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TECHNICAL NOTE

Percutaneous Intraductal Radiofrequency Ablation for Clearance of Occluded Metal Stent in Malignant Biliary Obstruction: Feasibility and Early Results

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Abstract
Purpose The major complication occurring with biliary stents is stent occlusion, frequently seen because of tumour in-growth, epithelial hyperplasia, and sludge deposits, resulting in recurrent jaundice and cholangitis. We report a prospective study with the results of first in man percutaneous intraductal radiofrequency (RF) ablation to clear the blocked metal stents in patients with malignant biliary obstruction using a novel bipolar RF catheter.
Methods Nine patients with malignant biliary obstruction and blocked metal stents were included. These patients underwent intraductal biliary RF ablation through the blocked metal stent following external biliary decompression with an internal–external biliary drainage.
Results All nine patients had their stent patency restored successfully without the use of secondary stents. Following this intervention, there was no 30-day mortality, haemorrhage, bile duct perforation, bile leak, or pancreatitis. Of the nine patients, six are alive and three patients are dead with a median follow-up of 122 (range 50–488) days and a median stent patency of 102.5 (range 50–321) days. Six patients had their stent patent at the time of last follow-up or death. Three patients with stent blockage at 321, 290, and 65 days postprocedure underwent percutaneous transhepatic drain insertion and repeat ablation.
Conclusions In this selective group of patients, it appears that this new approach is safe and feasible. Efficacy remains to be proven in future, randomized, prospective studies.

Keywords Interventional oncology · Radiofrequency ablation · Bile duct/gallbladder/biliary · Liver/hepatic · Pancreas · Cancer · Stenosis/restenosis · Tumour/neoplasm

Introduction

Endoscopic retrograde cholangiopancreatography or percutaneous transhepatic cholangiodrainage with stent placement has been documented to be an effective and widely accepted palliation of malignant biliary obstruction [1]. The major complication occurring with biliary stents is stent occlusion, resulting in recurrent jaundice and cholangitis. Occlusion of the stent is frequently seen because

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of tumour in-growth, epithelial hyperplasia, and sludge deposits. In order to increase the duration of stent patency and exert local tumour destruction, the Habib^{TM} Percutaneous Endobiliary Radiofrequency (Habib^{TM} PERF) catheter (EMcision Ltd, London, UK), has been developed for malignant biliary obstruction. Previous clinical studies have shown the safety and efficacy of this novel radiofrequency (RF) ablation catheter when used for endoscopic palliative procedures [2, 3]. Kahaleh and colleagues [4] showed that endoscopic RF ablation increased significantly the diameter of malignant biliary strictures. The catheter also has been used successfully with the percutaneous approach for intraductal ablation in patients with malignant biliary obstruction following biliary decompression [5].

Current standard of care for patients with obstructed primary metal biliary stents requiring percutaneous intervention is insertion of internal external drain through the blocked segment of the stent followed by insertion of a second stent through the primary occluded stent [6]. Insertion of the secondary stent in select cases is preceded by balloon dilatation of the blocked segment. We report a first in man prospective study of using the percutaneous approach with the Habib^{TM} PERF catheter to clear blocked metal stents in patients with malignant biliary obstruction. This study reports safety and feasibility of this technique in clearing blocked metal biliary stents.

Patients and Methods

Nine patients with malignant biliary obstructions and blocked metal stents were recruited to this study, which had ethical committee approval. These patients underwent RF ablation inside their stents without placement of a new metal stent. None of these nine patients had previous RF ablation of their malignant biliary strictures. These patients had inoperable malignant biliary strictures and blocked metal stents with histological or cytological diagnosis of cancer. Patients with uncorrected coagulopathy, cardiac pacemaker, and inability to insert guidewire across stricture were excluded from the study. Following an informed consent, all patients were investigated with blood tests: haematological, biochemical, tumour markers, WHO performance status, as well as radiological investigation, including CT scan and ultrasound scans.

Patient Characteristics

There were seven males and two females. The median age was 72 (range, 39–78) years. The diagnosis included: six cholangiocarcinoma (Bismuth classification: Type I, 1; Type II, 1; Type IIIb, 1; Type IV, 3), two pancreatic cancer, and one had metastatic invasion (Table 1).

Table 1 Patient characteristics

Total number of patients	9
Age (median), year	72 (39–78)
Male:female	7:2
Diagnosis	
Cholangiocarcinoma	6
Bismuth type	
I	1
II	1
IIIB	1
IV	3
Pancreatic adenocarcinoma	2
Metastatic disease	1

Device

Radiofrequency ablation was performed with a CE-approved percutaneous radiofrequency ablation catheter (Habib^{TM} PERF catheter, EMcision Limited, London, UK), which is connected to a compatible RF generator. The Habib^{TM} PERF catheter has European Conformity approval. The Habib^{TM} PERF catheter is a single-use, disposable, bipolar, 8F catheter with a working length of 90 cm that can be inserted using the percutaneous route for coagulation and ablation of tissue and passes over a 0.035-inch guidewire. RF power is applied to electrodes at the tip of the catheter so that heat is applied to tissue surrounding the catheter. The device comprises a catheter with two contact electrodes 8-mm apart with the distal electrode 5 mm from the leading edge, providing local a cylindrical coagulation/ablation over a 2.5-cm length (Fig. 1).

Intervention

Radiofrequency Ablation for Clearance of Obstructed Metal Stents

Using a guidewire technique, the Habib^{TM} PERF catheter was placed such that the device's working tip was positioned in the area of the occlusion. 10 W of RF energy was applied for 2 min using a RF generator (1500 generator; RITA Medical Systems Incorporation, Fremont, CA, USA). Depending on the length of the stricture, sequential applications of RF ablation treatment were applied to ensure to the whole length of the stricture with an overlap of treated areas of approximately 1 cm. The Habib^{TM} PERF

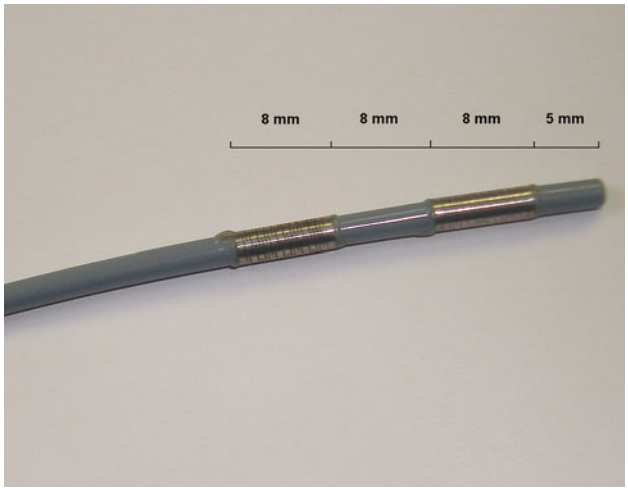

Fig. 1 Close up of the Habib™ Percutaneous Endobiliary Radiofrequency (Habib™ PERF) catheters showing the two spiral cut electrodes, 8-mm spacing, with the distal electrode 5 mm from the tip

catheter was removed and balloon ductoplasty was performed, followed by half-inflated balloon movement back and forth through the stent into the duodenum to remove ablated tissue and debris from the metal stent. The procedure was terminated with percutaneous transhepatic cholangiography catheter repositioning distal to the biliary stricture. Cholangiography was performed to document achieved patency, to wash out the debris, and to assess the biliary tree (Fig. 2).

Follow-up

Patients were followed up every 2 weeks for 1 month and thereafter as per the oncology follow-up protocol. Patients had clinical examination, liver function tests, and ultrasound scans to rule out cholangitis or biliary obstruction. Data are presented as mean ± standard deviations of the mean or median with range.

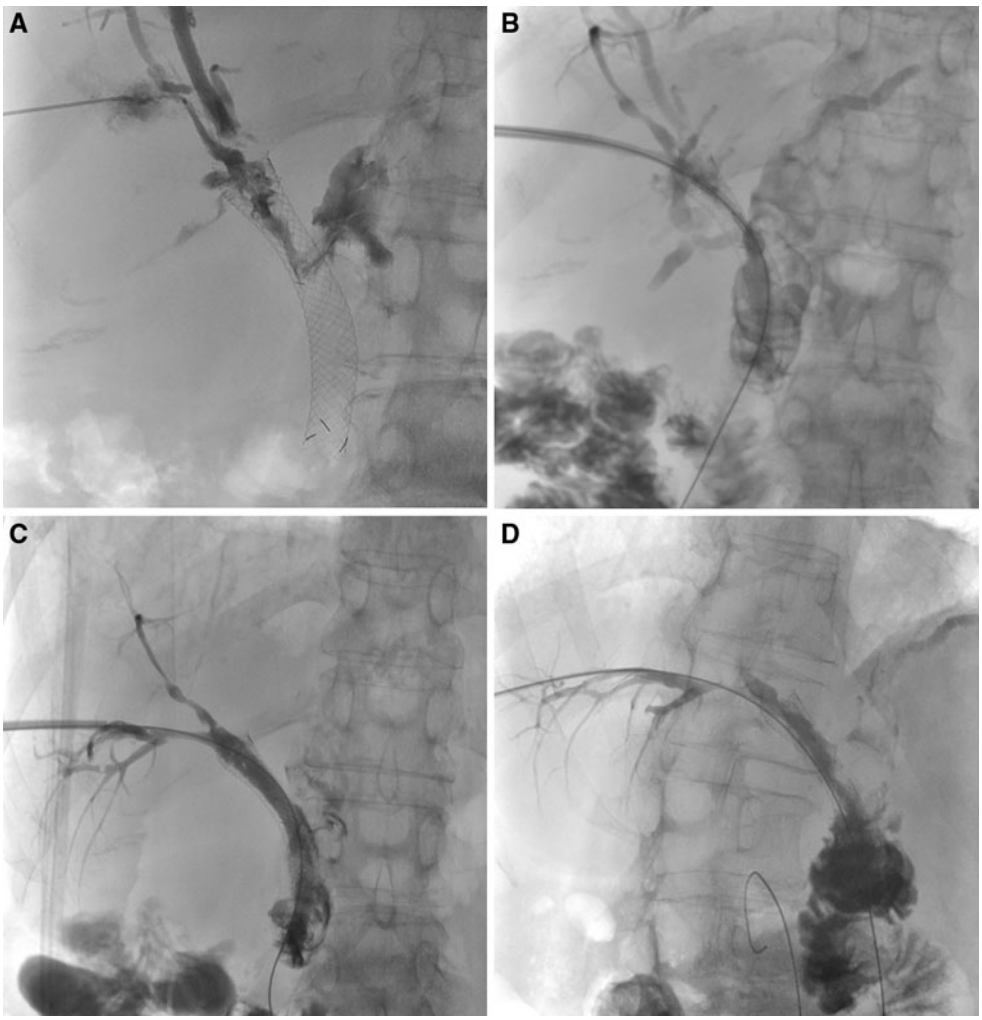

Fig. 2 **A** Preablation cholangiogram shows stent blockage. **B** Cholangiogram shows radiofrequency ablation with the Habib™ Percutaneous Endobiliary Radiofrequency (Habib™ PERF) inside the blocked stent. **C**, **D** Postablation cholangiogram shows patent stent

Table 2 Procedure details

Length of stricture (cm)	5.2 ± 1.6
Number of ablations	2 (1–3)
Duration of ablation (min)	6 (2–20)
Ablation energy (W)	10 (10–20)
Preablation diameter (mm)	1.6 (0–4)
Postablation diameter (mm)	8 (3–10)
Preablation bilirubin (μmol/L)	109 ± 43
Postablation bilirubin (μmol/L)	60 ± 27

Data are median (range) or mean ± SD

Results

Procedure Details

Percutaneous RF ablation and clearance of blocked metal stent was achieved in all nine cases without the use of secondary stent. The mean length of the metal stent obstruction was 5.2 (standard deviation ± 1.6) cm and the median pre ablation luminal diameter was 1.6 (range, 0–4) mm. The median number of application of the RF catheter was 2 (range, 1–3), whereas the median duration of each ablation was 6 (range, 2–20) min. The used ablation energy ranged from 10 to 20 (median 10) W. The median postablation luminal diameter was 8 (range, 3–10) mm (Table 2). The postablation bilirubin [mean (±SD)] was 60 (±27) μmol/L reduced from preablation levels of 109 (±43) μmol/L. The remaining biochemical parameters largely remained unchanged. The biliary drains were kept in situ for a median of 3 (range, 2–5) days. The cost of the percutaneous Habib™ Endobiliary RF ablation catheter is 500€. The median inpatient stay for the procedure was 4 (range, 2–6) days.

Follow-up and Stent Patency

There was no 30-day or hospital mortality after the application of percutaneous intraductal RF ablation to clear the blocked stent. No haemorrhage, bile duct perforation, bile leak, or pancreatitis was observed after the RF ablation procedure. Of the nine patients, six are alive and three patients are dead with a median follow-up of 122 (range, 50–488) days and a median stent patency of 102.5 (range, 50–321) days (Fig. 3). Six patients had their stent patent at the time of last follow-up or death. Three patients with stent blockage at 321, 290, and 65 days postprocedure underwent percutaneous transhepatic drain insertion and repeat ablation. Of the three patients with stent blockage, two had cholangiocarcinoma (type IIIB and type IV) and one had pancreatic adenocarcinoma. The postablation diameter achieved from the first RF ablation in these patients was 8 mm in two patients and 7 mm in the third patient. Among the patients who died ($n = 3$), the median stent patency was 71 (range, 50–184) days whilst the patients who are alive ($n = 6$) had a median stent patency of 141 (range, 50–321) days.

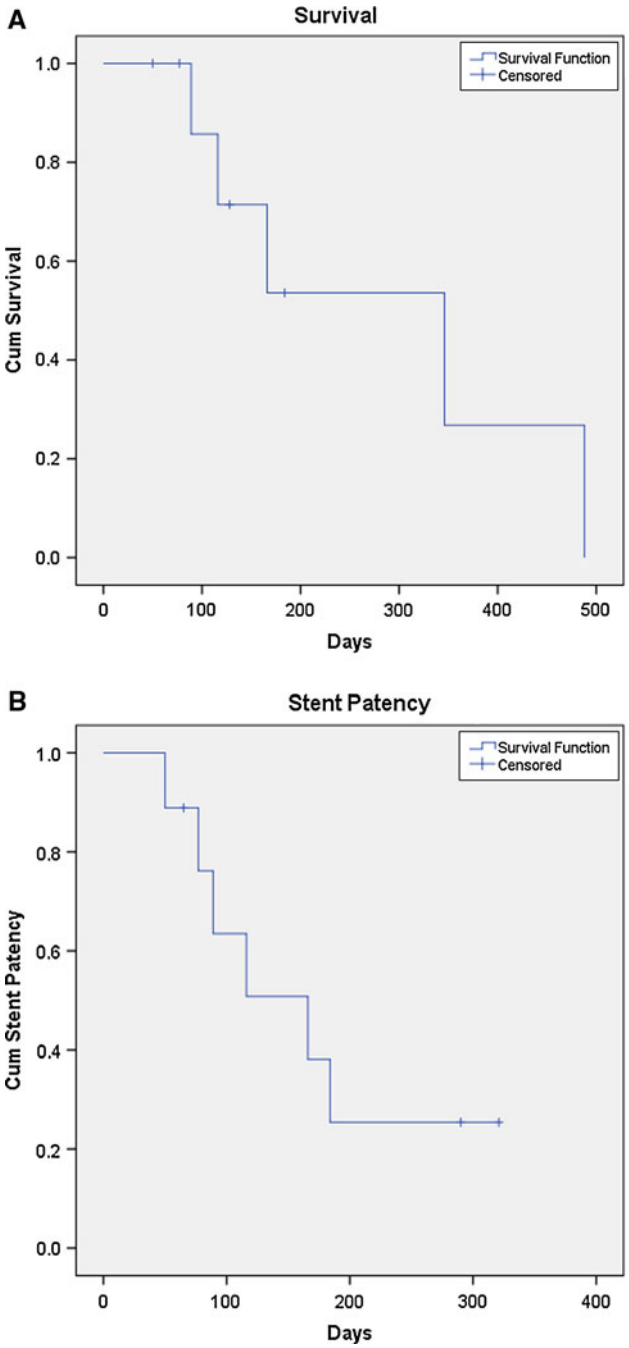

Fig. 3 **A** Survival trends postprocedure. **B** Stent patency postprocedure

Discussion

The use of self-expandable metal stents (SEMSs) in unresectable malignant obstruction has become the standard

technique if the patient's life expectancy is longer than 3 months [7, 8]. Tumour in growth, epithelial hyperplasia, biofilm deposition, and sludge limits median SEMS patency to 120 days [9]. Stent blockage resulting in biliary obstruction is associated with significant morbidity and mortality [10–13]. Despite attempts to find a potential solution to problem of SEMS occlusion, including the use of covered stents, different stent designs, and endobiliary photodynamic therapy, little progress has been made in terms of improving the duration of stent patency [14, 15]. To avoid tumour ingrowth, improve stent performance, and offer a palliative method allowing fewer reinterventions for the oncologic patients, covered metallic stents have been developed in the past 10 years, using various coverage materials [16–21]. Although initial data on the efficacy of the covered stents were controversial [16–18], recent studies have shown more promising results [22]. The disadvantages of covered stent are dysfunction due to sludge formation and tumour over growth at the ends. There also is risk of pancreatitis in stents placed at the distal bile duct due to obstruction to pancreatic ducts. The covered stents also are more prone to migration or dislocation as reported in some studies [23, 24]. With the increasing use of covered metallic stents for malignant distal biliary obstruction, tumour overgrowth, rather than ingrowth, is expected to become a more common cause of stent occlusion [15]. However, covered metallic stents are unlikely to uniformly replace bare metal stents, especially for cases of malignant hilar obstruction. The current management of occluded SEMS includes a second stent insertion (covered SEMS, uncovered SEMS or plastic stent) through an endoscopic or percutaneous approach and mechanical cleaning [6]. Mechanical cleaning with a balloon is less effective in a patient with concomitant tumor in growth [6].

RF ablation has been used for percutaneous and intraoperative delivery of heat energy, achieving localized tumor necrosis in primary and secondary hepatic cancers [25–27]. The Habib^{TM} PERF catheter takes advantage of the RF thermal effect as a means to locally destroy the malignant biliary stricture by delivering low RF energy from two electrodes to ensure the energy is evenly spread over a large volume. The local coagulative necrosis caused by RF ablation has the potential to delay tumour growth and may prolong the duration of stent patency. Furthermore, for obstruction of previously deployed metal stent, which cannot be removed, this RF approach can clear the occlusion and restore the biliary flow without the insertion of a new stent inside the obstructed stent thereby saving on the cost of a second stent (approximately 2000€) at an additional cost of only 500€ for the catheter.

The Habib^{TM} PERF catheter can be deployed via an endoscopic retrograde cholangiopancreatography (ERCP) or percutaneous transhepatic cholangiographic (PTC) route. In a recently published pilot study of 22 patients, the authors demonstrated safety and 90-day stent patency after endoscopic application of this RFA catheter for palliation of malignant obstructive jaundice [2]. Our group also has completed a pilot study on using the Habib^{TM} PERF catheter through the percutaneous route prior to insertion of SEMS in patients with malignant biliary obstruction in 39 patients. We have demonstrated safety and feasibility of this approach in a select group of patients without any ablation-related complications [5].

The Habib^{TM} PERF catheter is a RF catheter that can be deployed in bipolar or monopolar mode. In bipolar mode, it can be used for intraductal biliary RF ablation and for clearance of obstructed metal stents. On the other hand, in monopolar mode, it can cause ablation "outside" rather than "inside" a metal stent. This of course could be useful for tumour recurrence outside a metal or covered stent (unpublished data). In this study, the device was used in bipolar mode and it works only when both the active electrodes are in contact with the tumour in-growth in the stent. Contact with the metal stent cuts off the power and the catheter will have to be repositioned by advancing forward or withdrawing back by a few millimetres.

Radiofrequency ablation using the current device is palliative in nature as it does not ensure total tumour ablation. From previous preclinical porcine experiments, RF ablation thermal damage to adjacent structures, difficulty in reintroducing catheters after RF ablation, haemorrhage, and abscess formation were identified as potential complications [28]. Our group has shown the safety of this approach in the porcine biliary system with energy up to 10 W. Hemorrhage and abscess formation at the site of ablation are also recognized complications of hepatic RF ablation [26, 27]. These complications were not apparent in our patients. After application of the RF ablation, we were able to demonstrate flow of contrast through the previously blocked stent. However, the drainage procedure itself may have contributed to a certain extent to the improvement in bilirubin in these patients.

In conclusion, we report from our experience that the use of percutaneous intrabiliary tract RF ablation to clear occluded metal stents in patients with unresectable malignant biliary obstruction is safe and feasible. Randomized studies to determine the efficacy of percutaneously applied RF ablation therapy using the Habib^{TM} PERF catheter on long-term biliary stent patency and patient survival are warranted.

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Conflict of interest Nagy Habib is a shareholder and director of EMcision Limited, the company that developed The Habib^{TM}

Percutaneous Endobiliary RF ablation catheter. None of the other authors have a conflict of interest or a financial disclosure to declare.

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