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TECHNICAL NOTE

Hydrodissection of the Gallbladder Bed: A Technique for Ablations Located Close to the Gallbladder

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Abstract
Objective To report the technique of hydrodissection of the gallbladder bed, in order to separate the gallbladder wall from the liver surface during microwave ablation of liver malignancies located in segment V.
Materials and Methods Between January 2018 and March 2018, percutaneous hydrodissection of the gallbladder fossa was performed during four microwave ablation procedures in three patients (One patient was treated twice for the same lesion, making a total of four procedures for three lesions.) All treated lesions were located in segment V and abutting the gallbladder. Number of hydrodissection needles, volume of hydrodissection, repartition of hydrodissection, separation of tumour from the gallbladder post-hydrodissection, technical success of hydrodissection/ablation, and complications were recorded and evaluated.
Results Hydrodissection of the gallbladder fossa was technically feasible in all four procedures, and microwave ablation was performed at maximum power without any early interruption. Time to perform hydrodissection was 11.3 min on average (range 7–18 min). Minimal distance between the ablation area and the GB increased from virtual to 10 mm on average (range 6–13), with a mean volume of dissection of 65 ml (range 40–100). Technical success was 75%. There was no complication related to the hydrodissection itself, and no acute or delayed gallbladder complication.
Conclusion Hydrodissection of the gallbladder bed is a feasible technique to separate the gallbladder from the liver surface. This could potentially decrease the risk of thermal injuries to the gallbladder wall when ablating tumours located in segment V.

Keywords Hydrodissection · Gallbladder · Liver ablation

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Introduction

Percutaneous thermal ablation of liver malignancies abutting the gallbladder is a source of controversy. Some authors claim that the procedure can be safely performed with limited risk [1–3], while others argue that the risk of complications is not negligible [4, 5]. Complications, ranging from thermal cholecystitis to gallbladder perforation, have been described both in animal models and clinical reports [1, 6, 7]. For safety purposes, protection should therefore always be considered and may include pre-interventional cholecystectomy, gallbladder emptying, gallbladder cooling, or temperature monitoring [4, 8–10]. However, most of these techniques are either complex or with limited clinical application. We herein describe a technique to hydrodissect the gallbladder bed in order to physically separate the gallbladder from the liver parenchyma in its bare area.

Materials and Methods

This single-centre retrospective observational study was conducted with written informed patient consent for all procedures, and institutional review board-approved waiver of consent to participate in the study.

Study Population

Between January and March 2018, three patients (all male; mean age 80 years, range 78–81 years) with segment V liver metastases underwent four percutaneous microwave ablation (MWA) procedures with adjunctive gallbladder hydrodissection. In all cases, treated metastases abutted the gallbladder without intervening normal hepatic parenchyma, and the expected ablation zone partially encompassed the gallbladder. Patients and lesions characteristics are summarised in Table 1.

Procedures

All procedures were performed under general anaesthesia with the patient in supine position, using combined ultrasound and CT guidance (Infinix-I 4DCT, Canon Medical Systems, Japan). Anticoagulants were stopped 5 days and blood clotting parameters tested 24 h pre-procedure, ensuring minimum prothrombin time of 50% and platelet count of 50,000/mm^3. Between one and three microwave antennae were initially positioned within the target lesion in order to ensure complete lesion coverage with a minimum 5 mm ablation margin (Table 1).

Hydrodissection of the Gallbladder Fossa

Hydrodissection was performed using 22G spinal needles (Becton Dickinson, Franklin Lakes, USA) and a 5% solution of iodinated contrast (Visipaque, GE Healthcare, Little Chalfont, UK; 270 mg I/ml) in 0.9% saline to optimise CT visibility of the injected fluid [11]. A 22G spinal needle was advanced towards the hepatic hilum using a lateral transhepatic approach, targeting the lateral aspect of the inferior peri-hilar fat just superior to the gallbladder infundibulum (Fig. 1B). Five microlitres of hydrodissection fluid was initially injected, and appropriate fluid distribution (confined to the lateral portion of the supra-infundibular hilar fat space) was confirmed on subsequent CT imaging (Fig. 1D). A further 40–100 ml of hydrodissection fluid was then injected under intermittent CT guidance until the gallbladder was separated by one centimetre from the ablation zone (Fig. 1E, F). In cases where

Table 1 Patient, lesion, and ablation characteristics

	Patient 1		Patient 2	Patient 3
Age	78		80	81
Sex	Male		Male	Male
Tumour histology	Bellini duct carcinoma		Colon cancer	Clear cell renal carcinoma
Lesion localisation	Segment V		Segment V	Segment V
Lesion size (mm)	30		7	20
Previous liver surgery	No		No	No
Previous history of cholecystitis	No		No	No
Other liver metastases	No		No	Yes, segment VII
Other distant metastases	No		No	No
	Procedure 1	Procedure 2	Procedure 3	Procedure 4
MWA device	Emprint, medtronic	Neuwave, ethicon	Emprint, medtronic	Emprint, medtronic
Number of MW antennas	2	3	1	1
Number of MW generators	2	1	1	1
Ablation protocol	100 W–10 min	65 W–10 min	100 W–10 min	100 W–10 min

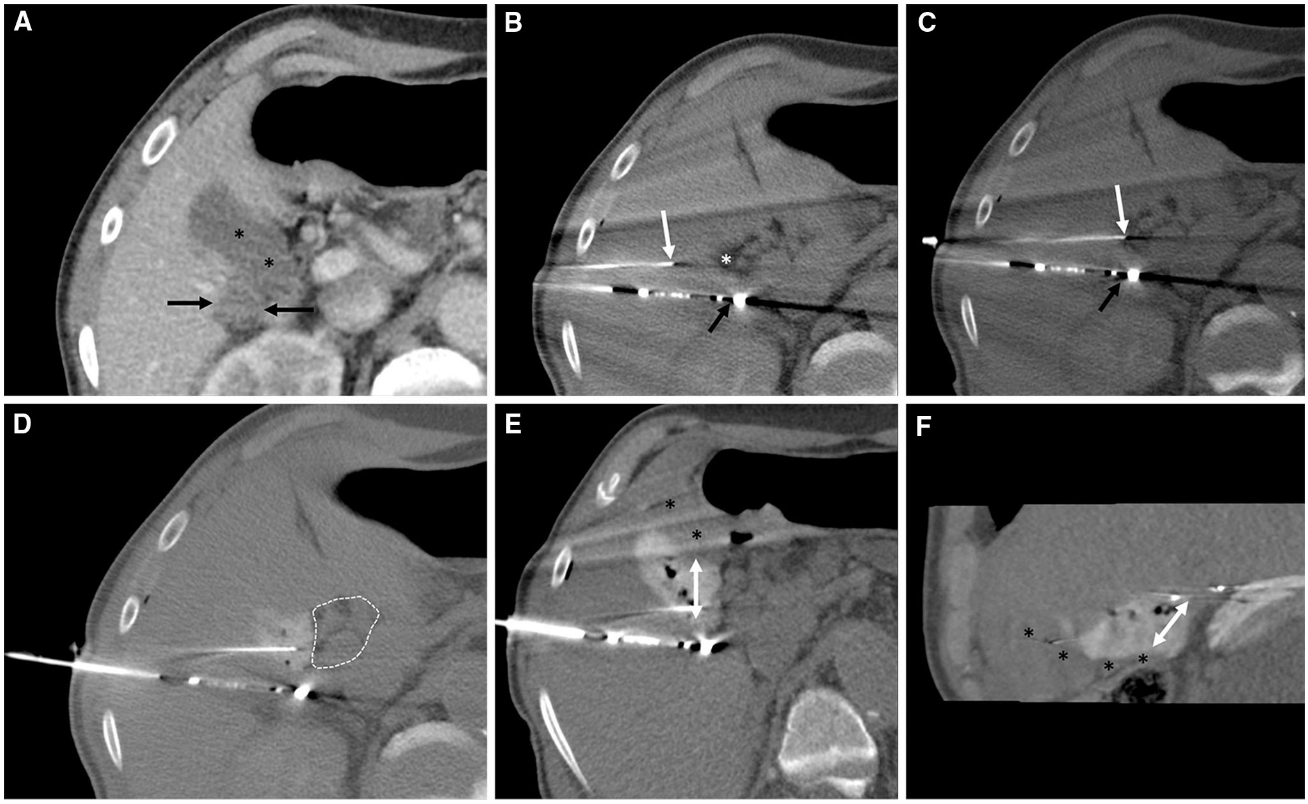

Fig. 1 Technique of gallbladder hydrodissection (patient 3; procedure 4). **A** pre-procedural axial contrast-enhanced CT image shows a metastasis (black arrows) abutting the posterior gallbladder neck (black asterisks). **B**, **C** Following the initial MW antenna insertion (black arrow), a 22G spinal needle (white arrow) was advanced into the lateral aspect of the hepatic hilar fat, just superior to the gallbladder infundibulum (white asterisk in **B**) using a transhepatic approach. After the initial injection of 5 ml to confirm position, a total of 60 ml hydrodissection fluid was injected to separate the gallbladder from the inferior hepatic surface. **D** Axial CT image demonstrates appropriate distribution of hydrodissection fluid in the gallbladder fossa. Note the absence of fluid diffusion into the porta hepatis (dotted area). **E**, **F** Axial and sagittal CT images illustrate excellent separation (double arrow) between the ablation zone and gallbladder (black asterisks)

the initial fluid distribution was inadequate, the needle-tip position was carefully advanced and further hydrodissection fluid was injected under intermittent CT guidance until appropriate distribution was observed. If the initial manipulation was unsuccessful, an additional spinal needle was inserted using an anterior transhepatic approach into the portion of the inferior hilar fat space devoid of injected fluid, superior to the gallbladder infundibulum, in order to access the correct dissection plane (Fig. 2).

Microwave ablation was then performed according to manufacturer protocol (Table 1). Following track cauterisation, MW probes and spinal needles were withdrawn and skin incisions were dressed. Patients were transferred to a recovery ward and discharged when medically fit, according to institutional protocol.

Follow-Up

Clinical examination (including assessment of post-procedural pain on visual analogue scale) and MR liver were performed after 24 h. Patients were systematically followed up by the referring physician after 1 month with repeat MR liver.

Data Collection and Analysis

For each procedure, the following data were collected using retrospective chart review: number of spinal needles required to perform hydrodissection; total injected fluid volume; minimum distance between inner border of tumour and gallbladder following dissection [measured on multi-planar reformatted (MPR) images]; complete vs. incomplete dissection of the bare area of gallbladder (assessed on MPR images); and time required to perform hydrodissection. Pain score 24 h post-procedure (according to visual analogue scale); general complications related to hydrodissection and/or ablation; specific gallbladder complications (perforation or cholecystitis) within 30 days post-procedure; and the presence of residual fluid on follow-up MR at 24 h and 1 month were also evaluated. Technical success was defined as complete hydrodissection of interface between tumour and gallbladder with

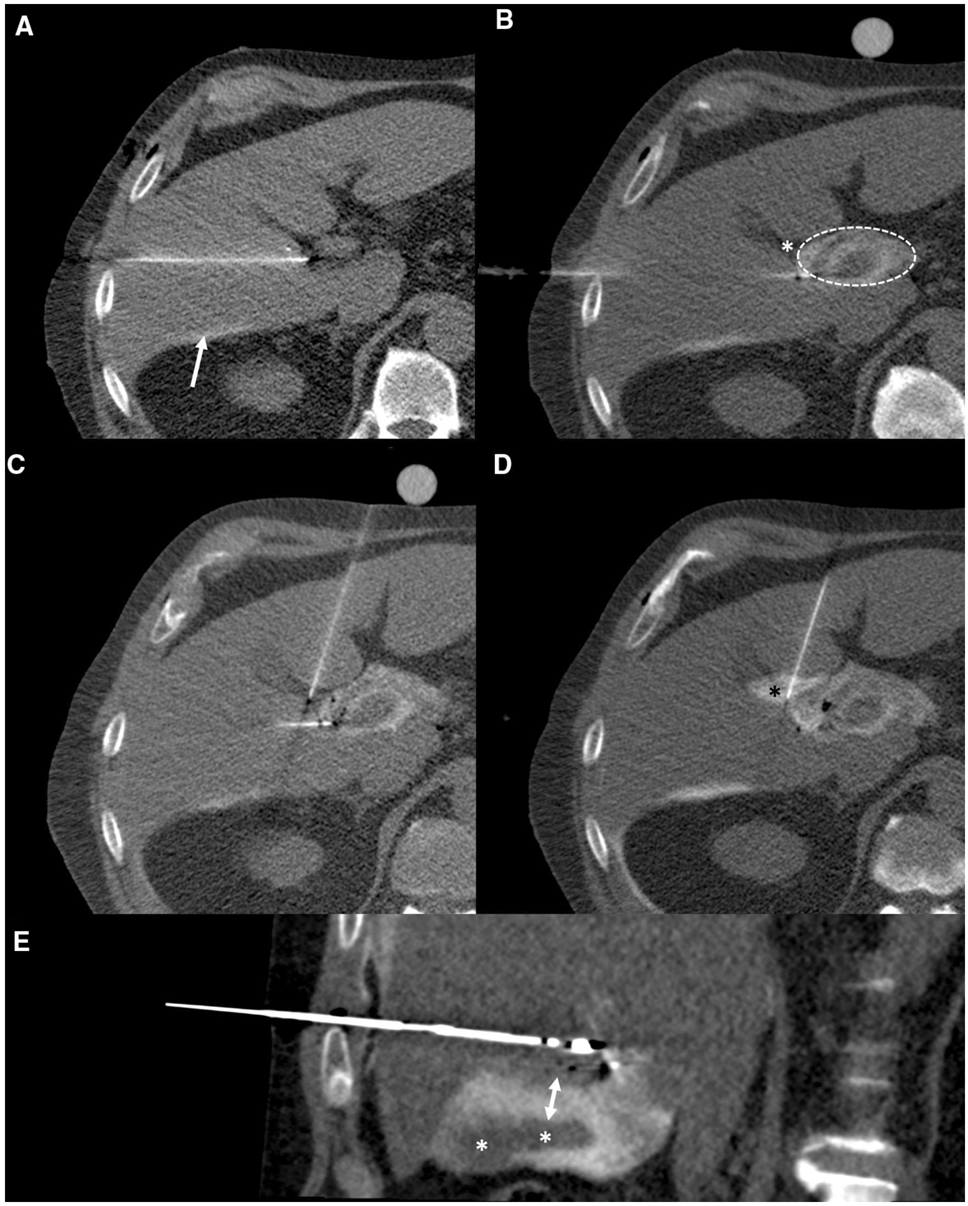

Fig. 2 Technique of gallbladder hydrodissection failed the initial dissection (patient 2; procedure 3). **A** Axial unenhanced CT image demonstrating the initial lateral transhepatic placement of a 22G spinal needle into the inferomedial hepatic hilar fat, at the level of the gallbladder fossa. Following test injection, hydrodissection fluid diffused away from the injection site, along the posterior hepatic surface (arrow), consistent with incorrect needle-tip position. **B** After advancing the needle a few millimetres, further injected hydrodissection fluid spread within the porta hepatis (dotted circle), but did not opacify the gallbladder fossa fat (white asterisk). **C**, **D** A second 22G spinal needle was advanced via an anterior transhepatic approach, and the needle tip positioned more medially and anterior, in the superior gallbladder fossa. Injected hydrodissection fluid now opacified the gallbladder fossa (black asterisk in **D**). **E** Sagittal oblique CT image illustrates achievement of a satisfactory 10 mm safety distance between the ablation zone and gallbladder (white asterisks)

separation of at least one centimetre, and completion of the full ablation protocol. Local oncological outcomes were also recorded, based on the results of follow-up contrast-enhanced MRI.

Descriptive statistics were tabulated using Microsoft Excel (Microsoft Corporation, Redmond, WA).

Results

Hydrodissection of the gallbladder fossa was technically feasible in all four procedures, and microwave ablation was performed at maximum power without interruption. Average minimum distance between the ablation zone margin and gallbladder wall increased from virtually zero to 10 mm (range 6–13 mm). Technical success was therefore 75%. (In patient 1–procedure 1, the distance between gallbladder and lesion was inferior to 10 mm, but ablation was still conducted at maximum power without interruption.) The non-peritonealised surface of the gallbladder was completely dissected in 50% of cases, and incompletely dissected (caudally) in 50%. Meantime to perform hydrodissection was 11.3 min (range 7–18 min), using a mean of 1.5 spinal needles (range 1–2) and 65 ml (range 40–100 ml) hydrodissection fluid (Fig. 3). There were no complications related to hydrodissection. No acute or delayed gallbladder complications were observed. Post-procedural pain was mild (VAS 0–3/10) and clinically not typical for cholecystitis, and there was no gallbladder abnormality on follow-up MRI at 24 h or 1 month. Primary and secondary technical efficacy was 75% and 100%, respectively. The incomplete treatment following the first ablation in patient 1 was not related to the limited gain of distance following hydrodissection (6 mm), but to mistargeting of the lesion that was ablated too posteriorly. One patient (patient 3) developed a liver abscess after 2 months; however, this was around a concurrently ablated segment VII lesion and was deemed unrelated. All patients completed the 9-month follow-up, without signs of local recurrence. One patient (patient 1) developed a new distant liver metastasis in segment IVa. Detailed results are presented in Table 2.

Discussion

Anatomically, the gallbladder has an inferior peritoneal surface, also called the free gallbladder, and a superior liver surface that does not include a serosa, known as the bare area of the gallbladder [12]. Artificial ascites can therefore offer a theoretical effective thermal protection if a lesion is abutting the peritoneal surface of the gallbladder, but not in case of vicinity with the liver surface [13]. The limit of the serosal reflexion cannot be assessed precisely with imaging. Hence, a transhepatic puncture does not preclude an intraperitoneal location of the needle in between the liver and the gallbladder [14]. To date, there is only scarce literature reporting hydrodissection of the gallbladder [8, 15]. Besides, the papers focus more on how to empty the gallbladder than on the precise description of the technique of hydrodissection [8, 15].

Our technique allowed to hydrodissect the gallbladder fossa in all cases. As the gallbladder bed is a closed anatomical space, the fluid does not spread away from the injection site (like in the peritoneum), and therefore, minimal amount of hydrodissection is required to achieve a significant safety distance, without the need to maintain injection during the ablation phase. It is however not possible to claim the reproducibility of the technique in case of post-therapeutic or post-inflammatory adhesions (cholecystitis).

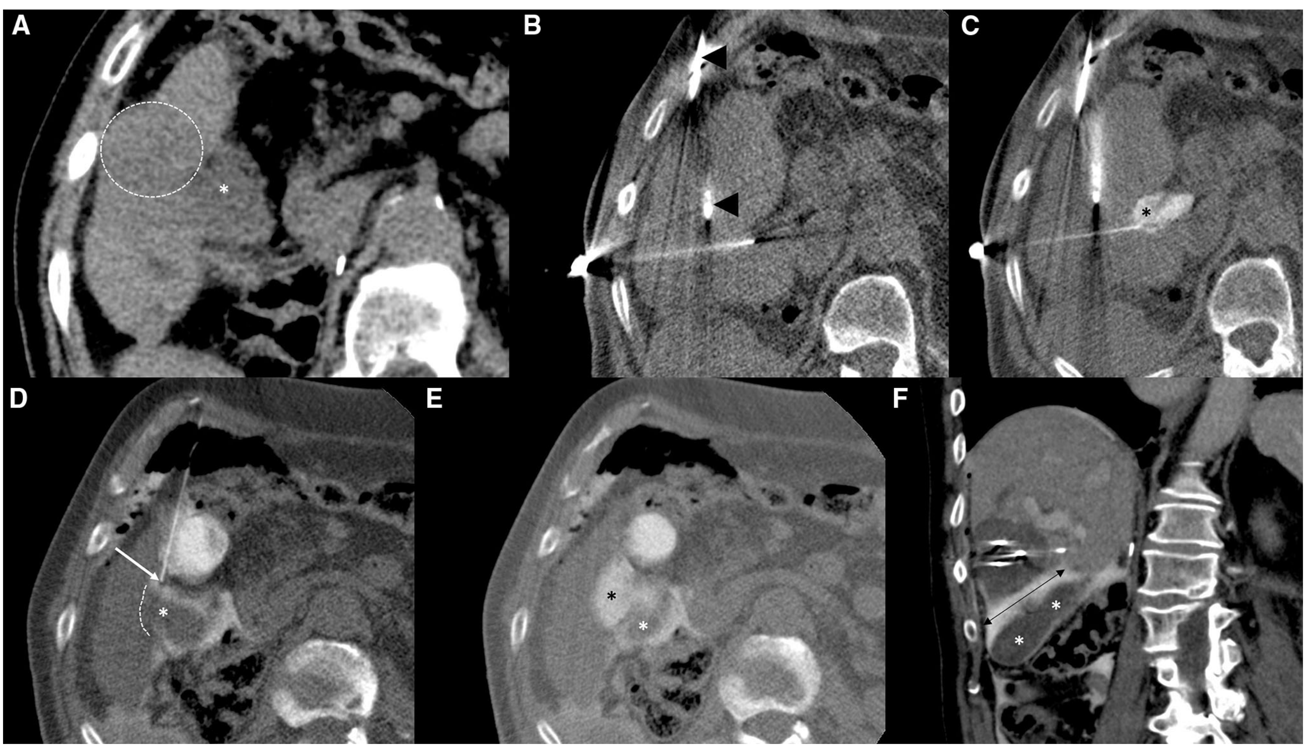

Fig. 3 Complete hydrodissection of the gallbladder bed (patient 1; procedure 2). **A** Unenhanced planning axial CT image illustrates a 30 mm metastasis (dotted circle) in contact with the superolateral gallbladder (white asterisk). **B**, **C** Following insertion of three MW antennae (arrowheads in **B**), A 22G spinal needle was positioned in the gallbladder fossa fat, superior to the infundibulum. Distribution of hydrodissection fluid appeared satisfactory, confined to the gallbladder fossa (black asterisk in **C**). **D** However, more caudal CT image demonstrates ongoing contact between the gallbladder fundus (white asterisk) and inferior hepatic surface adjacent to the tumour (dotted line). A second 22G spinal needle was positioned in the partially hydrodissected inferior portion of the gallbladder fossa (arrow). **E** Following injection of an additional 40 ml of fluid (black asterisk), the fundus of the gallbladder (white asterisk) was completely separated from the liver surface. **F** Coronal oblique CT image after completion of ablation (with MW antennae in situ) demonstrates complete separation (double black arrow) of the gallbladder (white asterisks) from the hepatic ablation zone surrounding the antennae, avoiding unintended collateral thermal injury. 24-h follow-up MRI (not shown) showed complete resorption of hydrodissection fluid

Table 2 Technical details and outcomes of hydrodissection of the gallbladder fossa

	Patient 1		Patient 2	Patient 3
	Procedure 1	Procedure 2	Procedure 3	Procedure 4
Number of needles for HD	1	2	2	1
Volume of HD (ml)	40	100	60	60
Minimum distance between tumour and GB post-HD (mm)	6	10	10	13
Extent of HD of GB fossa	Complete (minimal dissection of caudal portion)	Complete	Complete	Incomplete (caudal portion still abutting liver, but remote from ablation zone)
Opacification of the hilum of the liver	No	No	Yes (first HD needle not positioned accurately)	No
Time to perform HD (min)	8	12	18	7
Pain score 24 h after intervention	0/10	1/10	2/10	3/10
Complications related to HD	No	No	No	No
GB complications (< 30 days)	No	No	No	No
Other complications	No	No	No	Liver abscess 2 months after ablation related to a second ablated lesion
Residual fluid at 24-h MRI FU	No	No	No	Minimal (< 5 ml)
Complete ablation at 1-month MRI FU	No ≥ procedure 2	Yes	Yes	Yes
Local recurrence at 9-month MRI FU	–	No	No	No
New liver metastases at 9-month MRI FU	–	Yes (segment IVa)	No	No

HD hydrodissection, *GB* gallbladder, and *FU* follow-up)

As stated previously, the major question that remains truly unanswered is whether or not the gallbladder does need thermal protection. Many radiologists are still concerned when treating a tumour abutting the gallbladder, and therefore decrease the power of ablation [10, 16]. While mitigating the risk of thermal injury, this approach might lead to suboptimal oncological results. In our small series, hydrodissection of the gallbladder bed allowed us to proceed to microwave ablation at maximal power, while limiting as much as possible the risk of local complications. Hydrodissection of the gallbladder bed therefore seems to be an interesting and effective additional tool in case of thermal ablation of a lesion abutting the gallbladder.

Compliance with Ethical Standards

Conflict of interest Julien Garnon and Afshin Gangi received fees for oral presentations for Canon Medical. All the other authors declare that they have no conflict of interest.

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