

Acceptable results using small radio frequency ablation needle for liver parenchyma transection

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ABSTRACT

INTRODUCTION: The aim of this study was to investigate a single-electrode radio frequency ablation (RFA) needle as an instrument for liver resections with special emphasis on operation time, time of liver ischaemia, intra-operative blood loss and post-operative complications.

MATERIAL AND METHODS: A total of 40 consecutive patients having a liver transection performed by an RFA single electrode from 1 September 2011 to 28 February 2012 were included in the study. Data concerning type of liver resection, liver parenchyma transection time, intraoperative bleeding and transfusions were prospectively recorded and registered. Furthermore, complications were recorded with special emphasis on bile fistulas and abscesses.

RESULTS: In all, 20 females and 20 males had a liver resection performed by a single RFA electrode. The mean bleeding was 520 ml \pm 469 ml, and the mean liver parenchyma transection time was 52 min. \pm 22 min. Three patients, all of whom underwent major resections, received blood transfusions. Five patients developed bile fistulas and two abscesses. There were no re-operations for bleeding and no 30-day mortality.

CONCLUSION: A single electrode RFA needle is a suitable tool for liver parenchyma transection with regard to operation time and intraoperative bleeding, but the frequency of bile leakage seems to be unacceptably high in cases of hemi-hepatectomies.

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The first successful liver resection for colorectal liver metastases was performed in 1943 [1]. Since Adson & van Heerden published their results on major hepatic resections for colorectal liver metastases in 1980 [2], liver surgery has been performed increasingly worldwide for both malignant and benign tumours. During liver surgery, however, perioperative bleeding is a major concern [3] as transfusion requirements are known to raise post-operative morbidity and mortality, and transfusion after surgery for colorectal cancer has been associated with low long-term survival [4-6]. Therefore, several technologies for parenchyma transection and strategies for controlling the blood inflow to the liver have been developed. Today, the most frequently used method for

blood inflow control is the Pringle manoeuvre with complete arterial and portal inflow occlusion, which is achieved by temporary clamping of the hepato-duodenal ligament. The drawback of the Pringle manoeuvre is the risk of ischaemia/reperfusion injuries (I/R) to the liver parenchyma [7].

Radio frequency ablation (RFA) is a technique that has been used for approx. 15 years in the treatment of small liver cancers [8]. RFA applies alternating high-frequency electrical currents (in the 350-500 range kHz) to tumours which results in the development of intense heat that leads to thermal coagulation and kills the tumour.

The aim of the present study was to investigate a single electrode RFA needle as an instrument for liver resections with special emphasis on operation time, time of liver ischaemia, intra-operative blood loss and post-operative complications.

MATERIAL AND METHODS

A total of 40 consecutive patients who had a liver resection performed by open surgery from 1 September 2011 to 28 February 2012 were included in the study. Data concerning type of liver resection, liver parenchyma transection time, intraoperative bleeding and transfusions were prospectively recorded and registered. For practical reasons, blood loss was registered for the whole operation, i.e. also for the mobilisation of the liver and the dissection of the major vessels. Complications with special emphasis on bile fistulas and abscesses were recorded from patient files at discharge. Bile fistulas were in all cases diagnosed at endoscopic retrograde cholangiopancreatography and abscesses were diagnosed by computed tomography. Complications were also graded I-V according to the Dindo-Clavien classification for general surgical complications [9].

Hepatic resections were considered major if two or more Couinaud segments were resected and minor if one or no Couinaud segments were resected. We chose this definition because this was the one most widely used in the papers with which we compared our results.

A single electrode (Cool-tip, Radionics, Burlington, Mass., USA) was used for thermocoagulation of the hepatic parenchyma. Main vessels and bile ducts were dissected and ligated. The electrode was attached to a

ORIGINAL ARTICLE

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 **TABLE 1**

Patient characteristics.

Age, mean \pm SD, yrs	59 \pm 13
Male/female, n	20/20
<i>Diagnosis, n</i>	
Colorectal	31
Hepatocellular carcinoma	3
Sarcomas	2
Benign	4
<i>Hepatectomies, n</i>	
Major	24
Minor	16
Cirrhosis, n	0

SD = standard deviation.

 **TABLE 2**

Clinical variables.

Variable	Major resections	Minor resections	Total
Blood loss, mean \pm SD, ml	520 \pm 469	325 \pm 176	426 \pm 408
Duration of transaction, mean \pm SD, min.	56 \pm 21	45 \pm 23	52 \pm 22
Blood transfusion patients, n	3	0	3
Duration of clamping, min.	0	0	0

SD = standard deviation.

 **TABLE 3**

Complications. The values are n.

Complication	Major resections	Minor resections	Total
Bile leakage	5	0	5
Abscess	1	1	2
Reoperation due to bleeding	0	0	0
30-day mortality	0	0	0

 **TABLE 4**
Complications graded according to the Dindo-Clavien classification^a.

Category	Major resections	Minor resections	Total
I	2	0	2
II	0	0	0
IIIa	6	1	7
IIIb	0	0	0
IVa	0	0	0
IVb	0	0	0
V	0	0	0

a) 7 patients needed a radiological interventional procedure, all of which were performed without general anaesthesia.

500-kHz/150-200-W monopolar generator (Cool-tip, Radionics, Burlington, Mass., USA) and grounding was achieved with two pads placed on the thighs. The necrotic transection margin caused by the RFA needle was divided by a knife.

Trial registration: not relevant.

RESULTS

Patient demographics are presented in **Table 1**. A total of 36 patients underwent surgery for malignant disease. The clinical variables are shown in **Table 2**. Three patients who underwent major resections received blood transfusions.

Five patients developed bile fistulas, in all cases after hemi-hepatectomies. There were no reoperations for bleeding and no 30-day mortality in this study (**Table 3**). According to the Dindo-Clavien classifications, seven patients were in the IIIa category, six of these due to bile leakage (**Table 4**).

DISCUSSION

The main finding of the present study is that a single electrode RFA needle is a suitable tool for liver parenchyma transection with regard to operation time and intraoperative bleeding, but the frequency of bile leakage seems to be unacceptably high, especially in cases of hemi-hepatectomies.

The blood loss in the present study was 520 ml 469 ml for major resections and 325 ml \pm 176 ml for minor resections; the mean blood loss for all patients was 426 ml \pm 408 ml. This is comparable to or below the bleeding reported in other studies. Arita et al conducted a randomised trial in which they compared the clamp crushing method with a dissecting sealer for parenchyma transection [10]. They found an intraoperative bleeding of 665 (30-2,840) ml in the dissecting sealer group and an intraoperative bleeding of 733 (40-2,550) ml in the clamp crush group despite the fact that they used in-flow occlusion, please see below. Evrard et al compared a bipolar vessel sealer (LigaSure) with the clamp crushing technique in patients undergoing liver resections. Like Arita et al, they also used inflow occlusion in both groups [11]. They found an intraoperative blood loss of 500 ml (0-2,300) in both groups. The blood loss reported by Evrard et al is comparable to the blood loss of 426 \pm 408 ml reported in the present study despite the fact that they used in-flow occlusion.

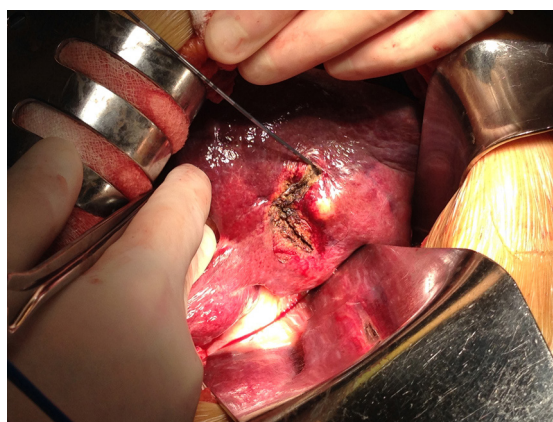
Lupo et al conducted a randomised trial in which they compared radiofrequency-assisted versus the clamp crushing technique for liver resection [12]. As in the present study, they did not use inflow occlusion. They did not report the intraoperative blood loss, but reported a transfusion frequency of 33% in the radiofre-

quency group and of 50% in the clam crushing group. Both of these figures are well above the transfusion frequency of 7.5% in the present study. For tissue coagulation of the resection plane, Lupo et al used two cooled triple needles at a time, compared to us using only one single electrode at a time. Using six electrodes at a time may compromise the accuracy of the radiofrequency coagulation and thereby the resection plane in the liver leading to more intraoperative bleeding and more blood transfusions. Using a single RFA electrode for tissue coagulation as in the present study is a very precise technique, i.e. the tissue coagulation and thereby resection plane can be created with great accuracy and this may reduce intraoperative bleeding and thereby the transfusion requirement.

As briefly mentioned in the introduction section, the Pringle manoeuvre – i.e. temporary clamping of the hepato-duodenal ligament – is a method frequently used to control the inflow to the liver and thereby reduce the perioperative blood loss. The drawback of the Pringle manoeuvre is the risk of I/R injuries to the liver parenchyma. Such injuries range from a light elevation of liver enzymes to liver insufficiency. Prolonged periods of ischaemia convert the cellular metabolism from aerobic to anaerobic which eventually leads to hypoxic damage. Reperfusion with restoration of the oxygen supply, on the other hand, results in accentuation of these damages [7, 13].

None of the 40 patients in the present study were at any time during the operations exposed to liver ischaemia because the single electrode RFA needle at all times resulted in control of intra-operative bleeding. This is clearly an advantage of the single electrode RFA-needle technique compared to many other transection techniques in which the majority of patients are exposed to in-flow occlusion, and thereby I/R has been reported [14, 15].

Post-operative bile leaks are a feared complication to liver surgery and negatively impact perioperative morbidity and mortality [15]. Castaldo et al compared crush clamp, stapler and dissecting sealer for hepatic transection [15]. Castaldo et al analysed 141 patients who underwent liver resection and they reported bile leaks in two of 51 patients who underwent the crush clamp technique, one of 66 patients who underwent stapler hepatectomy, and zero of 24 patients who underwent transection with the dissecting sealer. These figures are well under the reported bile leakage frequency of 13% seen in the present study and, in fact, five of ten patients undergoing hemi-hepatectomies developed bile leakage. When complications were graded according to the Dindo-Clavien classification, seven patients scored in the IIIa category, six of these due to bile leakage. Other studies using other technologies for liver transection,



Liver parenchyma being coagulated by a single-electrode radio frequency ablation needle.

such as vessel sealing systems and crush clamping, have reported bile leakage in 4% to 7% of patients which is also well below the figures found in the present study [16, 17]. The high incidence of bile leakage reported here indicates an inability of radiofrequency to coagulate bile ducts compared to other techniques.

The parenchyma transection time in the present study was 56 min. \pm 21 min. for major resections, 45 min. \pm 23 min. for minor resections, and for all resections it was 52 min. \pm 22 min. These figures are comparable with the transection times in other studies using other technologies. Doklestic et al reported a mean transection time of 85 min. for the vessel sealing system and a 40-min. mean transection time for the crush clamp technique, and Takayama et al found a mean transection time for the Cavitron Ultrasonic Surgical Aspirator of 61 min. [18, 19].

A single electrode RFA needle is a rather costly technology for liver transection, especially when compared to the crush clamp technique. The cost of a single electrode RFA needle is approx. 1,000 euro and as such this is the most costly technology for liver transection.

The findings in the present observational study should, of course, be interpreted with caution due to clinical diversity among the included patients; the patients operated were diverse and included both patients with primary cancer, metastatic cancer and benign disease. We did not register which segments were resected. We only registered the number of segments resected or whether a wedge resection was performed.

In conclusion, a single electrode RFA needle is a suitable tool for liver parenchyma transection with regard to operation time, intraoperative bleeding and transfusions requirement. RFA is, however, a costly technology, and the frequency of bile leakage is unacceptably high in cases of hemi-hepatectomies. These considerations have prompted us to abandon this technique for hemi-hepatectomies, and we now only use it for minor resections.

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LITERATURE

1. Poston GJ. Standing on the shoulders of giants. *Eur J Surg Oncol* 2008;34:253-5.
2. Adson MA, van Heerden JA. Major hepatic resections for metastatic colorectal cancer. *Ann Surg* 1980;191:576-83.
3. Belghiti J, Noun R, Malafosse R et al. Continuous versus intermittent portal triad clamping for liver resection: a controlled study. *Ann Surg* 1999;229:369-75.
4. Janargin WR, Gonen M, Fong Y et al. Improvement in peri-operative outcome after hepatic resection: analysis of 1,803 consecutive cases over the past decade. *Ann Surg* 2002;236:397-406.
5. Kooby DA, Stockman J, Ben-Porat L et al. Influence of transfusion on perioperative and long-term outcome in patients following hepatic resection for colorectal metastases. *Ann Surg* 2003;237:860-9.
6. Jensen LS, Puho E, Pedersen L et al. Long-term survival after colorectal surgery associated with buffy-coat-poor and leucocyte-depleted blood transfusion: a follow-up study. *Lancet* 2005;365:681-2.
7. Jaeschke H. Molecular mechanisms of hepatic ischemia/reperfusion injury and preconditioning. *Am J Physiol Gastrointest Liver Physiol* 2003;284:G15-G26.
8. Hompes D, Prevoo W, Ruers T. Radiofrequency ablation as a treatment tool for liver metastases of colorectal origin. *Cancer Imaging* 2011;11:23-30.
9. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205-13.
10. Arita J, Hasegawa N, Kokudo K et al. Randomized clinical trial of the effect of a saline-linked radiofrequency coagulator on blood loss during hepatic resection. *Br J Surg* 2005;92:954-9.
11. Evrard S, Becouarn Y, Brunet R et al. Could bipolar vessel sealers prevent bile leaks after hepatectomy? *Langenbecks Arch Surg* 2007;392:41-4.
12. Lupo I, Gallerani A, Panzera F et al. Randomized clinical trial of radiofrequency-assisted versus clamp-crushing liver resection. *Br J Surg* 2007;94:287-91.
13. Klune JR, Tsung A. Molecular biology of liver ischemia/reperfusion injury: established mechanisms and recent advancements. *Surg Clin North Am* 2010;90:665-77.
14. Lau WY, Lai EC, Lau SH. Methods of vascular control technique during liver resection; a comprehensive review. *Hepatobiliary Pancreat Dis Int* 2010;9:473-81.
15. Castaldo ET, Earl M, Chari RS et al. A clinical comparative analysis of crush/clamp, stapler, and dissecting sealer hepatic transection method. *HPB (Oxford)* 2008;10:321-6.
16. Saiura A, Yamamoto J, Koga R et al. Usefulness of LigaSure for liver resection. Analysis by randomized clinical trial. *Am J Surg* 2006;192:41-5.
17. Garancini M, Gianotti L, Mattavelli I et al. Bipolar vessel sealing system vs clamp crushing technique for liver parenchyma transection. *Hepatogastroenterology* 2011;58:127-32.
18. Doklestic K, Karamarkovic A, Stefanovic B et al. The efficacy of three transection techniques of the liver resection: a randomized clinical trial. *Hepatogastroenterology* 2012;59:1501-6.
19. Takayama T, Makuuchi M, Kubota K et al. Randomized comparison of ultrasonic vs clamp transection of the liver. *Arch Surg* 2001;136:922-8.