Health & Research Journal

Vol 8, No 4 (2022)

Volume 8 Issue 4 October - December 2022

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doi: [10.12681/healthresj.29409](https://doi.org/10.12681/healthresj.29409)

HEALTH AND RESEARCH JOURNAL
E-ISSN:2459-3192

(2022), Volume 8, Issue 4

RESEARCH ARTICLE

COST-EFFECTIVE SURGICAL MANAGEMENT OF LIVER DISEASE IN A UNIVERSITY HOSPITAL: A RETROSPECTIVE STUDY

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Abstract

Background: Hepatobiliary surgery is a high-end surgery comprising of complex operations associated with high economic burden to a healthcare system. The aim of this study was to evaluate the cost-effectiveness of a hepatobiliary surgery highly standardized operative protocol, that minimizes intraoperative and postoperative costs, implemented by the same surgical team, in a Greek university hospital for a five-year period (2012-2016).

Method and Material: The digital medical records of all patients undergoing liver resection at a tertiary university hospital from January 2012 to December 2016 by a single surgical team were retrospectively reviewed. The financial cost of the patients' treatment was calculated in collaboration with the hospital's logistics department, and it involved all preoperative, intraoperative, and postoperative expenses from admission to discharge, excluding physician fees and salary cost of the hospital's nurses.

Results: In this study, 127 patients underwent hepatectomy. The patient's health status was improved after the surgery in most of the cases (121, 95.2%). The mean Length of Stay (LOS) was 13.4 (SD±17.3) days. The mean total hospitalization cost was 4,729 (SD ± 5,486) euros (€), while the cost of surgery, the higher mean cost was noted in 2013 (925, SD±974.64 €) and the lower in 2015 (142, SD±219 €).

Conclusions: This protocol allows the performance of hepatectomies with a significantly decreased cost without compromising patient outcomes.

Keywords: Hepatobiliary surgery, cost estimation, cost-effective method, adverse events.

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Cite as: Tseka, I., Chrisofos, M., Kontis, E., Triantafyllou, C., Kokoropoulos, P., Arkadopoulos, N. (2022). Cost-effective surgical management of liver disease in a university hospital: a retrospective study. Health and Research Journal,8(4),284-292. https://ejournals.epublishing.ekt.gr/index.php/HealthResJ

INTRODUCTION

Primary liver cancer is the fifth most common malignancy worldwide, with yearly fatality ratio of the order of 1, indicating that the majority of the cases do not survive more than a year. [1] The highest incidence rates of liver cancer were observed in Eastern and South-Eastern Asia, Northern and Southern Africa, with China accounting for about 50% of all cases.[2]

Hepatobiliary surgery is a high-end surgery comprising of complex operations associated with high economic burden to a healthcare system. The laparoscopic liver surgery has developed progressively and cautiously over the last years.[3–5] A potential barrier to laparoscopic liver surgery diffusion is their uncertain effect on financial costs.

In a considerable number of studies, it was found that the considerable perioperative costs associated with the minimally invasive surgery technique resulted greatly counterbalanced by postoperative cost-savings, comparing with the open surgery, and have favored their implementation by health care systems.[6–8] For example, previous study that was conducted in Greece which aim to evaluate the cost-effectiveness of a standardized protocol of open liver resection,[9] found that this protocol allows the performance of hepatectomies with a significantly decreased cost without compromising surgical outcomes. This indicates that its application in financially struggling hospitals, that cannot afford minimal invasive procedures, or open liver surgery using expensive disposables is feasible.

Liver resection is the basic curative treatment for the majority of hepatobiliary malignant.[10] Progress in surgical techniques and perioperative management have led to an important drop in mortality to less than 5% in specialized center.[11] In spite of the low morbidity and good oncologic outcome,[12,13] the presumed intraoperative higher costs for the laparoscopic approach, comparing with the open surgery, may be a barrier to widespread adoption like the laparoscopic liver resections.[13]

A systematic review that assessed the cost of liver resections, the operative costs for the laparoscopic approach exceeded this of open surgery due to higher equipment costs.[14]. Although, the conflicting data of the existing studies,[15,16] suggest the need for additional studies.

Thus, the aim of this study was to evaluate the cost-effectiveness of hepatobiliary surgery highly standardized operative protocol, that minimize intraoperative and postoperative costs, implemented by the same surgical team, in a Greek university hospital for a five-year period (2012-2016).

METHODOLOGY

Study design, patient selection and operative technique

A retrospective observational study was carried out from January 2012 to December 2016, at a tertiary university hospital among all patients undergoing liver resection for any indication (primary or metastatic, benign, or malignant) by the same surgical team. The digital medical records of all patients included in the study. Regarding liver resections, all hepatectomies were performed with a standardized surgical protocol, which involves selective hepatic vascular exclusion (SHVE) of the liver and transection of the hepatic parenchyma with a scalpel, maintaining central venous pressure (CVP) within ±20 % of baseline values, and implementing a combination of general and epidural anesthesia to all patients.[17]

Summarily, the liver was assembled by transection of the hepatic ligaments and ligation of the short hepatic veins of the inferior vena cava. Intraoperative ultrasonography was used to certify lesion resectability and perform the transection plane. The liver inflow was disciplined by Pringle maneuver and the outflow by clamping both the right hepatic vein and the common trunk of the middle and left hepatic veins at the hepatocaval junction. Aberrant extrahepatic vessels were also disciplined with bulldog clamps. Coming the fixed plane of resection, the hepatic parenchyma was transected with the use of scalpel. The orifices of all major vascular and biliary structures were sutured with polypropylene sutures. Additional hemostatic sutures were placed after the release of hepatic outflow and inflow, while simple diathermy was also used when indicated. After completion of hemostasis, a patch of round ligament or greater omentum 2-0 polypropylene sutures on the liver cut surface. Before abdominal closure, a drain was placed in the right subdiaphragmatic space and connected to a closed system without suction.

Data collection

All eligible patients were identified from hospital records using

ICD-10 codes for both diagnosis and operational procedure. Data extracted included demographics, comorbidities, and preoperative diagnosis. Also details of the operation were recorded and intraoperative data were obtained from the operation notes. The financial cost of the patients' treatment was calculated in collaboration with the hospital's logistics department and it involved all preoperative, intraoperative, and postoperative expenses from admission to discharge, excluding physician fees and salary cost of the hospital's nurses.

Patients operated by a different surgical team was not included in this study.

Ethics approval and consent to participate

The study was approved by both the Ethics Committee of a Greek University and the Hospital's review board. The study was noninvasive and did not involve any risk or harm to the participants. Informed consent was waived due to the observational nature of the study.

Statistical analysis

Descriptive statistics, either parametric (mean (m), standard deviations (SD),) or non-parametric (counts, and percentages (%)) are presented as appropriately. All numeric variables were assessed for normality by Kolmogorov-Smirnov test. Student's t-test or Mann-Whitney U test was used for comparisons between treatment groups as appropriate. Chi-square test (x^2) was used to for categorical data. Spearman's rho was used to assess the association between continuous variables such as cost, duration of surgery, length of stay (LOS). Spearman's rho values between 0.1 and 0.39 (-0.39 and -0.1), 0.4 and 0.69 (-0.69 and -0.4), 0.7 and 0.89 (-0.89 and -0.7) and 0.9 and 1 (-1 and -0.9) indicate a weak, moderate, strong and very strong positive (negative) correlation, respectively [18]. A cut-off of p≤0.05 was set for statistical significance. The statistical software SPSS version 20.0 was used for the statistical analyses.

RESULTS

During the study period we identified 127 patients who underwent hepatectomy and their demographics and operation details are presented in **Table 1**. The majority (53.5%) were females; and their mean age was 62.1 (SD±13.5) year. Moreover, only 11 (8.6%) were admitted to Intensive Care Unit (ICU), and only 6 (4.7%) patients died during or after the surgery. The mean LOS was 13.4 (SD±17.3) days.

In **table 2** are presented data about the type of surgery, the volume and type of tumor and information about the cost of hospitalization and surgery. The majority of tumors were malignant (88, 69.2 %). Regarding hospitalization cost, the mean total cost was 4,729.02 ± 5,486.33 euros (€), the higher cost was observed in 2013 (6,357, SD±9,421€) and the lower in 2016 (3,689, SD±1,641€). Concerning the surgery cost, the higher mean cost was noted in 2013 (925, SD±974 €) and the lower in in 2015 (142, SD±219€).

Statistically significant weak correlation was found between LOS and duration surgery and between LOS and cost of surgery (rho=0.333, p<0.0005; 0.201, p=0.024, respectively). Moreover, hospitalization cost correlated moderately and statistically significantly with LOS (rho=0.612, p<0.005). Duration of surgery was correlated, weakly and statistically significantly with hospitalization cost (rho=0.298, p=0.001) and surgery cost (rho=0.390, p<0.0005).

Difference was found between males and females regarding duration of surgery. Specifically, the mean duration of surgery was longer in males (157.5 minutes) than in females (138.4 minutes) (**table 3**). Lastly, there was no statistically significant difference between patients' gender and outcome (death or not during or after the surgery) (x^2= 2.06, df = 1, p>0.05).

DISCUSSION

The goal of this study was to evaluate the cost-effectiveness of hepatobiliary surgery highly standardized operative protocol, that minimize intraoperative and postoperative costs, implemented by the same surgical team, in a Greek university hospital for a five-year period (2012-2016). This is the first study in which the evolution of cost was observed, when the same surgical team implemented the same standardized operative protocol many times. The results of this study will allow the exchange of information, among researchers and care providers worldwide, and may enable their implementation in everyday clinical practice worldwide.

Liver surgery for malignant and benign tumors used to be associated with individually increased mortality and morbidity.[19–22] Improvements in surgical performance and anesthesia, understanding of liver structure and function, better imaging, improvements in surgical technology, and accretion of experience have contributed to an acute decrease in mortality, less blood loss, less postoperative pain, fewer wound infections, and shorter hospital stay.[12,13,23] This upturn in surgery allowed the application of laparoscopic techniques in liver resection and later on robotics .[13,24,25] Prior to the establishment of laparoscopic and robotic liver resection and the ever-increasing use of energy devices and expendables, studies about perioperative and hospitalization cost were scarce.

In this study, it was found that the majority of patients that underwent hepatectomy, did not need ICU admission (91.3 %) or re-laparotomy for bleeding (98.4 %), only 6 (4.7 %) patients died during or after the surgery, while the mean total hospitalization and surgery cost was 4,729 € and 673€. These results indicated that this standardized operative protocol of liver resection is cost-effective due to the low number of deaths and complications that lead patient to ICU and to re-laparotomy. Moreover, these results are on the line with those of past studies assessing open liver resection in terms of clinical outcomes, perioperative parameters, and cost.[9,26,27] Although, the mean LOS was 13.46 days, which was higher than this that was observed in patient underwent laparoscopic liver resection in previous studies .[28–30]

This study has some limitations. It is a retrospective study of local data, and the presence of selection biases or elusive variables is possible. All financial data came from a single institution reducing the generalization of our results to other populations, clinical settings, and countries. One limitation of this study would be that the fees of the healthcare personnel has not be accounted for, although they have been subject to income deductions during the study period. Implementation of these amounts would directly affect the comparison with previously reported case series.

CONCLUSIONS

In conclusion, this protocol allows the performance of hepatectomies with a significantly decreased cost without compromising patient outcomes. Application of this protocol, in financially struggling institutions that cannot afford laparoscopic, robotic, or open liver surgery using expensive disposables is feasible. Accumulation of experience in this protocol is mandatory to achieve clinical and economical effectiveness.

Last but not least, all the new surgical techniques should be evaluated regarding their safety, clinical effectiveness, the learning curve surgeons encounter when adopting a new approach and their pre- peri- and post-operative costs, particularly given the economic implications for many healthcare systems of countries that struggle financially and apply health budget cuts.[31–33]

Conflict of interest

The authors declare that they have no competing interests.

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ANNEX

Table 1. Demographics and characteristics of the 127 patients that underwent hepatectomy.

	N (%), mean ± SD
Sex	
Female	68 (53.54)
Male	59 (46.46)
Age	62.12 ± 13.55
Length of stay (days)	13.46 ± 17.31
Duration of surgery (minutes)	147.34 ± 54,46
Re-laparotomy for bleeding	
Yes	2 (1.57)
No	125 (98.43)
ICU Admission	
Yes	11 (8.67)
No	116 (91.34)
Blood transfusion	
Yes	66 (51.97)
No	61 (48.03)
Outcome	
Death	6 (4.72)
Improvement	121 (95.28)

Note. ICU, Intensive Care Unit; SD, Standard Deviation

Table 2. Information regarding hepatectomies.

	N (%), mean ± SD
Type of surgery	
<2 seg	50 (41)
>3 seg	51(41,8)
Metastasectomy	21 (17,2)
Tumor volume (gr)	426.1 ± 374.2
Type of tumor	
Benign	36 (29)
Malignant	88 (71)
Hospitalization cost (€)	
2012	3,740 ± 2,797
2013	6,357 ± 9,421
2014	5,207 ± 3,029
2015	3,769 ± 1,512
2016	3,689 ± 1,641
Total	4,729 ± 5,486
Surgery cost (€)	
2012	837 ± 966
2013	925 ± 974
2014	891 ± 1,195
2015	142 ± 219
2016	342 ± 526
Total	673 ± 916

Note. Seg, segment; NALR, nonanatomic liver resection

Table 3. Student's t-test results and descriptive statistical indicators by gender (Hepatectomies).

Indicators	Gender						95% CI		
	Female			Male					
	M	SD	n	M	SD	n		t	df
LOS (days)	21.1	±18.9	68	20.6	±16.4	59	-4.7, 5.7	0.15	125
Surgery duration (minutes)	138.4	±51.6	68	157.5	±56.2	59	-34.9, -3.2	-1.98*	125
Tumor volume (gr)	423.8	±389.9	68	429	±358.8	59	-115.9, 105.5	-0.08	125
Hospitalization cost (€)	4,488	±2,897	68	5,011	±7,482	59	-2,248, 1,201	-0.50	125
Surgery cost (€)	630	±948	68	723	±881	59	-363, 177	-0,56	125

Note. M, mean; SD, standard deviation, CI, confidence interval, t, student's t-test; LOS, Length of Stay

* Pvalue <0.05.