DOI: https://doi.org/10.11144/Javeriana.umed60-2.curv

Experience and Learning Curve of Laparoscopic Appendectomy and Cholecystectomy of General Surgery Residents in a Latin American Hospital

Experiencia y curva de aprendizaje de apendicectomía y colecistectomía laparoscópica de los residentes de cirugía general en un hospital latinoamericano

Received: 04 July 2018 | Accepted: 01 November 2018

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ABSTRACT

Introduction: Laparoscopic surgery has revolutionized the surgical management of patients, generating a need for training in the area. Performance in real life is what allows a global determination of the competences in a procedure and establishes a training method. The objective of this study is to describe the evolution in the surgical experience of a group of general surgery residents. **Methodology:** Observational analytical study of a retrospective cohort at the Hospital Universitario San Ignacio. It included 4191 surgical procedures divided in 1045 laparoscopic appendectomies (LAs) and 3146 laparoscopic cholecystectomies (LCs) performed by a total of 52 residents between January 2008 and December 2014. **Results:** Both LAs and LCs showed an increase in the number of annual procedures. When comparing the mean times of LA per year of residency training, a decreasing trend in the median was observed, as the resident advanced in his/her training. Intraoperative complications were 0.77% for LA and 1.9% for LC; the most common postoperative complication was surgical site infection (SSI) and mortality was <0.5%. **Conclusion:** The results show the need to continue with residency programs that provide adequate training in the laparoscopic approach, possibly with increasingly early exposure to minimally invasive procedures.

Keywords
learning curve; laparoscopic cholecystectomy; laparoscopic appendectomy; residents.

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How to cite: Cuevas López L, Cortés Murgueitio N Díaz Castrillón CE, Pinzón F, Molina GR. Experience and learning curve of laparoscopic appendectomy and cholecystectomy of general surgery residents in a Latin American hospital. Univ. Med. 2019;60(2). https://doi.org/10.11144/Javeriana.umed60-2.curv

RESUMEN

Introducción: La cirugía laparoscópica ha revolucionado el manejo quirúrgico de los pacientes y ha generado una necesidad de capacitación en el área. El rendimiento en la vida real es lo que permite una determinación global de las competencias en un procedimiento y establece un método de formación. El objetivo de este estudio es describir la evolución en la experiencia quirúrgica de un grupo de residentes de cirugía general. **Metodología:** Estudio observacional analítico de cohorte retrospectiva en el Hospital Universitario San Ignacio. Incluyó 4191 procedimientos, divididos en 1045 apendicectomías laparoscópicas (AL) y 3146 colecistectomías laparoscópicas (CL), realizadas por un total de 52 residentes entre enero de 2008 y diciembre de 2014. **Resultados:** Tanto en AL como en CL se observó un aumento en el número de procedimientos anuales. Al comparar los tiempos promedios de AL por año de residencia, se observó una tendencia a la disminución en la mediana a medida que el residente avanzaba en su entrenamiento. Las complicaciones intraoperatorias fueron del 0,77% para AL y del 1,9% para CL. La complicación postoperatoria más frecuente fue infección del sitio operatorio, con una mortalidad menor al 0,5%. **Conclusión:** Los resultados muestran la necesidad de continuar con programas de residencia que proporcionen preparación adecuada en el abordaje laparoscópico, posiblemente con exposición cada vez más temprana a procedimientos mínimamente invasivos.

Palabras clave

curva de aprendizaje; colecistectomía laparoscópica; apendicectomía laparoscópica; residentes.

Introduction

Laparoscopic surgery has revolutionized the surgical management of patients with various pathologies. This has created the need for training in the area and a change in general surgery training programs (1,2) through technology, simulation equipment in organic, inorganic or virtual models (3,4). The American Board of Surgery and the Accreditation Council for Continuing Medical Education consider this training a priority. For this reason, they have developed the course Fundamentals of Laparoscopic Surgery as a requirement to approve the residency course. Although it is possible to evaluate the performance using simulators, training in laparoscopic surgery in a university hospital must be accompanied by quality control (5) in which the measurement and quantification of demographic and clinical outcomes data undergo descriptive evaluation so that ideas emerge on the best way to develop and teach these competences (6,7).

Laparoscopic appendectomy (LA) and laparoscopic cholecystectomy (LC) are the most performed general surgical procedures in the world (8,9), and are performed early in the surgery resident's training. These procedures offer an opportunity to master necessary skills before performing more complex procedures (10,11).

The aim of this study is to describe the evolution in the surgical experience of a group of general surgery residents, and the LA and LC morbidity and mortality trend at the Hospital Universitario San Ignacio during the period between January 2008 and December 2014. We expect that these results guide the training process of general surgery residents at university hospitals.

Materials and methods

An observational analytical retrospective cohort study was conducted in which we reviewed medical records taken from the institutional database. 3146 LCs and 1045 LAs carried out between January 1, 2008 and December 31, 2014 were included. In the case of LCs, elective and emergency procedures were evaluated. A total of 52 residents were analyzed, 10 of whom were fully followed up on their learning curve throughout their training time, and 6 withdrew before finishing their training.

The following demographic variables were analyzed: age, American Society of Anesthesiologists (ASA) anesthetic risk classification, severity grading according to the 2013 Tokyo Guidelines (12), and pathology report. The recorded outcomes were: operative time (minutes), hospital stay (days), and intraoperative complications: hollow viscus injury, conversion to open surgery, bile duct injury (according to Strasberg classification) (13) and bleeding (greater than 500 cm^3). The postoperative complications evaluated (at 30 days) were: unplanned reoperation, surgical site infection (SSI), bleeding and mortality.

We excluded records with incomplete data, surgeries in which an additional surgery was performed, and procedures performed by instructors. It is necessary to make it clear that all surgeries performed at the hospital are performed under in-person supervision in the operating room.

Surgical technique and follow-up

The abdominal cavity was accessed by 10 mm umbilical incision using the Hasson technique, pneumoperitoneum insufflation and diagnostic laparoscopy. In LAs, 5 mm and 10 mm trocars were placed under direct vision in the suprapubic region and in the left iliac fossa. The mesentery and the appendicular artery were managed with different types of energy: LigaSure™ (ValleyLab, Inc., Boulder, Colorado), HARMONIC ACE® + Shears (Ethicon Endo-Surgery, Cincinnati, OH) or monopolar electrocautery, according to the treating surgeon's criteria and the degree of inflammation of the tissues. Once the base was fully identified, it was ligated with Hem-O-Lok® (Weck Closure Systems, Research Triangle Park, Durham, NC, USA). To retrieve the surgical piece, a bag was used when the appendix was in gangrenous phase or with peritonitis, and in the latter case, the cavity was irrigated with saline and dried exhaustively.

For LCs, a 10 mm trocar was placed in the epigastrium and two 5 mm trocars in the right upper quadrant. The structures of the hepatocystic triangle were dissected and Strasberg's safety vision was obtained (14). The cystic artery and the cystic duct were clipped with metal clips and cut with scissors. In case of thick cystic duct, Hem-O-Lok was used. The gallbladder was dissected from the liver bed with monopolar electrocautery, in order to retrieve it through the epigastric port. Both for LAs and LCs, the patients were discharged after controlling the pain, when there was no systemic inflammatory response and the oral route was well tolerated.

Statistical analysis

Quantitative variables were analyzed with central tendency and dispersion measures, and qualitative variables with relative frequencies (percentages) and proportions. The Microsoft Excel 2016™ program was used to organize the variables and calculate proportions and percentages. The Stata version 8.0 program (Statacorp, College Station, TX) was used for the univariate and multivariate analysis, and nonparametric hypothesis tests were performed to compare the independent groups (Mann-Whitney U and Kruskall-Wallis) with p values <0.05.

Ethical aspects

This is an analytical observational study and therefore no intervention was carried out with the participants; it is rated as a "no risk" study, according to Resolution 008430 of 1993 of the Ministry of Health of Colombia. The criterion of respect for the autonomy and dignity of the subjects included in the study prevailed throughout the study, as well as that of protection of their rights, information and welfare.

Since this is a review of medical records of a university hospital, it was required that it be submitted to the research committee of the Surgery Department, and that it be approved by the Hospital Research Committee. In the approval it was recorded that there is no direct intervention on the patient, which is why informed consent is not required. In addition, this study was conducted under the ethical standards of the latest official version of the Declaration of Helsinki.

Results

Laparoscopic appendectomy

Patient demographic data are shown in Table 1. The majority of patients were women, were classified as ASA I, and the most common

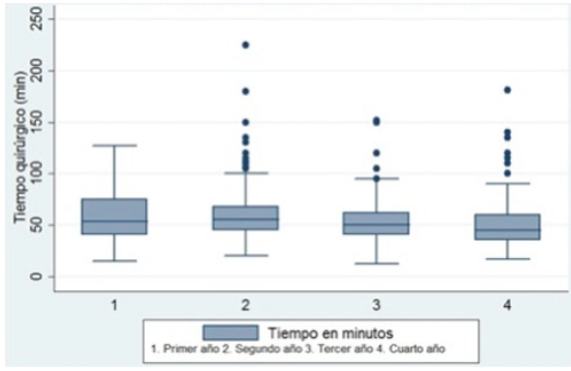
pathology was acute edematous/fibrinopurulent appendicitis. The mean hospital stay was 1.66 days (SD: 1.91). There was a sustained growth in the number of procedures, globally and per year of residency training; the number of LAs increased from 12 in 2008 to 456 in 2014.

Table 1
Demographic and clinical data of the analyzed population (n = 4191)

Appendectomy (n = 1045)		
Age (mean/SD)	36.99	16.27
Women (%)	52	
	n	**%**
ASA		
1	708	67.75
2	292	27.94
3	43	4.11
4	2	0.19
Pathology		
Edematous/fibrinopurulent	750	71.77
Gangrenous	233	22.30
Peritonitis	60	5.74
Cancer	2	0.19
Total	**1045**	**100**
Cholecystectomy (n = 3146)		
Age (mean/SD)	48.77	17.1
Women (%)	64	
	n	**%**
ASA		
1	1554	49.40
2	1333	42.37
3	257	8.17
4	2	0.06
Pathology		
Acute/chronic	2823	89.73
Gangrenous	316	10.04
Peritonitis	1	0.03
Cancer	6	0.19
Severity		
Symptomatic cholelithiasis	716	22.76
Tokyo I	1625	51.65
Tokyo II	800	25.43
Tokyo III	5	0.16
Total	**3146**	**100**

The mean operative time was 56.55 min with a SD of 25.63. When evaluating the times per year of residency training, the mean was 58.24 min (SD: 21.6) and a median of 55 for the first year; 61.1 minutes (SD: 24.7) and a median of 55 for the second year; 53.84 minutes (SD: 26.2) and a median of 50 for the third year, and 51.33 minutes (SD: 32.6) and a median of 45 for the fourth year. As shown in Figure 1, there was a decreasing trend in the median and in the interquartile range in the data distribution, without being statistically significant.

Figure 1
Surgical time for laparoscopic appendectomy by residency level



The mean operative time according to the severity and the histopathological report was 51.67, 66.77 and 76.80 min for edematous/fibrinopurulent appendicitis, gangrenous appendicitis and peritonitis, respectively. When comparing the operative times between edematous/fibrinopurulent and gangrenous appendicitis, the difference was statistically significant, with a p value > 0.05. An inverse relationship was documented between the mean operative time according to the pathology and the year of residency training, as shown in Table 2.

Table 2
Surgical time, in minutes, according to the pathology and year of residency training

	R1	R2	R3	R4
Edematous/fibrinopurulent				
Mean	54.92	53.43	50.51	45.68
Standard deviation	22.21	19.18	20.18	20
Median	50	50	45	40
Interquartile range	40-75	40-60	35-60	30-55
Gangrenous				
Mean	72.77	69.75	60.12	62.5
Standard deviation	25.82	28.11	22.53	30
Median	70	60	55	50
Interquartile range	55-85	50-80	45-75	40-80

Complications

There were 8 intraoperative complications (0.77%), 3 due to bleeding, and 5 related to hollow viscus injury, 4 (80%) of which were caused by third and fourth year residents. There were a total of 28 patients (2.68%) with conversion to open surgery. The main cause were

technical difficulties in the management of the appendicular base (25 patients); 11 (44%) of these cases occurred with second year residents.

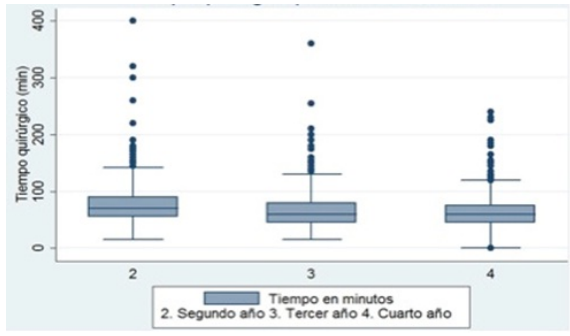
The most common postoperative complication was SSI, with 30 cases (2.87%), followed by adynamic ileus, with 25 cases (2.39%). Overall and within the course of time, the general behavior of intraoperative complications, conversions to open surgery, ileus, SSIs and readmissions decreased by year of residency training. A mortality of 0.57% was documented (n = 6).

Laparoscopic cholecystectom

Table 1 shows the demographic data. There was an increase in the annual number of LCs, with 370 in 2008 and 563 in 2014. This showed a greater exposure of residents to procedures in direct relation with time. This exposure was greater in the second year of residency training, with 1433 cholecystectomies performed, compared to 898 for third year residents, and 815 for fourth year residents. 77% of the LCs were performed in the context of acute cholecystitis, 67% of which were classified as Tokyo I. The mean hospital stay was 1.54 days (SD: 3.4).

The mean operative time was 69.87 min (SD: 30.78) with a median of 60 min, and 50-85 interquartile range. The surgical time decreased as the residency level advanced (Figure 2). When comparing the operating time per year of residency training, the mean times were 74.7, 66.9 and 64.5 min for second, third and fourth year residents, respectively. There was a statistically significant difference (p value <0.05) of the mean times in the Kruskall-Wallis test, and was higher in the LCs performed by second year residents.

Figure 2
Surgical time for laparoscopic cholecystectomy by level of residence



Likewise, when comparing between operative times of the second and third years, and between those of the third and fourth years, we found lower mean times as residents progressed in their residency training, with p values < 0.05.

The evaluation of the mean operative time according to the clinical severity as per Tokyo classification showed that it increased as the severity increased (Table 3). In addition, when comparing the severity according to the histopathological report and the mean time, there was a statistically significant difference (p value < 0.05), with mean times in acute/chronic phase of 67.85 min (SD: 29.97), and 88.01 min (SD: 32.87) in gangrenous phase. These data show that, although the times were longer as the severity increased, they decreased when the surgeries were performed by more advanced year residents.

Table 3
Operative time, in minutes, according to the clinical severity and level of residency training

	R2	R3	R4	Total
Symptomatic cholelithiasis				
Mean	62.23	59.94	59.29	63.02
Standard deviation	33.54	23.55	24.04	29.56
Median	60	55	50	60
Interquartile range	50-80	45-71	40-60	45-75
Tokyo I				
Mean	72.57	65.55	62.55	67.93
Standard deviation	27.74	28.87	25.08	27.73
Median	65	60	60	60
Interquartile range	55-90	55-75	45-75	50-80
Tokyo II				
Mean	84.67	74.85	77.07	79.76
Standard deviation	34.09	35.52	34.97	34.99
Median	79	65	70	75
Interquartile range	60-105	50-90	55-90	55-96
Tokyo III				
Mean	55	103.75	0	94
Standard deviation	-	37.5	0	39.11
Median	55	110	0	85
Interquartile range	55-55	72.5-135	0	60-135

Complications

There were a total of 61 (1.9%) intraoperative complications, 30 of which (6.7%) corresponded to bleeding, 17 (3.8%) to hollow viscus injury, and 14 (0.45%) to bile duct injury. The majority were Strasberg type A (n = 8). There were a total of 98 postoperative complications (3.1%), 29 of which (0.92%) corresponded to reoperation, 13 (0.41%) to bleeding, 29 (0.92%) to SSI, and 43 (1.37%) to conversion to open surgery. Table 4 shows the relationship between complications and the level of residency training. The majority of complications occurred in patients operated by second year residents.

Table 4
Complications of laparoscopic cholecystectomy per year of residency training

	R2	R3	R4	Total
Intraoperative complications				
Bleeding (> 500 cm^3)	16	6	9	31
Hollow viscus injury	4	7	4	15
Bile duct injury	4	7	4	15
Postoperative complications				
Bleeding	7	3	2	12
Surgical site infection	13	8	7	28
Reoperation	8	13	8	29
Conversion to open surgery	16	13	14	43
Readmission at 30 days	73	57	39	169

Eight deaths were documented (0.25%), 4 of which were related to massive postoperative bleeding; 2 of these patients had a medical indication for anticoagulation and received perioperative bridging therapy according to institutional protocols.

Discussion

The results of this study show an overall increase in the number of LAs and LCs performed during the period studied, and that surgical times improve as residency training progresses. According to our hospital data, there was an increase in the proportion of LAs performed per year: from 0.72% in 2010, to 73% in 2014, and exposure to this procedure in earlier stages of residency training; as reported by like Carson et al. (15), where most of the procedures performed by general surgery residents between 1999 and 2008 were minimally invasive (3.7 to 11.2%, p = 0.00001). According to Chung and Ahmed (16), within 10 years the percentage of open surgeries will be reduced by 60%, except in cases of trauma. These data demonstrate the need for residency programs to provide adequate preparation in the laparoscopic approach, and possibly an increasingly early exposure to minimally invasive procedures (17,18).

In our study we can see that in the first years evaluated, there were few LCs and LAs, most of which were performed by third and fourth year residents, while in recent years there has been an increase in interventions performed by second year residents. In the case of LCs, this phenomenon was observed as of 2011, when approximately 50% of cholecystectomies were performed by second year residents. This indicates that in our department the learning curve takes place during this period. This increasingly early exposure within residency training had no statistically significant differences in morbidity and mortality outcomes; this may indicate that with adequate training and supervision, trainee surgeons can achieve a satisfactory level of competence in these procedures, without increasing the number of complications (19). Similarly, Jolley et al. (17) wrote about the participation of residents in basic laparoscopic procedures, LAs and LCs, which did not have significant differences in terms of

mortality, morbidity or reoperation, although in both surgeries the presence of the resident was associated with longer operative times, which were 60 minutes or more for LAs (20). In our case, the mean time for LAs was 56 min, with differences between the levels of residency training, but without exceeding the mean time reported in the literature, and 69 min for LCs, which was shorter than the results reported in other international studies (6,8,10, 11,21,22,23).

There was a decreasing trend in the mean and median operative time, both for LA and LC, according to the year of residency training; this decrease was statistically significant, when compared according to the clinical severity and the histopathological report in LC. Kauvar et al. (24) obtained similar results, and reported a longer mean time in the first years of residency training and, like our data, show that the duration of LA and CL decreases during the 4 training years, as residents gradually advance in the learning curve (6,25,26). As raised by Garg et al. (27), our study showed a direct relationship between the severity of the clinical picture and the operative time, which was longer in the case of gangrenous appendicitis and Tokio III cholecystitis.

The context analyzed and the results show that a structured laparoscopic surgery training in basic procedures during residency in a university hospital improves the residents' surgical skills (28,29). This through keeping a record of procedures performed, especially in academic programs, in which this process demonstrates that university hospitals meet the teaching objectives in the teaching of laparoscopic surgery, which is accompanied by a better control of the academic process quality.

A limitation of the present study is its retrospective nature, since there may be sub- or over-registration of the information. To document of the operative time, the anesthetic record was used, in which the time variable was recorded as an interval variable and not as a ratio interval. Furthermore, given the retrospective nature of the study, each resident was not taken into account individually, since the objective was to assess the training evolution according to the year of residency training, rather than the evolution of each individual resident, which would have required an analysis to control for confounding variables, such as previous laparoscopic training. However, we consider that, despite the descriptive nature of the study, the large number of cases allows identifying existing differences between each year of residency training.

Conclusion

We see that the number of laparoscopic procedures, specifically LAs and LCs, has increased over time, which has involved greater efforts to teach basic and complex laparoscopic skills in the general surgery residency program. These should focus mainly on the first two training years, when there is a greater exposure, with a decrease in the operative time that will occur progressively as more experience is acquired during the first residency years, and during the learning curve, in which the complexity of these procedures will increase. All this process will require a system to record and provide feedback on the processes carried out in a learning-healthcare context that allows keeping morbidity and mortality within the expected margins for a given procedure, within what is reported worldwide.

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