



Current Trends in Training in the Surgical Management of Acute Appendicitis at a Veteran Affairs Hospital

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INTRODUCTION: An open appendectomy used to be one of the most common cases performed by interns and physical exam dictated operative intervention. We hypothesized that the management of acute appendicitis has drastically changed from these previous practices.

METHODS: A retrospective, single institution study was performed at the VA North Texas Health Care System between July 2005 to June 2017 for all patients who underwent an appendectomy. Using postgraduate year (PGY)-level (PGY 1-3 and PGY 4-5) as a dependent variable, univariate analyses, and multiple logistic regression analyses were performed. All statistical tests were 2-sided, and the statistical significance level was set at a $p \leq 0.05$.

RESULTS: Only patients with acute appendicitis were included ($n = 257$; male = 90.7%; age = 45.4 ± 15.6 year old; body mass index = 30.3 ± 6.3 Kg/m²). Of these, only 8 were performed by interns, 25 by PGY-2, 147 by PGY-3, 22 by PGY-4, and 55 by PGY-5. On presentation, 92.2% of patients had a computed tomography scan and 90.7% underwent a laparoscopic appendectomy. Conversion rate was 4.7%. There were 20 complications (7.8%) and length of hospital stay was 2.2 ± 3.7 days. Comparing patients operated by senior (PGY-4 and 5) to junior (PGY-1 to -3) residents: patients were of similar age, gender, body mass index, American Society of Anesthesiologists (ASA), and had similar WBC and blood pressure on initial presentation (all p 's > 0.05); but were more likely to have diabetes mellitus, hypertension or pulmonary disease. Complication rate was the same (7.8%) for both senior and junior residents.

CONCLUSIONS: At the VA North Texas Health Care System, most patients presenting with suspected appendicitis

undergo a computed tomography scan. Most cases are performed laparoscopically mainly by PGY ≥ 3 residents. The rate of post-operative complications was similar between junior and senior residents.

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KEY WORDS: Acute abdomen, right lower quadrant pain, McBurney, Rocky-Davis

COMPETENCIES: Systems-Based Practice

INTRODUCTION

Acute appendicitis is one of the most common emergent operations performed by general surgeons in the United States. It has a lifetime incidence of 7% to 15% and accounts for one million hospital days of stay annually.¹ In 2006, 341,000 appendectomies were performed in the United States.²

An accurate physical exam for the diagnosis of acute appendicitis has been the hallmark of experienced surgical hands since Charles McBurney published the surgical description of point of maximal tenderness for acute appendicitis in 1891, which is still a key component for the diagnosis.³ However, even in experienced hands, the diagnosis of acute appendicitis based on clinical exam has a sensitivity of 83% and specificity of 44%.^{4–6} Computed tomography (CT) with intravenous and oral contrast has a sensitivity of 90% to 100%, specificity of 91% to 99%, positive predictive value of 95% to 97.9% and a negative predictive value of 99.5%.^{7,8} In children, the sensitivity and specificity of ultrasonography is 98%.⁵ At a Veteran Administration (VA) hospital, over 90% of patients with appendicitis receive a CT scan prior to a surgical consultation. Accompanying the increase in the imaging-based diagnosis of acute appendicitis

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is the sharp surge of the laparoscopic approach to an appendectomy, which increased from 43.3% in 2004 to 75.0% in 2011.⁹

Acute appendicitis is an excellent opportunity for interns and junior residents to gain substantial experience in the diagnosis, operative, and postoperative management of patients with this disease. Open and laparoscopic appendectomies are excellent procedures for senior residents to serve as teaching assistants to junior residents.¹⁰ However, current trends in the diagnosis and management of acute appendicitis might influence surgical training from the typical clinical diagnostic approach and open surgical intervention to the current imaging-based diagnosis and laparoscopic appendectomy practices.

The following study was undertaken to assess the current experience of surgical trainees in the management of acute appendicitis at a VA hospital. We also investigated the method of diagnosis and approach to an appendectomy by postgraduate year level. Finally, we compared the rate of complications between junior and senior residents.

METHODS

A retrospective, single institution analysis at the VA North Texas Health Care System of patients who underwent an appendectomy over the past twelve years (between July 2005 to June 2017) was conducted. We interrogated the operative room (OR) database for 345 patients who had an appendectomy and then reviewed each record in the Computer Patient Record System (CPRS) at our institution. This study was approved by the Institutional Review Board at the VA North Texas Health Care System. All data was reviewed and entered in an excel spreadsheet.

Seventy-two variables were extracted from CPRS: operative date, consultation date, date of last examination, operative time, approach to repair, physical examination findings on presentation, laboratory finding on presentation; demographics: age, gender, body mass index, ethnicity; social history: history of smoking, current smoking (defined as smoking within 6 weeks of the operation), history of alcohol use, current alcohol use (defined as drinking within 6 weeks of the operation); comorbid conditions: hypertension, diabetes mellitus, obstructive sleep apnea, dyslipidemia, liver disease (defined by a Child's score of at least class A), cardiac disease (defined as any history of dysrhythmia, CHF, or valvular insufficiency); albumin level, length of hospital stay (LOS), ICU LOS, as well as morbidity and mortality. Cases were divided into 2 groups based on the postgraduate year (PGY) level. Residents in PGY-1, -2 and -3

years were assigned to one group and residents in their PGY-4 and -5 years to the second group.

Resident Composition During the Rotation at the VA

The University of Texas Southwestern Surgical Program graduates thirteen residents a year. For almost the entirety of the study period (11 years), the rotation at the VA was composed of 2 teams of residents each one consisting of a PGY-5, a PGY-3, and an intern. For the past year, changes in the residency program resulted in incorporation of a PGY-2 resident in one of the teams rather than a PGY-3. PGY-4 residents typically do not rotate at the VA during their training, except when they are covering for a PGY-5, at which time they assume a chief resident role for the rotation.

The database was queried for all patients who had an appendectomy. Patients who had an appendectomy for cancer, or incidentally for other reasons were excluded ($n = 47$) as well as patients with interval appendectomies ($n = 20$). We also excluded patients with perforated appendicitis requiring an exploratory laparotomy ($n = 21$). Thus, our analysis only included patients whose diagnosis was acute appendicitis at the time of admission for the index operation. After the exclusion criteria, 257 records were included in the analysis. Complications were graded according to the Dindo et al. classification system [26].

Statistical analysis

Using PGY-level (PGY 1-3 and PGY 4-5) as a dependent variable, univariate analysis was performed using Fisher's exact test for categorical and Student's *t*-test for continuous variables. All statistical tests were 2-sided, and the statistical significance level was set at a p value of ≤ 0.05 . The rate of complications was also set as the dependent variable and univariate analysis was then undertaken as above. Significant variables in this last analysis were entered in a multiple logistic regression model using SigmaPlot Software, Version 13.0 (Systat Software, San Jose, California).

RESULTS

Demographics

A total of 345 appendectomies were performed during the study period, of which 257 were included in the study. The average age at the time of operation was 45.4 year-old and the average body mass index was 30.3 Kg/m². The majority of patients were male (90.7%), Caucasian (62%) and had ASA scores of 1-2 (70%; [Table 1](#)).

TABLE 1. Demographics and Characteristics of Patients Presenting With Acute Appendicitis. Continuous Data are Presented as Means \pm Standard Deviation (SD). Categorical Variables are Presented as the Number of Patients and (Percentages)

General		Operative	
Age (y.o.)	45.4 \pm 15.6	Laparoscopic (n [%])	233 (90.7)
Gender (male) (n [%])	233 (90.7)	Open (n [%])	12 (4.7)
BMI (Kg/m ²)	30.3 \pm 6.3	Started with a Rocky-Davis	12 (4.7)
Comorbidities (n [%])		Converted lap to open (n [%])	12 (4.7)
Cardiac	33 (12.8)	OR Time (min)	60.4 \pm 27.4
Pulmonary	36 (14.0)	EBL (mL)	19.0 \pm 29.2
Renal	28 (10.9)	Findings on admission	
Liver	16 (6.2)	RLQ Tenderness (n [%])	246 (95.7)
DM	29 (11.3)	RLQ Guarding (n [%])	96 (37.4)
DM + Insulin	19 (7.4)	Rebound Tenderness (n [%])	78 (30.4)
HTN	91 (35.4)	Rosving's sign (n [%])	58 (22.6)
HLP	61 (23.7)	Psoas sign (n [%])	34 (13.3)
ASA [n (%)]		Obturator sign (n [%])	22 (8.6)
I - II	178 (69.3)	Temperature ($^{\circ}$ F)	98.3 \pm 1.4
III	72 (28)	Heart Rate (bpm)	85.6 \pm 16.9
IV	7 (2.7)	SBP (mmHg)	136.4 \pm 17.4
Race [n (%)]		DBP (mmHg)	77.6 \pm 12.3
Caucasian	159 (61.9)	WBC (K/uL)	13.2 \pm 4.2
African American	59 (23.0)	CT-Scan (n [%])	236 (92.2)
Hispanic	30 (11.7)	Negative appendicitis	9 (3.5)
Social [n (%)]		Hospital LOS (days)	2.2 \pm 3.7
Smoking current	90 (35.0)		
Alcohol current	118 (45.9)		

OR, operating room, EBL, estimated blood loss, RLQ, right lower quadrant, bpm, beats per minute, SBP, systolic blood pressure, DBP, diastolic blood pressure, mmHg, millimeters of mercury.

Clinical Characteristics

On presentation, 92.2% of patients with appendicitis had a CT scan in the Emergency Department (prior to a surgical consultation). 90.7% of total patients underwent a laparoscopic appendectomy. 4.7% procedures required conversion from laparoscopic to open approach (via a midline laparotomy). 4.7% of patients started with an open approach via a McBurney's incision. Average estimated blood loss was 19.0 mL and OR time was 60.4 minutes. LOS was 3.7 \pm 4.3 days (Table 1). The rate of negative appendicitis was 3.5%.

Complications

The rate of significant complications was 7.8% for the entire cohort. The most common complication within the junior cohort was an intra-abdominal abscess. There was also one mortality in this cohort that resulted from respiratory failure, prolonged hospital stay, candidemia, and sepsis. The rate of complications by the Dindo's classification system between junior versus senior resident was as follows: Grade I (14.3% vs 0.0%); Grade II (53.3% vs 50.0%, $p = 1.0$); Grade IIIa (7.4% vs 33.3%, $p = 0.2$); Grade IIIb (14.3% vs 16.6%, $p = 1.0$); Grade V (7.1% vs 0.0%).

After correcting for all factors, resident level (junior vs senior) was not significantly associated with complications.

A positive cardiac history was an independent predictor of complications (odds ratio and 95% confidence interval 4.6; 1.5 to 14.5). Overall, twelve patients started with an open operation (via a McBurney's incision) rather than laparoscopic. Starting the operation via an open approach was also an independent predictor of complications (odds ratio and 95% confidence interval 7.8; 1.3 to 45.5; Table 2).

Comparison of Outcomes By Postgraduate Year Level

Of 257 patients presenting with a diagnosis of acute appendicitis, 8 appendectomies were performed by interns (between 2019 and 2015), 25 by PGY-2, 147 by PGY-3, 22 by PGY-4, and 55 by PGY-5. There were no significant differences in patient demographics or ASA category in patients operated on by senior (PGY-4 and -5 [n = 77]) and junior (PGY-1 to -3 [n = 180]) residents. Both groups had similar WBC and blood pressure on initial presentation (all p 's > 0.05). Patients operated on by senior residents were more likely to have right lower quadrant guarding ($p = 0.01$) and rebound tenderness ($p = 0.03$). Patients operated on by senior residents were also more likely to have diabetes mellitus, hypertension or pulmonary disease (all p 's < 0.05). The estimated blood loss was minimally higher (25.3 \pm 43.3 vs 16.3 \pm 20.0 mL, $p = 0.02$) for senior residents. OR times were

TABLE 2. Univariate and Multivariate Analyses in Veteran Patients Who Had an Appendectomy and Experienced Complications Compared to Those Who Did Not Have Complications. Continuous Data are Presented as Means \pm Standard Deviation (SD). Categorical Variables are Presented as the Number of Patients and (Percentages)

Univariate Analysis		Multivariate Analysis		
Complications vs No Complications		p	OR	95% CI
Junior vs Senior (%)	30.0 vs 30.0	0.9	Not in the MVA analysis	
EBL (ml)	43.1 \pm 17.0.1 vs. 53.8 \pm 25.3	< 0.001	NS	NS
HR (bpm)	90.7 \pm 18.9 vs 85.2 \pm 16.7	0.2	Not in the MVA analysis	
OR time (min)	71.3 \pm 35.6 vs 59.5 \pm 26.5	0.06	NS	NS
Cardiac history (%)	40.0 vs 10.5	0.001	4.6	1.5-14.5
Perforated appendix (%)	50.0 vs 18.1	0.002	NS	NS
Complicated appendix (%)	65.0 vs 37.6	0.03	NS	NS
Started open (%)	15.0 vs 3.8	0.03	7.8	1.3-45.5

similar (64.1 \pm 34.2 vs 58.8 \pm 23.8 minutes, $p = 0.16$) for both groups. The incidence of complicated appendicitis on pathology was similar for both senior and junior residents (41.6% vs 38.9%, $p = 0.69$; Table 3).

When PGY-level was used as the dependent variable, the rate of complications between junior and senior residents was identical (7.8%). When the rate of complications was set as the dependent variable, PGY-level was not significantly different (Tables 2 & 3).

DISCUSSION

Our results showed that interns rarely perform laparoscopic appendectomies at our institution. The diagnosis of acute appendicitis is typically made by CT-scan at a Veterans Affairs Hospital. This is a drastic change in the previous paradigm in the management of acute appendicitis. As previously reported elsewhere,¹¹ the present analysis also demonstrated that there is no difference in the rate of complications whether an appendectomy is performed by junior versus senior residents.

At the time of publication of his paper, McBurney emphasized on history, physical exam and early laparotomy for the management of acute appendicitis.^{3,12} For over a century, the principles of the diagnosis and management of acute appendicitis remained unchanged. History, physical exam, and serology have been pivotal in the diagnosis of acute appendicitis. However, ultrasonography and CT scan have substantially added to the accurate diagnosis of appendicitis to the point that the accepted rate of negative appendectomies (~20%) has become almost zero with current imaging modalities.

In the present study, we show that 92.2% percent of patients underwent computed tomography for the diagnosis of acute appendicitis. This is similar to other studies demonstrating an increase in the use of imaging for the diagnosis of appendicitis. In a 10-year review at a single institution, the use of CT scan for acute appendicitis

increased from 19% in 1998 to 93% in 2007 and this change was associated with a sharp decrease of a negative appendectomy rate from 17.0% to 8.7%.¹³ Another study documented similar findings, in which the use of CT scan decreased the rate of negative appendectomies from 24% to 3% in adults, which led to a significant decrease of cases of perforated appendicitis.¹⁴ These findings are similar to our experience in which we had a 3.5% rate of negative appendectomies. Thus, the incorporation of imaging modalities for the diagnosis of acute appendicitis at our hospital has led to excellent outcomes.

Appendectomies are one of the most common operations performed by surgical residents in the United States.¹⁰ In an analysis of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) data inclusive of 11,451 laparoscopic appendectomies performed with residents compared to 5398 conducted by attendings, the authors concluded that while the operative times were longer with resident participation, perioperative outcomes were similar in both groups.¹¹ Avani's study also showed that there was no difference by PGY-level amongst residents that performed laparoscopic appendectomies. In previous studies, we have also shown that PGY-level involvement does not influence outcomes in patients undergoing inguinal hernia repair.¹⁵

In the present study, the operative room times of 59 and 64 minutes of junior and senior residents were higher than those previously reported (49 minutes) when residents performed the operation and substantially higher when the operation was undertaken exclusively by an attending (35 minutes).¹¹ The overall morbidity was also higher in our cohort of patients (7.8%) compared to that reported by others in patients undergoing a laparoscopic appendectomy with residents (3.7%) and without residents (2.8%). However, our cohort is largely composed of men compared to Avani's analysis (91% vs 54%). Compared to the ASC-NSQIP, we also had patients with a higher body mass index (30 vs 26 Kg/m²). Furthermore,

TABLE 3. Univariate Analysis Between Junior and Senior Residents. Continuous data are presented as means \pm standard deviation (SD). Categorical Variables are Presented as the Number of Patients and (Percentages)

	Junior (n = 180)	Senior (n = 77)	p
Age (years-old)	44.5 \pm 15.1	47.6 \pm 16.7	0.14
Male (n [%])	163 (90.6)	70 (90.9)	0.93
OR Time (min)	58.8 \pm 23.8	64.1 \pm 34.2	0.16
BMI (Kg/m ²)	30.6 \pm 6.6	29.6 \pm 5.4	0.23
Findings on admission			
Heart Rate (%)	84.2 \pm 16.1	89.1 \pm 18.4	0.03
Temperature (°F)	98.3 \pm 1.26	98.5 \pm 1.7	0.29
RLQ Tenderness (n [%])	172 (96.1)	73 (94.8)	0.64
RLQ Guarding (n [%])	58 (32.6)	38 (49.4)	0.01
RLQ Rebound (n [%])	47 (26.3)	31 (40.3)	0.03
WBC (k/uL)	13.2 \pm 3.9	13.4 \pm 4.9	0.76
Intraoperative			
Laparoscopic (n [%])	170 (94.4)	75 (97.4)	0.31
Open (n [%])	10 (5.6)	2 (2.6)	0.31
Open McBurney (n [%])	9 (5)	0 (0)	0.046
Lap converted to open (n [%])	6 (3.3)	6 (7.79)	0.12
EBL (mL)	16.3 \pm 20.0	25.3 \pm 43.3	0.02
Pathology (n [%])			
Gangrenous	22 (12.2)	15 (19.5)	0.13
Perforated	34 (18.9)	19 (24.7)	0.3
Fecolith	27 (15.0)	13 (16.9)	0.7
Complicated	70 (38.9)	32 (41.6)	0.69
Malignancy	2 (1.1)	3 (3.9)	0.14
Comorbidities (n [%])			
Cardiac	20 (11.1)	13 (16.9)	0.21
Diabetes	16 (8.9)	13 (16.9)	0.06
Hypertension	54 (30.0)	37 (48.1)	0.005
Pulmonary	20 (11.1)	16 (20.8)	0.04
Renal	21 (11.7)	7 (9.1)	0.55
ASA II	131 (72.8)	47 (61)	0.06
ASA III	46 (25.6)	26 (33.8)	0.18
ASA IV	3 (1.67)	4 (5.2)	0.11
30-day outcomes			
Complications (n [%])	14 (7.8)	6 (7.8)	1
30-d Readmission (n [%])	15 (8.5)	8 (10.5)	0.6
Hospital LOS (Days)	2.0 \pm 3.0	2.7 \pm 5.0	0.16

SBP = systolic blood pressure, HR = hear rate, bpm = beats per minute, HTN = hypertension, mmHg = millimeters of mercury, LOS = hospital length of stay, OR = odds ratio, 95% CI = 95% confidence intervals.

our group had a substantially higher rate of comorbidities such as hypertension (36% vs 12%), and heart disease (13% vs 2%).¹¹ Thus, the higher operative times and higher complication rate might be a reflection of our higher risk cohort of patients.

In the present study, only 3.1% of appendectomies were performed by interns. More than half were undertaken by PGY-3 residents who have experience with the laparoscopic approach to an appendectomy. In contrast to previous observations regarding PGY-level not influencing outcomes,^{11,15} we found an inverse relationship between operative room times and estimated blood loss based on the PGY-level. However, while these differences were statistically significant, they have no clinical relevance. Furthermore, the rate of complications was similar in both groups.

This study has several limitations. It is purely observational, it is severely limited by extracting the data from the computer record system, and given the retrospective nature of the study, it is prone to selection bias and systematic errors. The number of attendings involved during the study period was seventeen and performed from one to sixty appendectomies. This introduces a great deal of variability in resident involvement. However, most of the appendectomies performed in the study were undertaken by 5 attending who typically adhere to similar surgical approach to resident participation and education. Finally, the number of patients in this cohort is relatively low. However, this is a VA patient cohort. Over the past 5 years, our hospital performed an average of 1438.6 \pm 144.5 general surgery operations per year. Of these, about 25 per year have been appendectomies for the

management of acute appendicitis, which would be expected in an older patient population. However, the low number of laparoscopic appendectomies compared to the ACS-NSQIP¹¹ remains a substantial limitation.

CONCLUSIONS

In the present study, we show that most patients at a VA teaching hospital undergo CT scan for the diagnosis of acute appendicitis. The majority of patients are treated via a laparoscopic appendectomy performed by a PGY-3 resident or higher. The rate of postoperative complications was similar across PGY levels.

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SUPPLEMENTARY INFORMATION

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.jsurg.2018.07.029>.