Radiofrequency Assisted Hepatic Parenchyma Resection Using Radiofrequent Generator (RF) Generator

Jusuf Sabanovic, Samir Muhovic, Ajdin Rovcanin, Safet Musanovic, Salem Bajramagic, Edin Kulovic

Clinic for General and Abdominal Surgery, University Clinical Center Sarajevo (UCCS), Sarajevo, Bosnia and Herzegovina.

Corresponding author: Jusuf Sabanovic, prim.dr.,sci.med, Clinic for General and Abdominal Surgery, University Clinical Center Sarajevo (UCCS), Sarajevo, Bosnia and Herzegovina. E-mail: sabanovic.jusuf@hotmail.com. ORCID ID: http://orcid.org/0000-0002-9901-8264.

doi: 10.5455/aim.2018.26.265-268

ACTA INFORM MED. 2018 DEC 26(4): 265-268
Received: Oct 20, 2018 • Accepted: Nov 28, 2018

ABSTRACT

Introduction: The role of Radio frequent Generator (RF) has been extended from simple tumor ablation to routine hepatic resection. RF energy precoagulates the tissue and thus allows the closure of small blood vessels and bile ducts. The development of surgical techniques and modern technological advances have enabled liver resections to be significantly surgically better controlled in the sense of bleeding, and are more successful and safer for patients. The RF generator has its advantages and disadvantages and as such can be equally used in resective liver surgery. Aim: Display the intraoperative and postoperative complications among patients that had been subjected to liver resection using a RF generator (RF resection), compared to those that had been subjected to liver resection without the use of RF generators (classical liver resection methods of CC resection). Material and methods: The study included 60 patients of both sexes which had resective operative surgery or metastasectomy on the liver due to the basic process. The study was conducted at the Clinic for General and Abdominal Surgery of the Clinical Center of the University of Sarajevo in a four-year period. The study was designed as a comparative study of outcome and postoperative complications of surgical treatment, i.e. resective liver interventions using two operating techniques (RF–liver resection and Classical resection techniques on the liver). Results: The highest number of surgical procedures was due to colorectal cancer. A slightly smaller number was performed due to primary liver cancer and gallbladder cancer. The highest number of surgical interventions remain on non-anatomic resections. Smaller number remains to large resective operations. The length of hospitalization was significantly correlated with blood loss ($r = 713$ $p = 0.000$) and the average hospitalization time ranged from 10.5 to 53.3 days.

Conclusion: We have shown that the use of RF generators does not significantly reduce intraoperative and postoperative complications. There is a justification for using both techniques for resection on the liver. The resective liver operation depends mostly on the personal stance and the surgeons training.

Keywords: liver resection, RF generator, hospitalization, surgery.

1. INTRODUCTION

Liver resection is an operational procedure that carries a significant risk of intraoperative bleeding and is correlated with postoperative morbidity, mortality and long-term survival (1-10). Improvement of surgical and anesthetic techniques as well as the development of new technical aids have the consequence of minimal blood loss (11-18). The surgeon is often in dilemma when performing complex operations on the liver whether to use a classic method (Fractur fingers or Kellys techniques) with a hepatic pedicle (selective or total occlusion) or to use new technical aids such as an RF recipe (13, 19-29). Clamping the hepatic pedicle increases the potential risk of liver dysfunction from ischaemic-perfusion injuries, especially in patients with pronounced chronic liver disease. In the present years several techniques have been developed that would potentially reduce blood loss during transection of the liver parenchyma with or without vascular occlusion (7, 13, 26). The main problem with these methods is that although small blood vessels may be coagulated during transplantation, large blood vessels may be injured, which can result in significant blood loss during the operation, and thus require further cleavage to achieve adequate hemostasis. The role of Radiofrequent Generator (R.F) has been extended from simple tumor ablation to routine hepatic resection using RF probes to de-
Radiofrequency Assisted Hepatic Parenchyma Resection Using Radiofrequent Generator (RF) Generator

2. MATERIAL AND METHODS

This clinical study of retrospective-prospective character was performed at the Clinic for General and Abdominal Surgery of the Clinical Center of the University of Sarajevo in a four-year period. The study was designed as a comparative study of outcome and postoperative complications of surgical treatment, i.e. resective liver interventions using two operating techniques (RF—liver resection and Classical resection techniques on the liver).

The study included 60 patients of both sexes which had resective operative surgery or metatasectomy on the liver due to the basic process (primary tumor, hemangioma, metastasis, echinococcus, etc.). Depending on the type of surgical technique, patients are divided into two groups: RF-LR and CC-LR groups.

One group of patients (30) had been subjected to liver resection using a RF generator (RF resection), and the other group of patients (30) had been subjected to liver resection without the use of RF generators (classical liver resection methods of CC resection).

3. RESULTS

By analyzing the cause of the disease in our study, we had a large number of colorectal adenocarcinoma metastases: 18 (30.0%) in RF-LR group and 17 (28.33%) in the CC-LR group. There is a slightly smaller number of primary liver tumors (HCCs) in 5 (8.33%) cases in both groups, 2 (3.33%) on gall bladder cancers, also in both groups. As for the benign diseases, we had haemangioma, 2 (3.33%) cases in both groups, and Echinococcus, 2 (3.33%) cases in the RF-LR group and 3 (5%) cases in the CC-LR group. In both groups, respectively we had 1 (1.66%) case, which represents metastases of other gastrointestinal tract tumors (p=0,998).

| Pathology                  | RF-LR | CC-LR | Total N=60 |
|----------------------------|-------|-------|------------|
| colorectal metastases      | 18    | 17    | 35         |
| HCC’s                      | 5     | 5     | 10         |
| Haemangioma                | 2     | 3     | 4          |
| Gall bladder tumors        | 2     | 3     | 4          |
| Echinococcus               | 2     | 3     | 5          |
| Metastases from other tumors | 1     | 1     | 2          |

Table 1. Pathology of illness. P=0,998

We had a large number of non-anatomic resections: 15 (24.99%) of patients in the RF-LR group and 10 (16.66%) in the CC-LR group. Right hepatectomies were 1 (1.66%) in the RF-LR group and 2 (3.33%) in the CC-LR group. We had 2 (3.33%) of left hepatectomies in both groups. In...
the CC-LR group we had 3 (5%) resections of 3 and more segments while in the RF-LR group we had 1 (1.66%) case. We had 10 (16.66%) cases of segmentectomy and bisegmentectomy in the RF-LR group and 11 (18.33%) cases in the CC-LR group, p = 0.893.

Table 2. Types of resection procedures. Chi-square test p=0.893

| Resection of liver                  | RF-LR | CC-LR | Total N=60 |
|------------------------------------|-------|-------|------------|
|                                    | No    | %     | No         | %     |
| Right hepatectomy                  | 1     | 1.66  | 2          | 3.33  | 3 | 5 |
| Left hepatectomy                   | 2     | 3.33  | 2          | 3.33  | 4 | 6.67 |
| 3rd segment resection               | 1     | 1.66  | 2          | 3.33  | 3 | 5 |
| Extended left hepatectomy          | 1     | 1.66  | 2          | 3.33  | 3 | 5 |
| Small resection of the 1st segment  | 4     | 6.67  | 2          | 3.33  | 6 | 10 |
| Small resection (II, III)          | 2     | 3.33  | 2          | 3.33  | 4 | 6.67 |
| Small resection (IV, V)            | 1     | 1.66  | 1          | 1.66  | 2 | 3.33 |
| Small resection (VI, VII)          | 0     | 0.0   | 2          | 3.33  | 2 | 3.33 |
| Small resection (V, VI)            | 2     | 3.33  | 2          | 3.33  | 4 | 6.67 |
| 2nd segment resection              | 1     | 1.66  | 2          | 3.33  | 3 | 5 |
| Non anatomical resection. Single   | 8     | 13.33 | 5          | 8.33  | 13| 21.66 |
| Non anatomical resection. Multiple. | 7     | 11.66 | 5          | 8.33  | 12| 20 |
| Total                              | 30    | 100   | 30         | 100   | 60| 100 |

Table 3. Hemoglobin values (Hgb) and Hematocrit values (Hct)

Research has shown that there is a statistically significant difference in preoperative and postoperative values of Hgb and Hct in both groups. In CC-LR p<0.001, and in RF-LR group p<0.0005. Total blood loss in the RF-LR group ranges from 200 to 1100 ml with a mean value of M = 503.33 ± SD 258.62, while the blood loss in the CC-LR group ranges from 50 to 1200 ml with a mean value of M = 390 ± SD 284.48. We had a slightly higher statistically significant blood loss in patients with resection with radiofrequency generator. (Mann Whitney U test = 303) p = 0.029. Both complications were associated with loss of blood during resection and there was a negative significant correlation (r = -0.527 p <0.01) between complications and blood loss as well as the correlation between complications and hospitalization days of patients (r = -0.805 p <0.01). This means that patients who had a greater blood loss had a greater number of complications and stayed longer in the hospital, i.e. there is a positive significant correlation between blood loss and hospitalization (r = 0.406 p<0.01).

We had a slightly higher number of complications in the RF-LR group 14 (46.7%) while in the CC-LR group there were 7 (23.3%). 16 (53.3%) of patients in the RF-LR group had no complications while 23 (76.7%) of the patients in the CC-LR group had, but statistically not significant p = 0.104.

4. DISCUSSION

Surgery procedures on the liver have become relatively common. Liver resection is a crucial part of the treatment of primary liver cancers, secondary tumor changes, and sometimes injuries, hemangiomas and minor echinococcal cysts (32). The development of surgical techniques and modern technological advances have enabled liver resections to be significantly surgically better controlled in the sense of bleeding, and are more successful and safer for patients (36). It can be said that the history of liver surgery is at the same time the history of bleeding control. All technical innovations in modern liver surgery are focused on reducing bleeding during liver resection. Numerous studies introducing new surgical procedures have just demonstrated their strengths and weaknesses in parenchymal transduction, and unconditionally investigated blood loss and reimbursement during operative procedures. The highest number of surgical procedures was due to colorectal cancer, about 30.0% in RF-LR and 28.33% in CC-LR. A slightly smaller number was performed due to primary liver cancer and gallbladder cancer of about 6.66% in both groups. Primary liver tumors are represented by 12% -18%, while gallbladder cancer accounts for about 1% -2% of cases.

The highest number of surgical interventions remain on non-anatomic resections, somewhat less in CC-LR than in the RF-LR group (16.66% versus 24.99%). Smaller number remains to large resective operations. In the RF-LR group we had 1.66% of right hepatectomy and in CC-LR 3.33%. In both groups we had 3.33% of left hepatectomies. The number of hospitalization days was longer in the RF-LR group compared to the CC-LR group (21.90 ± 10.22 days versus 16.8 ± 8.96) p = 0.031. The length of hospitalization was significantly correlated with blood loss (r = 0.713 p = 0.000) and the average hospitalization time ranged from 10.5 to 53.3 days, according to world authors (34.9.35.10.16).

By analyzing the results of our study, we found that blood loss was slightly higher in the RF-LR group (503.33 ± 58.62 vs. 390 ± 284.48), and the blood loss range differed from 50-1200 ml in both groups. The analysis found that there is a significant increase in blood loss in the RF-LR group compared to the CC-LR group (p = 0.029).

The values of preoperative and postoperative values of hemoglobin in the CC-LR and RF-LR groups showed that there was a statistically significant difference in hemoglobin values in the CC-LR group (p<0.0006) and the RF-LR group (p<0.0005).

Also, analysis of preoperative and postoperative values of hematocrit in the CC-LR and RF-LR groups showed a statistically significant difference in the values of hematocrit in CC-LR (p<0.001) and RF-LR (p<0.0005). In both groups, there was a statistically significant decrease in hemoglobin and hematocrit values, associated with loss of blood.

We had a little, but no statistically significant difference in the number of postoperative complications between the investigated groups (X2-test = 2.637 p = 0.104). From post-
operative complications we had intraabdominal collections, pleural effusions, pneumothorax, biloma and biliary fistulas, early infections, postoperative ICU and pneumonia, which is the most common cause of death in elderly patients after resection on the liver, and dehiscence of operative wound.

5. CONCLUSION
We have shown that the use of R.F generators does not significantly reduce intraoperative and postoperative complications. The R.F generator has its advantages and disadvantages and as such can be equally used in resective liver surgery.

There is a justification for using both techniques for resection on the liver. Surgery today has a large number of surgical techniques and which one to use and adapt for the resective liver operation depends mostly on the personal stance and the surgeons training.

R.F ablation of the liver has a great advantage in small lesions (up to 3 cm) located near major vascular structures as well as in the diffuse layout of large numbers. There is a significant association between blood loss and length of hospitalization and the number of complications in both groups. RF-LR and CC-LR have good results and both need to be combined to maximize their potential.

- **Author’s contribution:** Study concept and design: J.S.; S.M; A.R; E.K.; S.M.; S.B. Acquisition of data: J.S.; S.M. Analysis and interpretation of data: J.S.; S.M; A.R; E.K.; S.M.; S.B. Drafting of the manuscript: J.S.; S.M.; A.R. Critical revision of the manuscript for intellectual content: J.S; S.M; A.R; E.K.; S.M.; S.B.

- **Financial support and sponsorship:** None.

- **Conflict of interest:** There are no conflict of interest.

**REFERENCES**

1. Huguet C, Nordinger B, Galopin JJ, et al. Normothermic hepatic vascular exclusion for extensive hepatectomy. Surg Gynecol Obstet. 1978; 147: 689-693.

2. Cantley J. On a New arrangement of the right and left lobes of the liver. J Anat Physiol Lond. 1998; 32: 4.

3. Delva E, Calmus y, Nordlinger B, et al. Vascular occlusions for liver resections: operative management and tolerance to hepatic ischemia:142 cases. Ann Surg. 1989; 209: 211-218.

4. Nakamura S, Tsuzuki T. Surgical anatomy of the hepatic veins and the inferior vena cava. Surgery, Gynecology & Obstetrics. 1981; 152: 43-50.

5. Bismuth H. Surgical anatomy and anatomical surgery of the liver. World J Surg. 1982; 6(1): 3-9.

6. Huguet C, Gavelli A, Bona S. Hepatic resection with ischemia of the liver exceeding one hour. J Am Coll Surg. 1994; 178: 454-458.

7. Elias D, Lasser P, Debaene B, et al. Interruption vascular exclusion of the liver (without vena cava clamping) during major hepatectomy. Br J Surg. 1995; 82: 1535-1539.

8. Gadžijev EM, Ravnik D. Atlas of Applied Internal Liver Anatomy. Wien, New York: Springer. 1996: 15-20.

9. Adam R, Bunthut H, Castaing D, et al. Repeat hepatectomy for colorectal metastases. Ann Surg. 1997; 5: 51-62.

10. Kim T, Nakajima Y, Kano H, Hiranuma A, Obayashi T, Nishio K, Shio M, Nagao M, Nakano H. Repeat hepatectomy for recurrent colorectal metastases. World J Surg. 1998; 22: 1087-1091.

11. Yamamoto J, Kosuge T, Shimada K, et al. Repeat liver resection for recurrent colorectal liver metastases. Am J Surg. 1999; 178: 75-81.

12. Fong Y, Fortner J, Sun RL, et al. Clinical score for predicting recurrence after hepatic resection for metastatic colorectal cancer: analysis of 1000 consecutive cases. Ann Surg. 1999; 230: 309-318.

13. Sugio H, Inoue S, Matsumoto F, Tsuurna H, Watanabe Y, Kojima K, Futaiga S. Hepatic resection using the harmonic scalpel. Surg today. 2000; 30: 959-962.

14. Blumgart LH, Fong Y. Surgery of the Liver and Biliary Tract. 3rd ed. London: Saunders WB, 2000; 1397-422.

15. Belghiti J, Hiramatsu K, Benoist S, et al. Seven hundred forty-seven hepatectomies in the 1990s: an update to evaluate the actual risk of liver resection J Am Coll Surg. 2000; 191: 38-46.

16. Suzuki S, Sakaguchi T, Yoki Y, Kurachi k, Okamoto K, Okumura T, Tsuiahi Y, Nakamura T, Konno H, Baba S, Nakamura S. Impact of repeat hepatectomy on recurrent colorectal liver metastases. Surgery 2001; 129: 421-428.

17. Torziall G, Makuchi M, Midorikawa Y, et al. Liver resection without total vascular exclusion: hazardous or beneficial? An analysis of our experience. Ann Surg; 2001; 233: 167-175.

18. Strasberg SM, Belghiti J, Clavien PA, Gadžijev E, Garden Jo, Lau WY, Makuchi M, Strong RW. Terminologija jetrene anatomije in resekcij-Brisbane 2000: The Brisbane 2000 terminology of liver anatomy and resection. Zdrav Vetro. 2002; 71: 105-110.

19. Hribernik M, Gadžijev E, Miklar B, Ravnik D. Variations of inarehaptic and proximal extrarehepatic bile ducts. Hepatogastroenterol. 2003; 50: 342-348.

20. Inamura H, Seyerma Y, Kokudo N, et al. one thousand fifty-six hepatectomies without mortality in 8 years. Arch Surg. 2003; 138: 1198-1206.

21. Sakamoto Y, Yamamoto J, Kokudo N, Seki M, Kosuge T, Yamaguchi T, Muto T, Makuchi M. Bloodless liver resection using the monopolar floating ball plus ligaure dthureh: preliminary results of 16 liver resections. World J Surg. 2004; 28: 166-172.

22. Navarra G, Ayav A, Weber JC, et al. Short-and long-term results of intraoperative radiofrequency ablation of liver metastases. Int J Colorectal Dis. 2005; 20: 521-528.

23. Lee CC, Chau GY, Lui WY, Tsay SH, King KL, Loong CC, Hsia CY, Wu CW. Risk factors associated with bile leakage after hepatic resection for hepatocellular carcinoma. Hepatogastroenterology. 2005; 52: 1168-1171.

24. Milicvic M, Bulajic P, Žuvela M, Dervenis C, Basaric D, Galun D. A Radiofrequency-assisted minimal blood loss liver parenchyma dissection technique. Dig Surg. 2007; 24: 306-313.

25. Ayav A, Jiao LR, Habib NA. Bloodless liver resection using radiofrequency energy. Dig Surg. 2007; 24: 314-317.

26. Hutchinson R, Bertucci M. Experience with tissueLinkTM—radiofrequencypassed parenchimal division. Dig Surg. 2007; 24: 318-321.

27. Delis SG, Madariaga J, Bakoyiannis A, Dervenis C. Curent role of Bloodless liver resection. World J Gastroenterol. 2007; 13: 86-89.

28. Liao KH, DeMatteo RP. Segment-oriented anatomic liver resections. In: Blumgart LH, ed. Surgery of the Liver and Biliary Tract. London: WB Saunders, 2007: 1440-1451.

29. Bachellier P, Ayav A, Pai M, et al. Result of radiofrequency-assisted laparoscopic liver resection. Am J Surg. 2007; 193: 143-148.

30. El-Gendi AM, Khorosandi SE, Pai M, Zacharoulis D, Nicholls JP, Spalding DRC, Jiao LR, Habib NA. Repeat hepatic resection using a radiofrequency-assisted technique. Dig Surg. 2008; 25: 293-299.

31. Aleksandar RK, Kristina SD. Resekcije jetre u lijećenju kolorektalnih metasta. Sanamed. 2010; 5: 9-16.

32. Eldar M, Gadžijev, Aleksandr R, Karamarković. Resekcije jetre u lijećenju kolorektalnih metasta. Sarajevo Med. 2001; 50: 342-348.

33. Sadamori H, Yagi T, Matsuda H, Shinoura S, Umeda Y, Fujiwara T. Infradiaphragmatic bile leakage after hepatectomy for hepatocellular carcinoma in 359 recent cases. Dig Surg. 2012; 29: 149-156.

34. Petrowsky H, Gonen M, Jarnagin W, et al. Second liver resections are safe and effective treatment for recurrent hepatic metastases from colorectal cancer: a bi-institutional analysis. Ann Surg 00; 25: 863-871.

35. Tanaka K, Adam R, Shimada H, et al. Role of neoadjuvant chemotherapy in the treatment of multiple colorectal metastases to the liver Br J Surg. 2003; 90: 963-969.

36. Clavien PA, Petrowsky H, De Oliveira ML, Graf R. [0079 Strategies for safer liver surgery and partial liver transplantation. N Engl J Med. 356: 1545-1559.