ORIGINAL PAPER

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

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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 pedicel (selective or total occlusion) or to use new technical aids such as an RF recipe (13, 19-29). Clamping the hepatic pedicel 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 (RF) has been extended from simple tumor ablation to routine hepatic resection using RF probes to de-

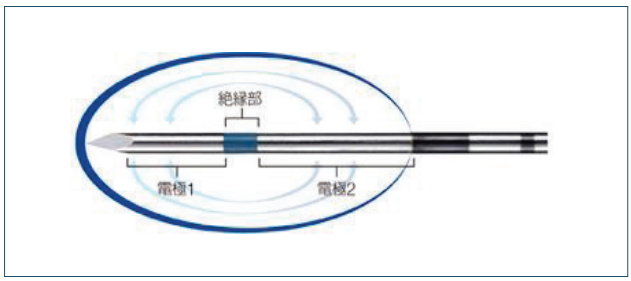

Figure 1. Needle probes used for RF resection

velop coagulant necrosis along the planned parenchymal resection line (13, 19, 25).

Radiofrequency currents generated in modern devices are characterized by a wider bandwidth compared to standard electrodes at frequencies of 400 to 500 KHz. The higher drop length along with the continuous cooling of the system leads to a condition in which the tissue is supplied with a smaller amount of heat energy with a tissue temperature below 100 °C. Warming up of tissue over 100 °C leads to boiling of intra and extracellular fluid, desiccation, tissue drying, and electrical barrier formation, which is a barrier to further coagulation. Keeping the temperature below this level does not allow the formation of the eschar, which leads to better visibility of the liver microstructure during the dissection. The tissue that is coagulated in such a way is softer and more suitable for dissection. Collagen types I and III, which are parts of blood vessel's wall and bile duct's wall, are particularly heat sensitive and are circularly arranged. Collagen denaturation is formed by the melting of hydrated crystals which leads to splashing of the hydrogen bonds and the decomposition of the triple helix in randomly organized chains. Since intermolecular connections are maintained, the long-chained collagen-like rods are collected in the perpendicular direction, relative to the normal orientation of the fibers, leading to the closing of lumen of coagulated blood vessels and bile ducts up to 6 mm (22). Thanks to its characteristics, RF currents are suitable for use on parenchymal organs (25, 30-34). There are numerous parameters which determine the quality of liver resection. The most important of these are; the duration of ischemia, the loss of blood, technical errors and the appearance of complications, which precisely determines the success of liver surgery with an adequate resection margin and exposure to anatomical orients (1, 6, 35). Based on the above parameters, it is possible to determine the success of certain devices used in resective liver surgery. The RF generator is useful in reducing blood loss that is expressed in the first and subsequent resection procedures, and also the need for introduction into selective or total vascular occlusion is less with the use of this generator. RF–resector uses RF energy over a standard heat generator that is transmitted over a metal probe and physiological solution. RF energy precoagulates the tissue and thus allows the closure of small blood vessels and bile ducts. (1, 25, 26).

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

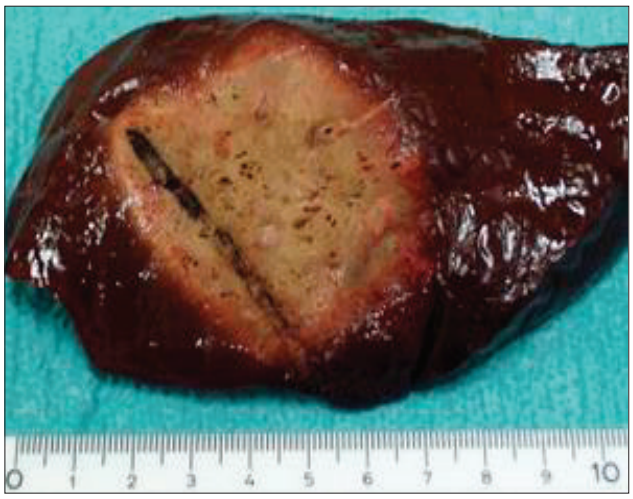

Figure 2. Appearance of resective surface after RF liver resection.

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 metastasectomy 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	
	No.	%	No.	%	No.	%
Colorectal metastases	18	30,0	17	28,33	35	58,33
HCC's	5	8,33	5	8,33	10	16,66
Haemangioma	2	3,33	2	3,33	4	6,67
Gall bladder tumors	2	3,33	2	3,33	4	6,67
Echinococcus	2	3,33	3	5,0	5	8,34
Metastases from other tumors	1	1,66	1	1,66	2	3,33

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.

Resection of liver	RF-LR		CC-LR		Total N=60	
	No	%	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	3	5	4	6,67
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 (VI,VII)	1	1,66	1	1,66	2	3,33
Small resection (V,VI)	0	0,0	2	3,33	2	3,33
Small resection (IV,V)	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 2. Types of resection procedures. Chi-square test p=0,893

	Hgb and Hct X±SD	
	RF-LR	CC-LR
Preoperative HgB	135,03±12,23	135,97±20,98
Postoperative. HgB	116,80±20,6	117,23±19,75
Preoperative. Hct	39,67±3,72	39,70±4,84
Postoperative. Hct	33,17±3,73	34,30±5,08

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 ml ± 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 ml ± 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 = -, 527 p <0.01) between complications and blood loss as well as the correlation between complications and hospitalization days of patients (r = -, 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.

All complications	RF-LR		CC-LR	
	No	%	No	%
Complications	14	46,7	7	23,3
Without complications	16	53,3	23	76,7
X2 –test 2,637				
P value 0,104				

Table 4.

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 = 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 ICV 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 RF generators does not significantly reduce intraoperative and postoperative complications. The RF 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.

RF 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.

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