ORIGINAL ARTICLE

# Initial experience of minimally invasive liver resection at a reference center in Mexico

## *Experiencia inicial de hepatectomía de mínima invasión en un centro de tercer nivel en México*

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## Abstract

**Objective:** *Minimally invasive liver resection is employed worldwide for the management of benign and malignant liver lesions. There is no description of postoperative outcomes in the Mexican population. This study aims to report the initial experience in Mexico.* **Method:** *A cross-sectional analysis was performed on 20 patients undergoing minimally invasive liver resection between 2018 and 2024 at a reference center in Mexico. Quantitative variables are reported as mean ± standard deviation or median with range, while qualitative variables as frequencies with percentages.* **Results:** *The most frequently performed procedures were left lateral sectionectomy in five cases, 7/20 were classified as intermediate and 10/20 as expert difficulty, according to the IWATE scoring criteria. Additional results included major complication (35%), intrahospital mortality (5%), surgical reintervention (0%), median hospital length of stay (6 [3-54] days) and R0 resection rate (76.9%).* **Conclusions:** *The initial experience of minimally invasive liver resection in Mexico includes complex cases, with great difficulty according to the IWATE criteria, with comparable R0 resection rates.*

***Keywords:*** *Minimally invasive surgical procedures. Hepatectomy. Outcomes assessment. Learning curve.*

## Resumen

**Objetivo:** *La hepatectomía de mínima invasión se utiliza para el manejo de lesiones hepáticas benignas y malignas. No existe una descripción de los resultados postoperatorios en población mexicana. El siguiente estudio pretende reportar la experiencia inicial en México.* **Método:** *Se realizó un análisis transversal de 20 pacientes sometidos a hepatectomía de mínima invasión entre 2018 y 2024 en un centro de referencia en México. Los datos cuantitativos se reportan como media ± desviación estándar o mediana con rango, mientras que los cualitativos como frecuencias con porcentajes.* **Resultados:** *Los procedimientos realizados con mayor frecuencia fueron la seccionectomía lateral izquierda en cinco casos, 7/20 siendo clasificadas como dificultad intermedia y 10/20 como experto, de acuerdo con la escala IWATE. Resultados adicionales: complicación mayor (35%), mortalidad intrahospitalaria (5%), reintervención quirúrgica (0%), mediana de estancia hospitalaria (6 [3-54] días) y tasa de resección R0 (76.9%).* **Conclusiones:** *La experiencia inicial de hepatectomía por mínima invasión en México incluye casos complejos, de alta dificultad, de acuerdo con la escala IWATE, con tasas similares de resección R0.*

***Palabras clave:*** *Hepatectomía de mínima invasión. Resección hepática. Curva de aprendizaje. Resultados postoperatorios.*

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# Introduction

In recent years, minimally invasive liver surgery has gained ground in clinical practice worldwide and has gradually become the standard for the management of liver parenchymal lesions, whether solid or cystic, and benign or malignant.[1] Since the first description of a laparoscopic wedge resection by Reich et al.[2], progress in the development of minimally invasive surgery for liver lesions has increased steadily over the last two decades, making it technically feasible and associated with complication and mortality rates similar to, or even better than, those of open liver resections.[1,3,4] Minimally invasive hepatectomy is most widely performed for colorectal cancer metastatic to the liver, for which there is greater evidence of reduced length of stay, intraoperative bleeding, perioperative morbidity and mortality, and need for reintervention.[5-7] Similarly, in terms of long-term oncological outcomes, minimally invasive hepatectomy seems to be as effective as open hepatectomy regarding the R0 resection rate, recurrence of malignancy, and disease-free survival for hepatocellular carcinoma and intrahepatic cholangiocarcinoma.[8-10] Because of all these benefits, in recent expert meetings and in the development of international guidelines, minimally invasive hepatectomy has achieved a position as standard treatment for properly selected patients worldwide, as described in the 2017 Southampton consensus guidelines.[11]

Despite this international trend toward implementing minimally invasive hepatectomy as the standard management for liver lesions, in Mexico progress toward this new era has been slower, with little description in the literature regarding its performance and the postoperative outcomes of patients undergoing this procedure.

Therefore, it is necessary to describe the initial experience in Mexico with this procedure to identify areas for improvement and document the progress of this surgical technique in our country. The primary objective is to describe the initial experience with minimally invasive hepatectomy at a tertiary care center in Mexico, evaluating the prevalence of complications and mortality in the immediate postoperative period, during hospitalization, or within the first 30 postoperative days. The secondary objectives were to evaluate the need for admission to the intensive care unit (ICU), the need for reintervention, length of hospital stay, the need for postoperative transfusion, the need for surgical reintervention, and mortality at 90 postoperative days.

## Method

This was a retrospective, cross-sectional observational study that followed the methodology described by the STROBE (STrengthening the Reporting of OBservational Studies in Epidemiology) guidelines, including their checklist.

The study was approved by the Human Research Ethics Committee of our center, under registration No. SCI-4853-23-24-1. All patients who underwent minimally invasive hepatectomy between January 2018 and January 2024 were reviewed. Their preoperative characteristics, perioperative and postoperative information, including surgical indication, selected hepatectomy technique, previous neoadjuvant interventions, duration of surgery, intraoperative bleeding, postoperative complications, reported according to the Clavien-Dindo classification, considering Clavien-Dindo ≥ III as a major complication, length of hospital stay, ICU admission, need for reintervention, 30-day mortality, and 90-day mortality, were reviewed. Patient information was obtained from the institute's electronic medical record, as well as from outpatient follow-up notes. Data collection ended in April 2024.

## Surgical technique

The surgical technique was standardized across all cases and was consistent with former descriptions of laparoscopic hepatectomy.[12] All patients underwent the procedure through 11-mm supraumbilical incisions for optical trocar placement using the Hasson technique, with pneumoperitoneum of 12-15 mmHg. Diagnostic laparoscopy was performed, followed by placement of auxiliary ports under direct visualization, varying in number according to each surgeon's preference. Umbilical tape, a Nelaton catheter, or a chest tube was placed through the foramen of Winslow for the Pringle maneuver in all cases, although the maneuver was performed only in those in which it was considered necessary (n = 14, 70%), as described in figure 1. Depending on the location of the lesion, as well as whether vascular structures were invaded, liver resection was performed according to the Brisbane classification.[13] In cases in which it was necessary, conversion to open surgery was performed through a midline or right subcostal incision, depending on the indication for conversion.

Data are expressed as mean ± SD or as median and range for parametric or nonparametric continuous variables, respectively, and as frequencies with percentages for categorical variables.

To analyze postoperative outcomes according to the degree of difficulty of the resection, measured by the IWATE criteria, patients were divided into two groups: those with a low degree of difficulty, with low and intermediate scores on the IWATE scale, and those with a high degree of difficulty, with advanced and expert scores on the same scale. The chi-square test, Fisher's exact test, and Mann-Whitney U test were used to compare these groups.

Statistical analyses were performed using SPSS (IBM SPSS Statistics for Mac, v. 25.0). The level of statistical significance was $p < 0.05$ ($\alpha = 0.05$).

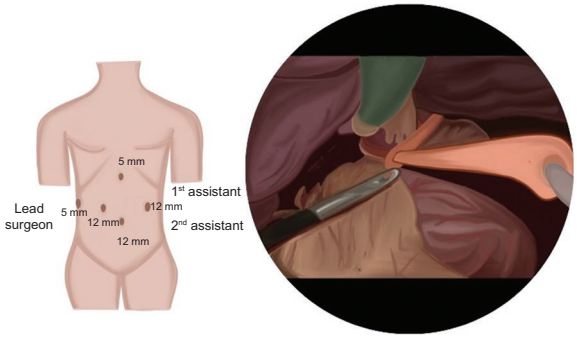


**Figure 1.** *The image on the left shows the distribution and standard size of the ports used at our center, as well as the position of each member of the surgical team. The image on the right shows how a Nelaton catheter is placed around the hepatic pedicle, through the foramen of Winslow, to perform the Pringle maneuver laparoscopically when necessary* (images by the authors).

## Results

Twenty out of a total of 183 patients who underwent hepatectomy for a benign or malignant liver lesion during the established time period were operated on using a minimally invasive technique, representing 10.9% of the patients operated on during the study period. Eleven (55%) patients were men, and 9 (45%) were women. The median age was 64.45 (23-83) years, and the median body mass index (BMI) was 24.73 (20.57-34.96) kg/m². Four (20%) patients had diagnosed liver cirrhosis, all classified as Child-Pugh A. The remaining baseline characteristics of the patients are summarized in table 1.

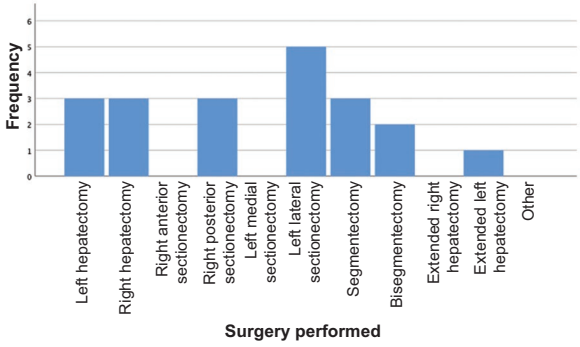


**Figure 2.** *Distribution of liver resections performed in the patients included in the study according to the Brisbane classification* (image by the authors).

### *Postoperative outcomes*

The type of liver resection and details related to surgery are summarized in table 2 and figure 2. Four patients (20%) had liver cirrhosis diagnosed before surgery, and 2 (10%), metabolic dysfunction-associated steatotic liver disease. Ten (50%) major hepatectomies were performed, 3 of which were right hepatectomies, 3 left hepatectomies, 3 right posterior sectionectomies, classified as major hepatectomy because of their degree of difficulty, and 1 extended left hepatectomy. Additionally, in 2 of the patients who underwent right hepatectomy, complete caudate resection was necessary. Ten (50%) minor hepatectomies were performed, of which the most frequent resection was left lateral sectionectomy, with five cases, followed by three isolated segmentectomies and two bisegmentectomies. A total of 18 (90%) of these surgical procedures were performed laparoscopically, whereas 2 (10%) were performed hand-assisted laparoscopically. Only 3 (15%) patients required conversion to open surgery, 2 because of bleeding that was difficult to control using laparoscopic hemostatic methods and one because of the complexity of laparoscopic resection, after multiple adhesions that hindered dissection were found. The laparoscopic resection difficulty score was calculated for all patients according to the IWATE criteria; based on this classification, 2/20 resections were considered low difficulty, 7/20 intermediate difficulty, 1/20 advanced difficulty, and 10/20 expert difficulty (Fig. 3). The median operative time was 300 (150-625) minutes, with a median estimated blood loss of 500 (100-2400) mL. Six (30%) patients required intraoperative transfusion, and in 14 (70%) resections the Pringle maneuver was used at least once, with a median Pringle time of 42 (15-105) minutes.

**Table 1. Baseline characteristics of the patients included in the study**

| Variable | n (%) | Mean ± SD/median (range) |
|---|---|---|
| **Demographic characteristics** | | |
| Sex | | |
| Male | 11 (55%) | |
| Female | 9 (45%) | |
| Age, years | | 64.45 (23-83) |
| BMI, kg/m$^2$ | | 24.73 (20.57-34.96) |
| ASA | | |
| I | 3 (15%) | |
| II | 4 (20%) | |
| III | 11 (55%) | |
| IV | 2 (10%) | |
| V | 0 (0%) | |
| VI | 0 (0%) | |
| **Comorbidities** | | |
| Chronic hepatitis | 1 (5%) | |
| MASLD | 2 (10%) | |
| Liver cirrhosis | 4 (20%) | |
| Child-Pugh | n = 4 | |
| A | 4 (100%) | |
| B | 0 (0%) | |
| C | 0 (0%) | |
| MELD-Na | | 8 (7-10) |
| CCI | | 7.5 (0-13) |
| Alcohol use disorder | 9 (45%) | |
| Smoking | 7 (35%) | |

ASA: preoperative risk according to the American Society of Anesthesiologists classification; CCI: Charlson Comorbidity Index; BMI: body mass index; MASLD: metabolic dysfunction-associated steatotic liver disease; MELD-Na: Model for End-Stage Liver Disease-Sodium.

**Table 2. Technical details related to the surgeries performed**

| Variable | n (%) | Mean ± SD/median (range) |
|---|---|---|
| Degree of liver resection | | |
| Minor hepatectomy | 10 (50%) | |
| Major hepatectomy | 10 (50%) | |
| Caudate resection | 2 (10%) | |
| Approach | | |
| Laparoscopic | 18 (90%) | |
| Hand-assisted laparoscopic | 2 (10%) | |
| Conversion to open surgery | 3 (15%) | |
| Operative time, min | | 300 (150-625) |
| Blood loss, cc | | 500 (100-2400) |
| Intraoperative blood transfusion | 6 (30%) | |
| Use of the Pringle maneuver | 14 (70%) | |
| Pringle time, min | | 42 (15-105) |

SD: standard deviation.

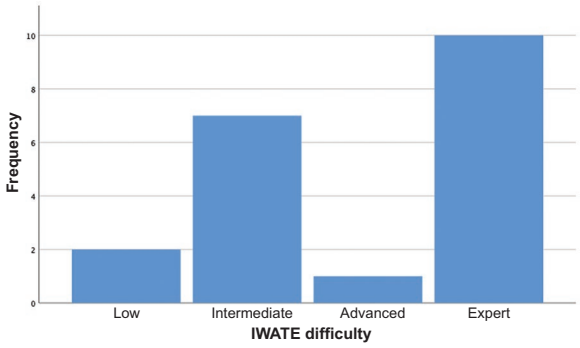


**Figure 3.** *Distribution of the degree of difficulty of laparoscopic liver resection according to the IWATE criteria* (image by the authors).

Short-term postoperative outcomes are summarized in table 3. Seven (35%) patients developed a major complication. These complications included bleeding, 2 patients; duodenal perforation, 1; intra-abdominal collections requiring drainage by interventional radiology, 1; pleural effusion requiring drainage, 2; and death, 1. In the latter case, the patient had Child-Pugh A liver cirrhosis as a comorbidity before liver resection, which consisted of right hepatectomy without caudate resection; she developed postoperative liver failure, ascites, and multiorgan failure, ultimately dying 11 days after surgery. Three (15%) patients required admission to the intensive care unit, and none required surgical reintervention within the first 30 days. Additionally, one (5%) patient was readmitted within the first 30 days because of secondary abdominal sepsis. The median hospital stay was 6 (3-54) days. Likewise, at 90-day follow-up, no additional deaths were recorded beyond the one already mentioned, 1/20, 5%.

The histopathological results of the lesions are summarized in table 4. Seventeen (85%) patients had a unifocal lesion, whereas 3 (15%) had multifocal lesions, all with 2 lesions, all corresponding to colorectal cancer metastases. The mean tumor size was 69.3 ± 51.23 mm, and R0 resection was achieved in 10 (76.9%) patients with malignant lesions. The most common diagnoses were hepatocellular carcinoma, in 6 patients; colorectal cancer metastases, 4; non-colorectal cancer metastases, 3; and symptomatic simple cyst, 3.

**Table 3. Postoperative outcomes of patients undergoing minimally invasive hepatectomy**

| Variable | n (%) |
|---|---|
| Early major complication | 7 (35%) |
| Clavien-Dindo classification of early major complication | n = 7 |
| IIIA | 3 (42.8%) |
| IIIB | 0 (0%) |
| IVA | 1 (14.2%) |
| IVB | 2 (28.5%) |
| V | 1 (14.2%) |
| ICU admission | 3 (15%) |
| Decompensation of cirrhosis | n = 4<br>1 (25%) |
| Postoperative MELD-Na | 10 (8-35) |
| Surgical reintervention within the first 30 postoperative days | 0 (0%) |
| Death within the first 30 postoperative days | 1 (5%) |
| Length of hospital stay, days | 6 (3-54) |
| Hospital readmission within the first 30 postoperative days | 1 (5%) |
| Death at 90 postoperative days | 1 (5%) |

MELD-Na: Model for End-Stage Liver Disease-Sodium; ICU: intensive care unit.

**Table 4. Histopathological results of the specimens obtained after resection**

| Variable | n (%) / mean ± SD |
|---|---|
| Malignant etiology | |
| Hepatocellular carcinoma | 6 (30%) |
| Stage IA | 1 (16.6%) |
| Stage IB | 2 (33%) |
| Stage II | 2 (33%) |
| Stage IIIA | 1 (16.6%) |
| Colorectal cancer metastasis | 4 (20%) |
| Noncolorectal cancer metastasis | 3 (15%) |
| Benign etiology | |
| Focal nodular hyperplasia | 1 (5%) |
| Hepatocellular adenoma | 1 (5%) |
| Hepatic hemangioma | 1 (5%) |
| Simple cyst | 3 (15%) |
| Hydatid cyst | 1 (5%) |
| Number of lesions | |
| 1 lesion, unifocal | 17 (85%) |
| 2 or more lesions, multifocal | 3 (15%) |
| Tumor size, maximum lesion diameter, mm | 69.3 ± 51.23 |
| Surgical margin | |
| R0 | 10 (76.9%) |

SD: standard deviation.

### *Comparison by groups according to the degree of resection difficulty*

In the group comparison, 9 patients were categorized as having a lesion with a low degree of difficulty for resection, whereas 11 had a lesion with a high degree of difficulty. Patients with a high degree of difficulty had a higher prevalence of major complications, 6/11, 54.5%, compared with patients with a low degree of difficulty, 1/9, 11.1%, without reaching a statistically significant difference (p = 0.07). The remaining postoperative outcomes also did not show a statistically significant difference between groups (Table 5).

## Discussion

Minimally invasive hepatectomy has become, in recent years, a standard management approach for liver lesions, whether benign or malignant, solid or cystic, and can be performed safely in properly selected patients, even in the presence of liver cirrhosis.[14] In this study, we present the initial experience in our setting with minimally invasive resection of liver lesions. The population undergoing minimally invasive hepatectomy in our experience had a large number of comorbidities, but the prevalence of liver cirrhosis was lower, 4/20 patients, all of whom had Child-Pugh grade A. Major complications observed within the first 30 postoperative days occurred in 35% of the population, with one death in the immediate postoperative period, 5%. The latter was due to postoperative liver failure in a patient with stage IA hepatocellular carcinoma measuring 1.8 × 1.5 cm, who underwent right hepatectomy with expert-level difficulty according to the IWATE classification and had Child-Pugh grade A liver cirrhosis. The surgical intervention in this patient did not generate any intraoperative complication, with minimal bleeding, 300 cc, and an operative time of 442 minutes, without need for conversion.

Tranchart et al.[15] reported a complication rate of 21.4% in 140 patients undergoing minimally invasive hepatectomy, with 12.85% reaching the grade of major complication; additionally, they found that the incidence of complications increased by 60% with each additional hour of estimated operative time, with a mean operative time of 209 ± 119 min, whereas our experience involved longer procedures. This may be influenced by a difficult learning curve to overcome. In a review by Guilbaud et al. (2019)[16] of 13 articles

**Table 5. Comparison by difficulty groups according to the IWATE classification in postoperative outcomes**

| Variable | Low degree of difficulty (n = 9) | High degree of difficulty (n = 11) | OR (95% CI) | p |
|---|---|---|---|---|
| Major complication | 1 (11.1%) | 6 (54.5%) | 9.6 (0.87-105.1) | 0.07 |
| Hospital readmission | 1 (11.1%) | 0 (0%) | 1.12 (0.89-1.4) | 0.45 |
| ICU admission | 0 (0%) | 3 (27.2%) | 0.72 (0.5-1.04) | 0.21 |
| Death within the first 30 days | 0 (0%) | 1 (9.09%) | 0.9 (0.75-1.09) | > 0.99 |
| Hospital stay, median with range, days | 5 (3-7) | 8 (3-54) | - | 0.061 |
| Death at 90 postoperative days | 0 (0%) | 1 (9.09%) | 0.9 (0.75-1.09) | > 0.99 |

95% CI: 95% confidence interval; OR: odds ratio; ICU: intensive care unit.

that evaluated the learning curve for minor and major laparoscopic hepatectomies, the number of cases needed to reach this curve in minor laparoscopic hepatectomies was found to be highly variable, ranging from 15-60 cases, whereas for major laparoscopic hepatectomies, the range was 45-98 cases.

Regarding oncological outcomes, in a study by Rahimli et al.[17] comparing 13 patients who underwent laparoscopic hepatectomy with 12 who underwent robotic hepatectomy for metastatic colorectal carcinoma, the R0 resection rate was found to be 77% in the laparoscopic hepatectomy group. In our population, which included only 13 patients with malignancy, the R0 resection rate was 76.9%, similar to that reported in that study. Of the cases in which R0 resection was not achieved, 2 corresponded to metastatic lesions: 1 colorectal cancer metastasis and 1 pancreatic neuroendocrine tumor metastasis. Additionally, in a single-center, open-label, nonrandomized clinical trial by Stravou et al.[18] aimed at defining the sensitivity, specificity, and accuracy of intraoperative ultrasound for detecting colorectal metastases during hepatectomy, with a total of 47 patients, accuracy was found to be 98%, higher than that demonstrated by magnetic resonance imaging, computed tomography, and preoperative contrast-enhanced ultrasound, 93%, 72%, and 63%, respectively. Therefore, the use of intraoperative ultrasound increases the ability to detect malignant lesions during resection that were not detected preoperatively, and its use could increase the R0 resection rate.

Particularly in our population, the IWATE difficulty encountered was most frequently categorized as intermediate level, 7/20, or expert level, 10/20. This is because, even though the most frequent technique was left lateral sectionectomy, lesion size was large, with a mean of 6.6 ± 5 cm for hepatic cystadenomas, 15 ± 4.24 cm for hepatic cysts, 10 cm for hepatic hemangioma, and 14.5 cm for hepatocellular adenoma, most occupying more than one segment, which increases the degree of resection difficulty according to the IWATE criteria.[19] The high IWATE difficulty grade found in our experience appears to influence postoperative outcomes, specifically a higher grade of complications in the high-difficulty group compared with the low-difficulty group, 54.5% compared with 11.1%, p = 0.07, as demonstrated by the analysis by difficulty groups.

The results obtained and contrasted with the international literature may be explained by multiple factors: minimally invasive hepatectomy is a technique that is beginning to be performed in Mexico, still in the learning-curve phase, which, because of the characteristics of our hospital, includes patients with lesions of high resection difficulty.

Our study has numerous limitations: the population is small, which does not allow us to perform multivariate analyses to identify predictors of complications in our population. Similarly, the rate of major complications observed may be due to the growing learning curve in our setting, which requires a larger number of cases. In addition, the analysis was carried out without a comparison of patient subgroups to explain the occurrence of these complications.

Although the population is small, maintaining a registry of operative outcomes with an innovative technique is essential to detect areas for improvement. Sánchez-Clariá et al.[20] demonstrated this by publishing their initial experience of 26 cases, involving benign lesions and a large proportion of minor hepatectomies, in which minimally invasive hepatectomy as an initial experience was shown to be safe but performed in a small proportion, with only 6% of hepatectomies at their center being laparoscopic,

something similar to what was observed at our center, with only 20/183 (10.9%) cases being minimally invasive.

## Conclusions

Based on the foregoing, minimally invasive hepatectomy is a surgical technique with which initial experience is still being gained in our country, with a difficult learning curve to overcome and cases with a high IWATE difficulty grade. It is necessary to continue developing this technique, whose beneficial outcomes have been widely demonstrated in other practice settings.

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The authors declare that they received no funding for this study.

## Conflicts of interest

The authors declare that they have no conflicts of interest.

## Ethical responsibilities

**Protection of humans and animals.** The authors declare that no experiments on humans or animals were performed for this research.

**Confidentiality, informed consent, and ethical approval.** The authors obtained approval from the Ethics Committee for the analysis of routinely obtained and anonymized clinical data. Because of the nature of the study, individual informed consent was not necessary. The relevant ethical recommendations were followed.

**Declaration on the use of artificial intelligence.** The authors declare that no type of generative artificial intelligence was used for the writing or creation of content in this manuscript.

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