoptosis and cell death [7]. IRE has been shown to preserve the extracellular matrix and is less likely to damage critical structures such as bile ducts

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[8–10]. Studies have demonstrated complete response rates between 77% and 92% and complete pathologic necrosis rates of 83% in HCC lesions treated with IRE [11,12]. However, IRE is limited by the requirement for general anesthesia, parallel probe placement, adequate probe spacing, and other patient-related limitations such as history of cardiac arrhythmias and pacemaker placement [6]. IRE probes must be placed in a parallel arrangement to avoid nonuniform ablation of the field of interest [6]. Placement of multiple parallel probes can be time consuming and is limited by local anatomic factors such as the bones and costal cartilage. This case report describes the use of the Bonopty Penetration Set (Apriomed, Upsala, Sweden), which was originally designed for bony penetration during a bone biopsy, to enable transchondral access and facilitate parallel probe placement during IRE.

Case report

A 79-year-old male patient who previously underwent 2 successful radiation segmentectomies presented with a new 1.5 cm HCC involving the main right bile duct bifurcation. Thermal ablation was not performed due to risk of injury to local structures and heat sink effects from the adjacent portal vein. Mapping angiography was performed which demonstrated an inadequate microvascular conduit, watershed arterial supply, and nontarget preferential flow which precluded ablative radioembolization. The lesion was initially treated with percutaneous ethanol injection but there was residual tumor likely due to heterogeneous diffusion of ethanol and incomplete necrosis. The lesion was subsequently embolized with lipiodol to improve visibility for IRE. A safe window was identified that would not transgress the adjacent ducts, portal vein, or hepatic artery from a ventral approach. An initial attempt at probe placement was unsuccessful due to the costal cartilage impeding parallel placement. A plane was identified where 2 probes could be placed through the interchondral space guided by fluoroscopic CT into the superomedial and inferolateral aspects of the tumor. In order to maintain a parallel nonconvergent arrangement of the other 2 probes, two 14-gauge bone biopsy sheaths were advanced through the costal cartilage into the liver followed by 2 coaxial ablation probes in the superolateral and inferomedial planes of the tumor (Figs. 1A, B and 2). IRE was performed without any complications. Liver function tests were obtained at 24 hours, 2 weeks, 1 month, and 3 months. Aspartate transaminases and alanine transaminases were elevated 24 hours postprocedure (50 and 176, respectively), but they gradually decreased to normal preprocedure levels. Liver MRI at 8 months demonstrated Modified Response Evaluation Criteria in Solid Tumors (mRECIST) complete response, an adequate ablation margin, and no evidence of biliary injury.

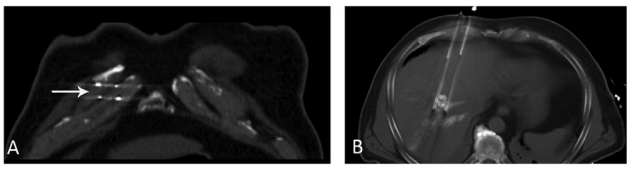

Fig. 1 – (A) Intraprocedural coronal computed tomography demonstrates placement of 2 irreversible electroporation probes through the interchondral space along the inferolateral and superomedial aspect of the tumor. The final 2 probes were advanced through the costal cartilage facilitated by the bonopty sheath in the inferomedial and superolateral aspect of the tumor. The white arrow denotes the probe array.
(B) All 4 probes are bracketing the lesion in a parallel fashion prior to ablation.

Fig. 2 – Two 14-gauge bone biopsy sheaths (white asterisks) advanced through the costal cartilage into the liver allowing nonconvergent uniform tumor ablation.

Discussion

Ablation has matured into a definitive therapy for HCC. It requires a careful assessment of tumor presentation to individualize therapy and ensure complete treatment of the target lesion and at-risk margin without complications. IRE is useful in ablating anatomically challenging tumors due to its nonthermal nature, which induces cell death by producing high-voltage electrical impulses leading to permanent cell membrane pores [13]. Favorable results have been demonstrated in very early stage HCC with studies achieving 6-month progression-free survival of 71.4% in 21 patients (median tumor size: 26 mm) [14] and 87% for 75 nodules in 58 patients (median tumor size: 24 mm) [11]. A significant limitation to IRE is parallel probe placement with treatment otherwise resulting in nonuniform tumor ablation [6]. Prior studies utilizing transosseous and transchondral access for

ablating pulmonary masses have demonstrated greater than 90% tumor necrosis in approximately 90% of treated lung lesions [15]. Other studies utilizing transosseous access for ablating renal masses demonstrated complete ablation rates of 83.3% at a mean follow-up of 19.5 months [16] and no local recurrence in 1 patient at 8-month follow-up [17]. Reported complications after the transosseous access have included nerve injury that can lead to neuralgia [16]. To our knowledge, this is the first report of transchondral access for locoregional therapy of HCC. Placement of the transchondral bonopty sheaths was efficient and facilitated advancement of multiple parallel IRE probes into a challenging location. This maneuver can decrease procedural time and enable precise probe placement to maximize ablative results in challenging locations.

Conclusion

The bonopty kit can be used to drill through bone/cartilage and facilitate coaxial placement of parallel IRE probes during anatomically challenging HCC ablation.

REFERENCES

[1] Marrero JA, Kulik LM, Sirlin CB, Zhu AX, Finn RS, Abecassis MM, et al. Diagnosis, staging, and management of hepatocellular carcinoma: 2018 practice guidance by the American Association for the Study of Liver Diseases. Hepatology 2018;68(2):723–50. doi:10.1002/hep.29913.

[2] Galle PR, Forner A, Llovet JM, Mazzaferro V, Piscaglia F, Raoul JL, et al. EASL clinical practice guidelines: management of hepatocellular carcinoma. J Hepatol 2018. doi:10.1016/j.jhep.2018.03.019.

[3] Llovet JM, Fuster J, Bruix JBarcelona-Clínic Liver Cancer Group. The Barcelona approach: diagnosis, staging, and treatment of hepatocellular carcinoma. Liver Transplant 2004. doi:10.1002/lt.20034.

[4] Teratani T, Yoshida H, Shiina S, Obi S, Sato S, Tateishi R, et al. Radiofrequency ablation for hepatocellular carcinoma in so-called high-risk locations. Hepatology 2006. doi:10.1002/hep.21164.

[5] Künzli BM, Abitabile P, Maurer CA. Radiofrequency ablation of liver tumors: actual limitations and potential solutions in the future. World J Hepatol 2011;3(1):8–14. doi:10.4254/wjh.v3.i1.8.

[6] Narayanan G, Irreversible Electroporation, 2015, doi:10.1055/s-0035-1564706.

[7] Deipolyi AR, Golberg A, Yarmush ML, Arellano RS, Oklu R. Irreversible electroporation: evolution of a laboratory technique in interventional oncology. Diagn Interv Radiol 2014;20(2):147–54 Turkish Society of Radiology. doi:10.5152/dir.2013.13304.

[8] Rubinsky B, Onik G, Mikus P. Irreversible electroporation: a new ablation modality-clinical implications. Technol Cancer Res Treat 2007;6(1):37–48.

[9] Lee EW, Chen C, Prieto VE, Dry SM, Loh CT, Kee ST. Advanced hepatic ablation technique for creating complete cell death: irreversible electroporation. Radiology 2010;255(2):426–33. doi:10.1148/radiol.10090337.

[10] Silk MT, Wimmer T, Lee KS, Srimathveeravalli G, Brown KT, Kingham PT, et al. Percutaneous ablation of peribiliary tumors with irreversible electroporation. J Vasc Interv Radiol 2014;25(1):112–18. doi:10.1016/j.jvir.2013.10.012.

[11] Sutter O, Calvo J, N'Kontchou G, Nault JC, Ourabia R, Nahon P, et al. Safety and efficacy of irreversible electroporation for the treatment of hepatocellular carcinoma not amenable to thermal ablation techniques: a retrospective single-center case series. Radiology 2017;284(3):877–86. doi:10.1148/radiol.2017161413.

[12] Cheng RG, Bhattacharya R, Yeh MM, Padia SA. Irreversible electroporation can effectively ablate hepatocellular carcinoma to complete pathologic necrosis. J Vasc Interv Radiol 2015;26(8):1184–8. doi:10.1016/j.jvir.2015.05.014.

[13] Tameez Ud Din A, Tameez-ud-din A, Chaudhary FMD, Chaudhary NA, Siddiqui KH. Irreversible electroporation for liver tumors: a review of literature. Cureus 2019. doi:10.7759/cureus.4994.

[14] Kalra N, Gupta P, Gorsi U, Bhujade H, Chaluvashetty SB, Duseja A, et al. Irreversible electroporation for unresectable hepatocellular carcinoma: initial experience. Cardiovasc Interv Radiol 2019;42(4):584–90. doi:10.1007/s00270-019-02164-2.

[15] VanSonnenberg E, Shankar S, Morrison PR, Nair RT, Silverman SG, Jaklitsch MT, et al. Radiofrequency ablation of thoracic lesions: part 2, initial clinical experience—technical and multidisciplinary considerations in 30 patients. Am J Roentgenol 2005;184(2):381–90. doi:10.2214/ajr.184.2.01840381.

[16] Iguchi T, Hiraki T, Ishii H, Gobara H, Fujiwara H, Matsui Y, et al. Transosseous route for CT fluoroscopy-guided radiofrequency ablation of lung tumors. J Vasc Interv Radiol 2015;26(11):1694–8. doi:10.1016/j.jvir.2015.08.012.

[17] Gul ZG, Griffith JJ, Welch C, Fischman A, Palese MA, Badani KK, et al. Focal ablative therapy for renal cell carcinoma in transplant allograft kidneys. Urology 2019;125:118–22. doi:10.1016/j.urology.2018.12.003.