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PICTORIAL ESSAY

Artificial Ascites and Hydrodissection in Percutaneous Thermal Ablation Cases at a Tertiary Institution: A Pictorial Essay

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INTRODUCTION

Percutaneous thermal ablation is gaining popularity as a curative form of treatment for many cancers. With increasing demand for such treatment, there are likewise increasing challenges when handling tumours close to vital structures and unintended thermal injury now needs to be considered. This may arise due to an inadequate margin as the operator attempts to avoid a critical structure. Artificial ascites and hydrodissection are effective and economical techniques that can push away critical structures, allowing a safe and complete ablation. This pictorial review demonstrates the various ways in which artificial ascites and hydrodissection can be used in percutaneous ablation, and discusses the different methods and mediums used at our institution as well as the challenges and complications encountered over a 3-year review period.

Cases with hydrodissection performed under ultrasound (US), computed tomography (CT), and magnetic resonance (MR) guidance from January 2018 to September 2021 were retrieved from the Radiology Information System under Hospital Authority of Hong Kong using keywords ‘hydrodissection’ and ‘artificial ascites’. Images from illustrative cases have been selected to showcase different areas in the body where hydrodissection was performed.

Artificial ascites and/or hydrodissection was performed in 128 patients at our centre, Queen Elizabeth Hospital, with the majority involving hepatocellular carcinomas (85.9%, n = 110) or renal cancers (10.2%, n = 13). Miscellaneous target lesions included adrenal nodules, iliac lymph nodes, pelvic collections, and breast nodules. Examples of hydrodissection include the gallbladder fossa, hepatic bare area, duodenum, and abdominal large vessels. Hydrodissection of the renal pelvis and porta hepatis have also been successfully performed.

All our percutaneous thermal ablation patients are referred to us by the surgical department. Patients with liver lesions first undergo a targeted US to ascertain whether the index lesion can be well visualised on US. The targeted US, as well as correlation with previous cross-sectional imaging, also identifies nearby non-target structures and determines whether artificial ascites

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or hydrodissection is needed. If the index lesion and the hydrodissection pathway are suboptimally seen on US, a CT-guided approach will be chosen.

An MR-guided approach for liver lesions, which is rare, is reserved only for cases in which the lesion is both US and CT occult. On the contrary, all renal tumours are referred for MR-guided cryoablation. This is due to departmental preference. Patients with renal tumours are seen by our interventionists at the interventional radiology clinic, where cross-sectional imaging of patients is reviewed and the procedural details and complications were discussed with the patient. Since most of our MR-guided renal tumour ablations are performed under local anaesthesia and/or conscious sedation, one of the important issues debated during the interventional radiology clinic session is the ability of the patient to lie prone for an extended period of time as this is pivotal to these procedures.

TECHNIQUES AND PROCEDURES

Ultrasound Guidance

Ultrasound-guided (USG) artificial ascites and hydrodissection remain the most common technique, especially for liver lesions, making up to 87.5% (n = 112) of reviewed cases. For artificial ascites, two methods are adopted at our institution. In the first,[1,2] the liver is directly punctured superficially with a 16-gauge angiocatheter needle (Becton Dickinson Infusion Therapy Systems Inc, Mexico) under US guidance. The needle is removed and the patient is instructed to breath in and out making use of the relative movement between the peritoneum and liver to allow the plastic sheath to fall into the peritoneal space. Concomitant gentle advancement of a 0.035-inch guidewire (Terumo Medical Corporation, Japan) is continued until smooth guidewire advancement is felt. CT or fluoroscopy may be used to confirm the intraperitoneal location of the guidewire prior to exchange for a 6-French Neo-hydro catheter (Bioteque Corporation, Taiwan) for fluid infusion. Another method involves a 14- to 18-gauge Portex Tuohy epidural needle (Smiths Medical, Czech Republic) rather than an angiocatheter. This method is not well described in the literature but has been proven effective and less invasive, and is popular among our departmental interventionists. This method utilises the epidural needle's upward-curving tip to displace the liver away and allow insertion into the peritoneal cavity while avoiding puncture of the liver capsule.[3]

In hydrodissection, the target area is punctured under US guidance, usually with a 21-gauge Chiba needle (Cook Medical, Bloomington [IN], U.S.) or a 20-to-22-gauge spinal needle (Becton, Dickinson and Company, U.S.), depending on operator preference. Once the needle is perched at the intended position, 5% dextrose (D5) solution is carefully injected under USG visualisation until the desired effect is achieved.

Computed Tomography Guidance

CT-guided hydrodissection is usually performed for CT-guided percutaneous thermal ablations. In these cases, an angiocatheter or Chiba needle is inserted under CT guidance to the desired region and fluid is injected directly to the expected site. During our review period, 4.7% (n = 6) of hydrodissection procedures were performed under CT guidance, mainly for renal, adrenal and ischial bone lesion biopsies or ablation. For CT-guided ablation cases that require artificial ascites, the ascites is usually created under US guidance using the technique described in the previous section; in these cases, CT serves as an adjunct in confirming guidewire and drain catheter positioning.

Magnetic Resonance Imaging Guidance

MR-guided hydrodissection is performed when the thermal ablation is subsequently performed under MR guidance. Artificial ascites is rarely induced since most of our MR-guided ablation cases involve renal tumours. During our review period, 7.8% (n = 10) of cases received MR-guided hydrodissection.

Our department uses a designated 1.5T MR imaging machine (Siemens) for MR-guided procedures with a DORADOnova laser marking system (LAP, Germany). The procedure begins with patients undergoing a MR scan for planning. T2-weighted BLADE sequence (TR/TE 3000/116 ms, field of view 256 × 256, slice thickness 6 mm) is usually performed since most lesions are visible on this sequence and motion artefacts are reduced. The lesion is identified, and skin entry sites and pathways for hydrodissection and cryoprobe insertion are determined. Their respective coordinates and slice numbers are noted, and the skin entry sites are marked and labelled accordingly on the patient with the aid of laser marking projections. Then, a MR-compatible spinal needle (Innovative Tomography Products GmbH, Germany) is inserted to the desired area under the guidance of MR BEAT-IRTTT sequence (Siemens, Germany; TE/TR 2.2/5.35 ms, flip angle 50°, field of view 400 mm × 400 mm, reconstructed in-plane resolution 1.8 mm × 1.8 mm, slice thickness 4 mm, acquisition time per slice 1000 ms). After needle insertion, the patient is scanned again (using T2-weighted BLADE sequence) to confirm needle position. The needle is re-adjusted as needed and the patient is re-scanned until the needle tip is at the desired location. D5 solution is then injected carefully. The patient is re-scanned to ensure accurate and adequate hydrodissection.

Cryoablation accounts for more than 90% of our MR-guided ablation cases, with <1% being MR-guided microwave ablation. The choice of ablation method is largely by operator preference, but also rests on the fact that the ice-ball ablation zone in cryoablation is well depicted on MR, which ensures good coverage of the tumour. In contrast, microwave ablation zones are not as clear as on MR.

Anatomical Locations Requiring Hydrodissection

Gallbladder Fossa

Liver lesions situated in segment 5 of the liver often require hydrodissection to dissect away the gallbladder and prevent injury and cholecystitis or rupture. This is done by inserting a Chiba needle under US guidance between the gallbladder and the target lesion (Figure 1). Fluid is then injected into the gallbladder fossa under US visualisation to cushion the gallbladder from thermal injury.[4]

Duodenum

Often, lesions located at the caudate lobe, right inferior segment or left medial segment of the liver may abut the proximal duodenal loop. The duodenum can be dissected away in a similar fashion to the gallbladder (Figure 2).

Colon

Right inferior segment liver lesions and renal lesions are often adjacent to large bowel loops. Hydrodissection can be performed by inserting an angiocatheter at the pericolic space and injecting fluid under US, CT or MR guidance (Figure 3).

Through or Across Stomach

Lesions in deeper parts of the liver are often difficult to

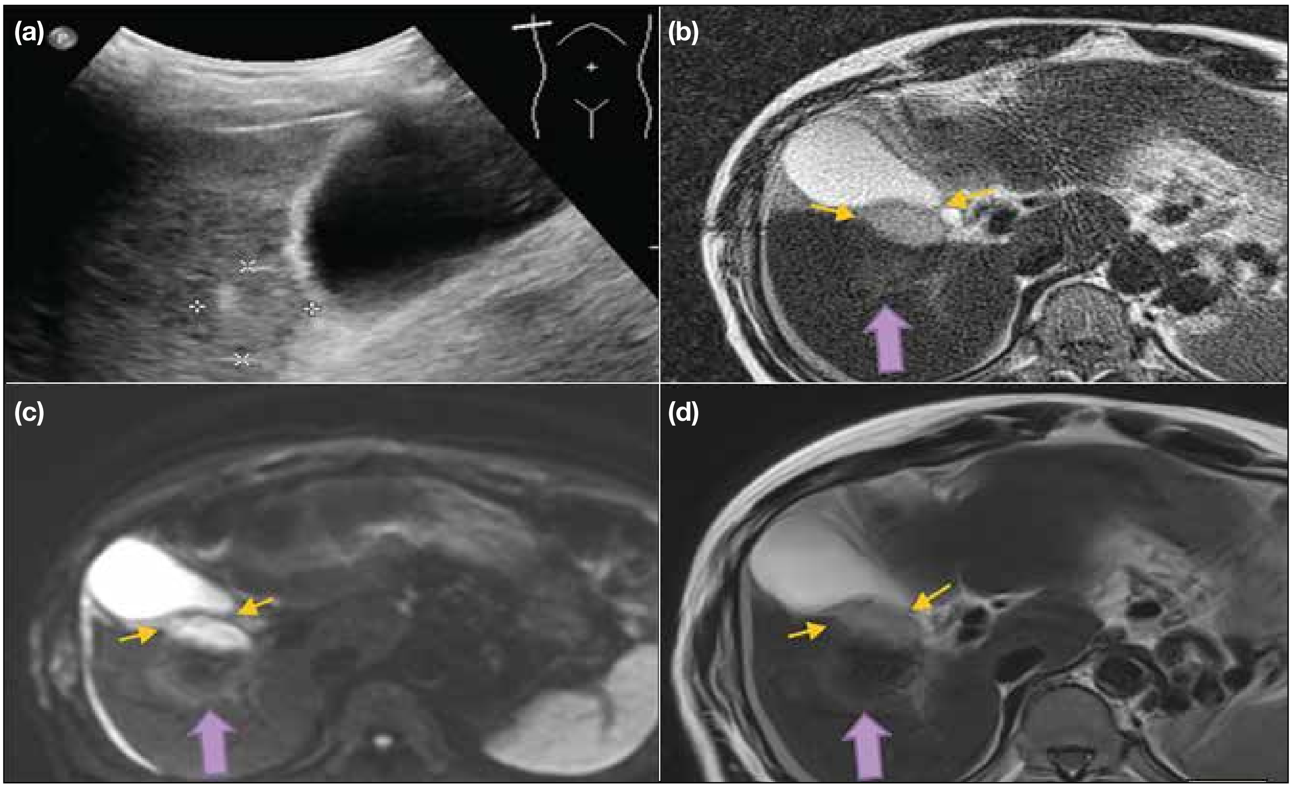

Figure 1. (a) The index lesion is only vaguely seen adjacent to the gallbladder on ultrasound (US). The operator elected to perform magnetic resonance–guided ablation. Under US guidance, the targeted pericholecystic area is punctured with a 16-gauge angiocatheter needle. (b-d) 30-mL 5% dextrose solution is instilled. T2-weighted BLADE, diffusion-weighted and T1-weighted images showing a water cushion (arrows) dissecting the gallbladder away from the target lesion (thick arrows).

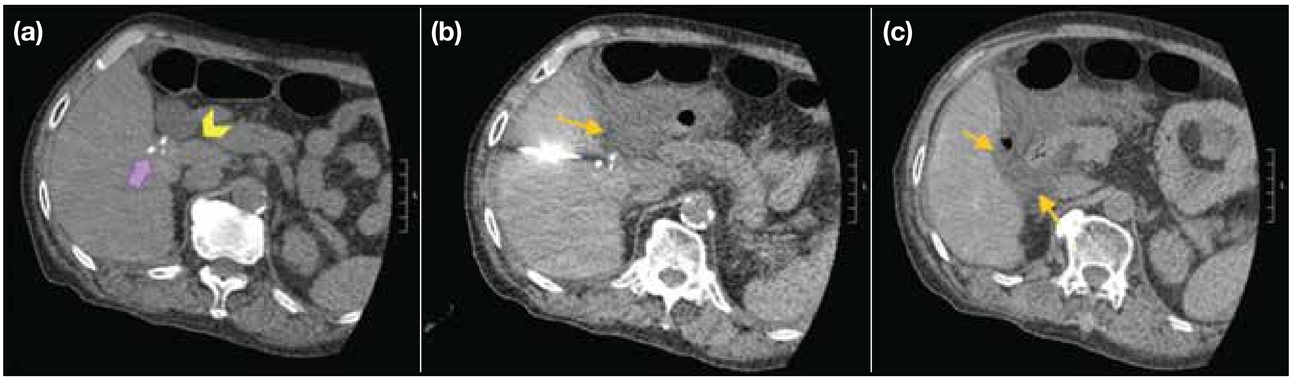

Figure 2. (a) Faint lipiodol uptake in segment 5 of the liver reveals the target lesion (thick arrow), abutting the proximal duodenum (arrowhead). (b) The ablation needle is partially seen (arrow). (c) Hydrodissection is successfully performed, pushing the loop of small bowel away from the target lesion (arrows).

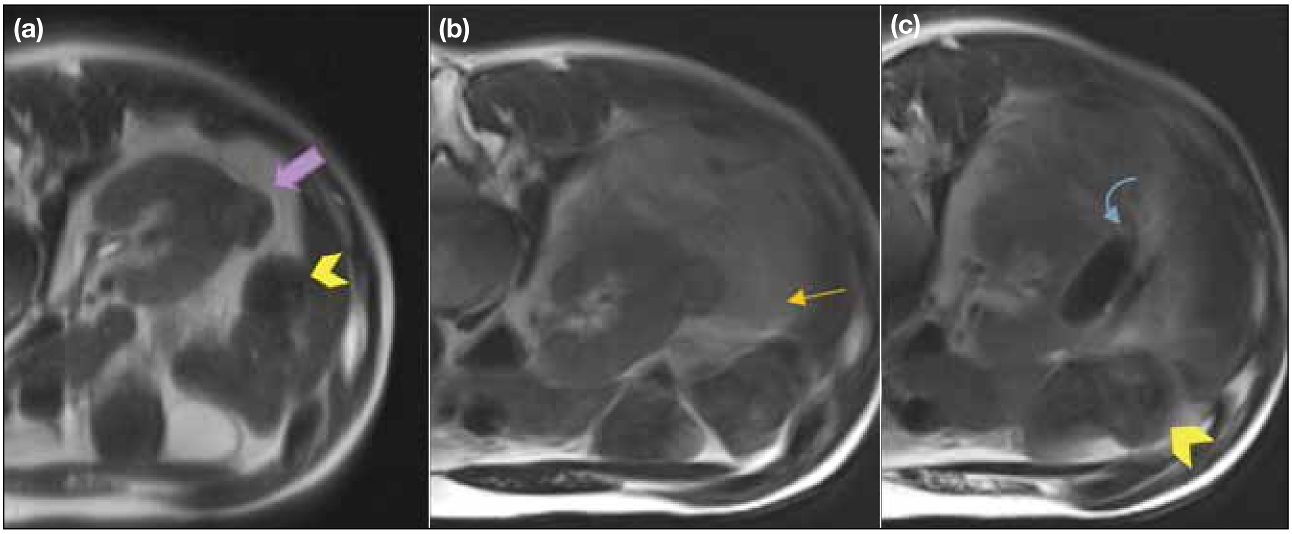

Figure 3. (a) Target lesion is seen in the right kidney (thick arrow), close to a large bowel loop (arrowhead). A 16-gauge angiocatheter is inserted into the right pararenal space and 70-mL 5% dextrose solution is injected. (b and c) Post-hydrodissection images showing fluid (arrow) successfully displacing the large bowel (arrowhead) away from the target lesion. The ice ball (curved arrow) of the cryoprobe is partially seen, successfully ablating the target lesion with no non-target ablation.

access as they are surrounded by various major organs, for example the stomach and the pancreas. In two (1.6%) of our cases during the review period, transgastric hydrodissection was performed for ablation of liver lesions in segment 3, aided by both US and CT. US-guided transgastric insertion of a 21-gauge Chiba needle into the retroperitoneal space is performed and 60- to 70-mL D5 solution is injected (Figure 4). The needle position and hydrodissection effect is confirmed with CT.

Hepatic Bare Area

Lesions can occur in the posterior liver dome and ablating these lesions may mean injuring the diaphragm and the pleura. In these cases, hydrodissection of the hepatic bare area is helpful.[5,6] One case of hydrodissection of hepatic bare area was performed during our study period. The hepatocellular carcinoma appeared as a sizable lipiodol-stained mass in the right liver dome, abutting the right hemidiaphragm. Under US guidance, the hepatic bare area was punctured with a 21-gauge Chiba needle. D5 solution was injected under USG visualisation to directly observe the desired hydrodissection effect. In this case, the hydrodissection effect was minimal despite instillation of 50-mL D5 solution. Interval CT scanning showed that the needle tip was in the correct position but that most of the fluid had flown to the peritoneal cavity. In the end,

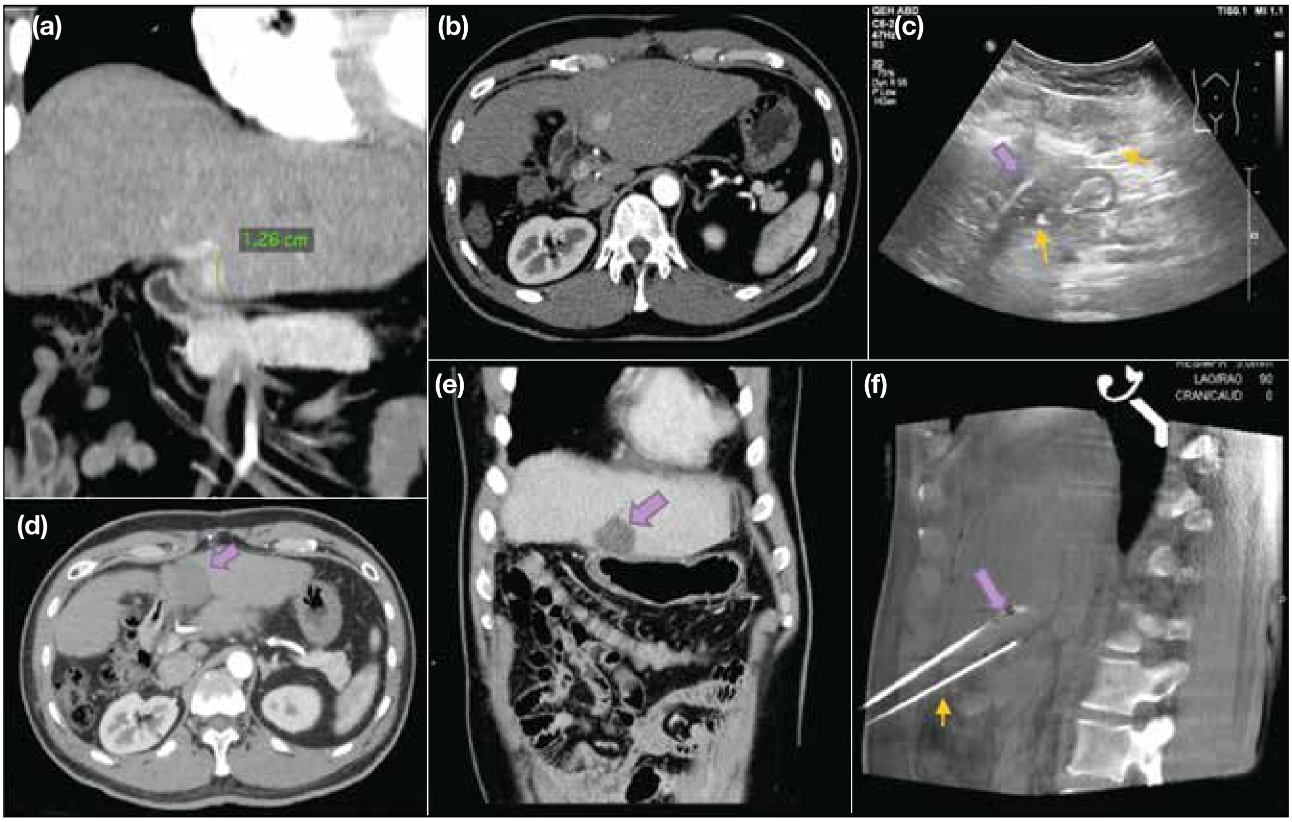

Figure 4. (a and b) Pre-ablation contrast coronal and axial computed tomography (CT) images of the liver showing the segment 3 hepatocellular carcinoma abutting the stomach. (c) Ultrasound image with ablation needle (thick arrow) within the liver lesion, and transgastric insertion of Chiba needle (arrows) into the retroperitoneal space for hydrodissection. (d and e) Post-ablation images 1 month later showing close proximity of the ablation zone (thick arrows) to the stomach and pancreas. (f) DynaCT during the ablation episode showing effective hydrodissection by the inferiorly located Chiba needle (arrow), dissecting away the stomach and pancreas, and successful puncture of target lesion by the microwave antennae (thick arrow).

200-mL D5 solution was injected with a thin layer of fluid retained at the hepatic bare area (Figure 5). The liver dome tumour was successfully ablated. Post-ablation CT showed a small ipsilateral hydropneumothorax that may have been caused by inadvertent Chiba puncture or from ablation-related minor diaphragmatic injury, and for which a 7-French Neo-hydro drain catheter (Bioteque Corporation, Taiwan) was inserted.

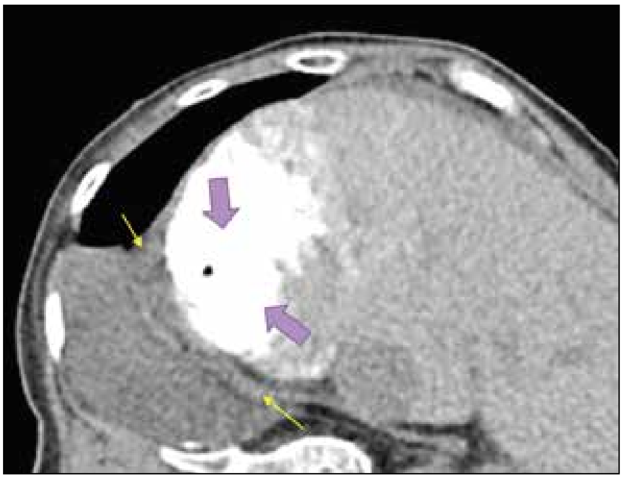

Figure 5. The index tumour in the posterior right liver dome showing avid lipiodol staining (thick arrows). The hepatic bare area is punctured with a 21-gauge Chiba needle under ultrasound guidance and 200-mL 5% dextrose solution was instilled. Only a thin layer of fluid is retained in the hepatic bare area (thin arrows). Small hydropneumothorax is seen after ablation.

Artificial Ascites and Hydrodissection Medium

D5 solution was used as a medium in most of our cases for artificial ascites or hydrodissection. This was due to the high prevalence of radiofrequency ablation cases at our centre that comprised 49.2% (n = 63) of all cases during the review period. In these cases, D5 solution was chosen for its reduced electrical conductivity compared with normal saline. In non-radiofrequency ablation cases, both D5 and normal saline solutions have been used —

these choices are operator dependent or by operator preference. In four cases (3.1%), diluted contrast was used for hydrodissection. Diluted contrast has the added advantage of providing stark contrast to adjacent intra-abdominal organs in unenhanced CT-guided procedures.

Complications

During the review period, there were 12 cases (9.4%) of failed hydrodissection. All were due to iatrogenic adhesions, mostly due to previous surgeries. In one case, ablation was still performed successfully but with possible irritation of the diaphragm causing chest and shoulder pain. There were seven cases (5.5%) of hydrodissection-related complications that included three cases of inadvertent pleural effusion, one case of pneumothorax, one case of gallbladder puncture, one case of hepatic venous injury, and one case of portal venous injury. Pleural-related complications may be due to unintentional puncture or guidewire manipulation and subsequent catheterisation of the pleural cavity, possibly due to puncture near the pleural recess, or due to passage of the guidewire through diaphragmatic fenestrations. In the same inadvertent manner, a hepatic venous branch and a portal venous branch were respectively punctured.

In the case of hepatic venous injury, the left liver lobe was punctured with a 16-gauge angiocatheter needle. Unopposed guidewire manipulation was felt so the catheter-guidewire system was thought to be in the peritoneal cavity, and a 6-French Neo-hydro drain catheter was inserted over the guidewire. Nonetheless active venous bleeding was noted from the drain catheter, and angiogram through the drain catheter under fluoroscopy showed misplacement of the drain within a hepatic vein. A 5-French BRITE TIP sheath (Cordis, Miami [FL], United States) was exchanged and the segmental hepatic vein was cannulated with a 5-French C1 catheter (Terumo Medical Corporation, Japan). This was followed by embolisation with one 12 mm × 40 cm Interlock coil, followed by 50% n-butyl cyanoacrylate glue (mixed with lipiodol) embolisation of the needle tract. No gross intra-abdominal haemorrhage was evident on postoperative US. The ablation procedure was aborted for this case and the patient subsequently referred for transarterial chemo-embolisation.

The cases of portal venous injury and inadvertent gallbladder puncture were self-limiting. Other known complications documented in the literature such as hydro-electrolytic disorders were not encountered in our case series. No cases of non-target ablations occurred during the review period.

CONCLUSION

Adequate artificial ascites and hydrodissection enable the operator to perform ablation in difficult locations by reducing the risk of non-target ablation, hence allowing ablation with an adequate margin. Hydrodissection also has the benefit of aiding access to previously difficult-to-access lesions. Additionally, hydrodissection may improve the patient's comfort during percutaneous intervention, for example reducing pain when the tumour is adjacent to the diaphragm. Further investigation into patient comfort and treatment outcomes would be worthwhile. Comparison of the efficacy of hydrodissection with other thermoprotective methods such as endoluminal cooling, pneumodissection or organ filling would also be helpful.

To conclude, artificial ascites and hydrodissection are easy, effective and economical ways to achieve thermal protection and improve lesion accessibility for ablations.

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