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A survey of the practice and attitudes of surgeons regarding the treatment of appendicitis

D. Dante Yeh [a,*], Joseph V. Sakran [b], Rishi Rattan [a], Ambar Mehta [b], Gabriel Ruiz [a], Howard Lieberman [a], Michelle Mulder [a], Nicholas Namias [a], Tanya Zakrison [a], Gerd Daniel Pust [a]

[a] Ryder Trauma Center, USA
[b] Johns Hopkins University, USA

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ABSTRACT

Background: We surveyed surgeons to document their attitudes, practice, and risk tolerance regarding the treatment of appendicitis.
Methods: A web-based survey was sent to the EAST membership. The primary composite endpoint was defined as 1-year incidence of perioperative complications, antibiotic failure, infections, ED visits, and readmissions.
Results: A total of 563 of 1645 surveys were completed (34% response). Mean age was 47 ± 10 years and 98% were from the United States. Most (72%) were employed at academic teaching hospitals and 66% practiced in an urban setting. There were significant differences in treatment recommendations for different presentations of appendicitis. Regarding the primary composite endpoint, surgeons would tolerate a median 17% [10%–25%] excess morbidity in order to avoid an operation (i.e. non-inferiority) and would require a median 24% [10%–50% lower morbidity for the surgical approach in order to declare it a superior treatment (i.e. superiority).
Conclusions: To be considered non-inferior, antibiotic therapy of appendicitis cannot have >17% excess morbidity and appendectomy must have at least 24% lower morbidity to be considered superior.

Background

Since the first description of appendectomy in 1886 by Fitz,[1] the standard treatment of acute appendicitis in North America has been appendectomy. This practice has been based on the historically high mortality rate of perforated appendicitis observed in the pre-antibiotic era. Although reports of successful non-operative management (with or without antibiotics) have suggested that not all patients require an operation,[2] appendectomy has remained the standard treatment in North America over the past century. However, recent studies[3–7] have challenged this convention and some physicians now believe that acute appendicitis may be successfully treated with antibiotics alone. Changes in practice have already been observed: the proportion of acute appendicitis managed non-operatively increased by nearly 33% from 2004 to 2011.[8]

When analyzing recently published European trials, various methodological differences become evident, limiting their usefulness to surgeons practicing in the United States.[9] For example, the Non Operative Treatment for Acute Appendicitis (NOTA) study patients did not receive axial imaging, thus, calling into question the actual diagnosis of appendicitis.[10] In the APPAC trial,[3] the majority of operations were performed via the open technique (vs. laparoscopic) and the chosen medical and surgical outcomes were unequal in terms of being patient-centric.[11] Furthermore, the mandatory three days of intravenous antibiotic therapy used in the APPAC trial may not be attractive to surgeons practicing in the cost-conscious American healthcare landscape. Applying the results of high-profile publications requires an understanding of both the

* Corresponding author. Ryder Trauma Center DeWitt Daughtry Family Department of Surgery University of Miami Miller School of Medicine, PO Box 016960 D40, Miami, FL, 33101, USA.

E-mail addresses: dxy154@miami.edu (D.D. Yeh), jsakran1@jhmi.edu (J.V. Sakran), rrattan@miami.edu (R. Rattan), amehta25@jhmi.edu (A. Mehta), gruiz3@med.miami.edu (G. Ruiz), hlieberman@med.miami.edu (H. Lieberman), mbm139@med.miami.edu (M. Mulder), nnamias@med.miami.edu (N. Namias), tzakrison@med.miami.edu (T. Zakrison), gpust@med.miami.edu (G.D. Pust).

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practice context as well as surgeons' risk tolerance for complications and treatment failure, a hitherto unstudied topic. In light of these randomized controlled trials and new evidence informing the management of appendicitis, we surveyed the membership of an American surgical society to document their attitudes, practice, and risk tolerance regarding the treatment of acute and perforated appendicitis.

Methods

This study was approved by the local Institutional Review Board. A recruitment email was sent with a link to an online survey. Informed consent was implied upon survey completion. Three recruitment emails were sent to the Active, Senior, Provisional, and International membership list of the Eastern Association for the Surgery of Trauma (EAST). Study data were collected and managed using Research Electronic Data Capture (REDCap) electronic data capture tools hosted at University of Miami.[12] REDCap is a secure, web-based application designed to support flexible yet robust data capture for research studies, providing 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources.

The web-based survey of demographics, attitudes, imaging, self-treatment preferences, and patient care preferences and was developed in consultation with multiple surgeons with experience treating appendicitis (content experts) (**Supplementary Figure).**

The final two questions of the survey presented the participant with definitions for a composite surgical endpoint and a composite medical endpoint. The primary composite surgical endpoint was defined as 1-year incidence of intra- and post-operative complications: immediate post-surgical complications (anesthesia complications, myocardial infarction, congestive heart failure, respiratory insufficiency, etc.), surgical site infection requiring antibiotics or incisional opening, intra-abdominal abscess requiring percutaneous drainage, failure of surgery (i.e. stump appendicitis), and return to ED or postoperative readmission. The primary composite medical endpoint was defined as 1-year incidence of: failure rate (appendectomy and/or intra-abdominal abscess requiring percutaneous drainage) and return to ED or readmission related to appendicitis. In order to assess risk-tolerance and acceptability, the respondent was asked to choose a threshold for their patient of: 1) excess morbidity (if any) that he/she was willing to tolerate in order to avoid an operation (*non-inferiority*), and 2) lower morbidity that the surgical approach must have to declare that treatment *superior*.

Parametric data are reported as mean ± standard deviation and non-parametric data are reported as median [interquartile range]. Chi-squared tests was used to compare differences in responses by varying physician characteristics. A p value of <0.05 was considered statistically significant.

Results

A total of 563 out of 1645 surveys were completed (34% response rate). All included responses were received within 8 weeks of the initial email survey. Only complete (>80% of items completed) surveys were included in the analysis. All 563 surveys had >80% of items completed.

Demographics

All (100%) respondents answered this section and the demographics of the respondents are displayed in Table 1. The mean age of respondents was 47 ± 10 years and there was a relatively even distribution across the four categories of "Years since completing training". The vast majority (98%) of respondents were from the United States and more than half practiced on the East Coast, consistent with the demographics of EAST membership. Most (72%) were employed at academic teaching hospitals and about two-thirds (66%) practiced in an urban setting. Over two-thirds (68%) have mandatory in-hospital call.

Table 1
Demographics.

n = 563	
Age (years) (n = 539)	47 (10), range 31–100
Years since completing training: (n = 541)	
<5	127 (23%)
5–10	130 (24%)
11–20	143 (26%)
>20	141 (26%)
Practice region (n = 541)	
In U.S.	530 (98%)
Northeast	166 (31%)
Southeast	125 (24%)
Southwest	54 (10%)
West Coast	25 (5%)
Midwest	139 (26%)
Northwest	9 (2%)
Other	10 (2%)
Canada	5 (1%)
Other	6 (1%)
Practice environment (n = 541)	
Academic teaching facility	387 (72%)
Community-based practice	127 (23%)
Public/Government hospital	12 (2%)
Military hospital	9 (2%)
Other	6 (1%)
Urban	355 (66%)
Rural	48 (9%)
Suburban	129 (24%)
Other	9 (2%)
On-Call (n = 541)	
Home call	151 (28%)
Mandatory in-hospital	369 (68%)
Other	21 (4%)
Scope[a]	
Elective general surgery	300 (52%)
Emergency general surgery	503 (89%)
Trauma surgery	494 (88%)
Surgical critical care	440 (78%)
Other	34 (6%)

[a] Percentages add up to >100% because the respondent was allowed to choose multiple options.

Attitudes

A total of 518 (92%) of respondents answered this section. A histogram of the responses to the 10-point Likert scale survey questions is displayed in Fig. 1." For the purposes of statistical comparisons, a response of 7, 8, 9, or 10 was considered "important" and the answers were dichotomized as important or not important. The percentage of respondents who rated the factor as "important" was: pain = 65%; risk of recurrence of appendicitis = 55%; hospital length of stay = 41%; days of work missed = 36%; complications of treatment = 75%; baseline co-morbidities = 74%; anticipated difficulty of operation = 51%.

The responses to the question "How would you want to be treated initially if you developed …" are displayed in Table 2. For perforated appendicitis with a 2 cm abscess, a greater proportion of surgeons practicing for 11–20 years (32%) or >20 years (30%) selected a laparoscopic appendectomy relative to those practicing <5 years (21%) or 5–10 years (18%). In contrast, among surgeons taking call, surgeons taking home call were more likely to select a

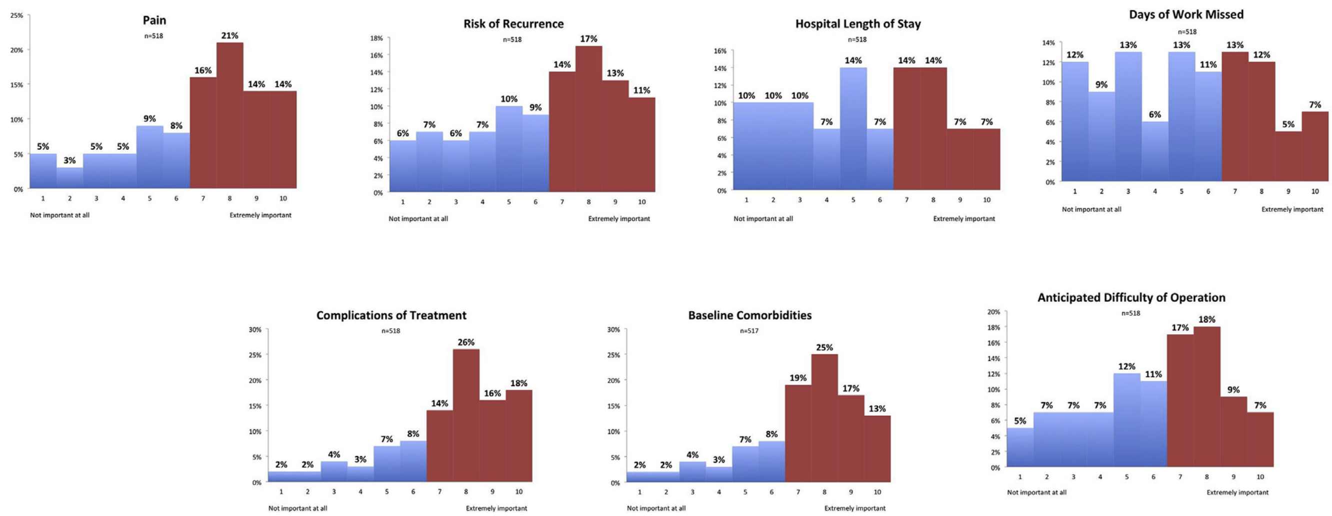

Fig. 1. Attitudes about appendicitis.
1) When making treatment recommendations to a patient with *acute, non-perforated appendicitis*, how important are the following considerations?.

laparoscopic appendectomy (35%) than those taking mandatory in-hospital call (22%).

Imaging

A total of 511 (91%) of respondents answered this series of questions and the responses are also displayed in Table 2. When assessing these responses by Years Since Completing Training, there were similar results, except for the clinical presentation regarding the young woman.

Treatment

A total of 494 (88%) respondents answered this series of questions and the responses are displayed in Table 3. These responses varied slightly among the more clinically acute vignettes by Years Since Completing Training and On-Call.

Equivalence testing of primary composite endpoints

A total of 467 (83%) respondents answered the final two questions. In response to the question "how much excess morbidity (if any) would you be willing to tolerate in order to avoid an operation", the median was 17% [10%–25%], and range was 0%–90%. In response to the question "how much lower morbidity must the surgical approach have in order for you to declare it a superior treatment", the median was 24% [10%–50%], and range was 0%–90%.

Discussion

This survey study of the membership of EAST documents the clinical equipoise in the American surgeon population in treating appendicitis and also provides an estimate of risk-tolerance and equivalence testing (superiority and non-inferiority) which is required for design of future randomized trials.

The responses to the "Attitudes" section of the survey provide insight into the thought process and relative importance of various factors which surgeons must consider when counseling patients regarding treatment. It is interesting to note that while the majority of surgeons reported that complications of treatment (75%) and comorbidities (74%) were important considerations when making treatment recommendations, only a minority felt that hospital length of stay (41%) and days of work missed (36%) were important. Thus, in future appendicitis trials, it will be important to collect detailed information about medical comorbidities to ensure accurate balancing of groups and a composite endpoint must necessarily include complications of treatment, in order to be considered meaningful to surgeons.

The widely divergent attitudes and practice preferences are evident in Tables 2 and 3. Two conclusions may be drawn: 1) with the exception of acute, non-perforated appendicitis, there exists clinical equipoise for treatment; and 2) open appendectomy is no longer preferred by anyone. Less than 2% of all surgeons responding to the survey would initially choose open appendectomy for any type of appendicitis. According to the U.S. Nationwide Inpatient sample, the proportion of adult appendectomies performed laparoscopically has increased dramatically over the past 15 years, from about 40% in 2003 to over 80% in 2011.[13] Our study reflects the current practice preference of American surgeons in 2017 and future studies must reflect this practice preference in order to be considered meaningful to 21st century surgeons. Future studies would likely be of great interest to American surgeons if they address topics with divergent opinions: treatment of appendicitis with phlegmon; non-perforated appendicitis in a surgically challenging patient; non-perforated appendicitis in a high-risk medical patient; perforated appendicitis with no drainable collection; and interval appendectomy.

Imaging studies to confirm the diagnosis of appendicitis are commonly obtained in the United States. The increased rate in axial imaging has resulted in decreased rates of negative appendectomy.[14,15] However, our survey suggests that about two-thirds of surgeons would not request any additional imaging studies for a young man with a classic "textbook" presentation of acute appendicitis. Furthermore, only a minority would request oral or rectal contrast. Since CT scans are sometimes obtained by Emergency Medicine physicians prior to surgical consultation, knowing these preferences may improve patient care by eliminating unwanted CT scans or decreasing the amount of time required obtain the scan (i.e. to wait for oral contrast to reach the colon) or patient discomfort by avoiding rectal contrast administration.

Because the mortality rate of appendicitis is so low (<1%),[13,16,17] clinicians must make treatment decisions based on other endpoints and clinical trials must use composite endpoints to practically

Table 2
Self-treatment preferences and imaging preferences.

	All (n = 518)	Years Since Completing Training					Home Call (n = 148)	Mandatory In-Hospital (n = 352)	P
		<5 (n = 124)	5–10 (n = 123)	11–20 (n = 137	>20 (n = 135)	P			
Acute, non-perforated appendicitis									
Antibiotics only	33 (6%)	7 (6%)	13 (11%)	3 (2%)	10 (7%)	0.27	9 (6%)	23 (7%)	0.75
Antibiotics followed by interval appendectomy	4 (1%)	1 (1%)	1 (1%)	1 (1%)	1 (1%)		2 (1%)	2 (1%)	
Laparoscopic appendectomy	471 (91%)	116 (94%)	108 (88%)	127 (93%)	120 (89%)		136 (92%)	321 (91%)	
Open appendectomy	6 (1%)	0 (0%)	1 (1%)	3 (2%)	2 (1%)		1 (1%)	4 (1%)	
Other	4 (1%)	0 (0%)	0 (0%)	2 (1%)	2 (1%)		0 (0%)	2 (1%)	
Acute appendicitis with a phlegmon									
Antibiotics only	77 (15%)	18 (15%)	19 (15%)	20 (15%)	20 (15%)	0.51	19 (13%)	55 (16%)	0.52
Antibiotics followed by interval appendectomy	180 (35%)	39 (31%)	40 (33%)	50 (37%)	51 (38%)		57 (39%)	114 (32%)	
Percutaneous drainage	14 (3%)	3 (2%)	2 (2%)	6 (4%)	3 (2%)		4 (3%)	10 (3%)	
Percutaneous drainage followed by interval appendectomy	37 (7%)	13 (10%)	10 (8%)	10 (7%)	4 (2%)		7 (5%)	30 (9%)	
Laparoscopic appendectomy	196 (38%)	49 (40%)	50 (41%)	48 (35%)	49 (36%)		56 (38%)	137 (39%)	
Open appendectomy	5 (1%)	1 (1%)	1 (1%)	0 (0%)	3 (2%)		2 (1%)	3 (1%)	
Other	9 (2%)	1 (1%)	1 (1%)	2 (1%)	5 (4%)		3 (2%)	3 (1%)	
Perforated appendicitis but no drainable abscess									
Antibiotics only	63 (12%)	21 (17%)	17 (14%)	14 (10%)	11 (8%)	0.09	13 (9%)	46 (13%)	0.59
Antibiotics followed by interval appendectomy	116 (22%)	31 (25%)	30 (24%)	24 (18%)	31 (23%)		34 (23%)	76 (22%)	
Percutaneous drainage	13 (3%)	1 (1%)	4 (3%)	4 (3%)	4 (3%)		2 (1%)	10 (3%)	
Percutaneous drainage followed by interval appendectomy	43 (8%)	7 (6%)	7 (6%)	17 (13%)	12 (9%)		10 (7%)	32 (9%)	
Laparoscopic appendectomy	262 (51%)	62 (50%)	59 (48%)	73 (54%)	68 (50%)		81 (55%)	175 (50%)	
Open appendectomy	11 (2%)	1 (1%)	1 (1%)	2 (1%)	7 (5%)		4 (3%)	7 (2%)	
Other	10 (2%)	1 (1%)	5 (4%)	2 (1%)	2 (1%)		4 (3%)	6 (2%)	
Perforated appendicitis with a 2 cm abscess									
Antibiotics only	33 (6%)	10 (8%)	8 (7%)	5 (4%)	10 (7%)	0.01	(4%)	24 (7%)	0.01
Antibiotics followed by interval appendectomy	82 (16%)	16 (13%)	22 (18%)	24 (18%)	20 (15%)		19 (13%)	61 (17%)	
Percutaneous drainage	72 (14%)	19 (15%)	26 (21%)	17 (13%)	10 (7%)		14 (9%)	57 (16%)	
Percutaneous drainage followed by interval appendectomy	184 (36%)	52 (42%)	43 (35%)	43 (32%)	46 (34%)		49 (33%)	126 (36%)	
Laparoscopic appendectomy	132 (25%)	26 (21%)	22 (18%)	43 (32%)	41 (30%)		52 (35%)	78 (22%)	
Open appendectomy	8 (2%)	1 (1%)	0 (0%)	1 (1%)	6 (4%)		4 (3%)	4 (1%)	
Other	7 (1%)	0 (0%)	2 (2%)	2 (2%)	2 (1%)		4 (3%)	2 (1%)	
Imaging Preferences									
A 22 year-old man presents to the ED with 12 h of symptoms: periumbilical pain migrating to the RLQ, vomiting, RLQ tenderness, positive Rovsing's sign. He is afebrile and his WBC is 12. What is the first imaging study (if any) that you would request?									
None, I'm ready to treat the patient based on the information I already have	334 (65%)	71 (58%)	81 (67%)	98 (73%)	84 (63%)	0.18	93 (63%)	230 (66%)	0.13
RLQ ultrasound	39 (8%)	10 (8%)	10 (8%)	6 (4%)	13 (10%)		16 (11%)	21 (6%)	
CT Abd/Pelvis	135 (26%)	42 (34%)	29 (24%)	30 (22%)	34 (26%)		36 (24%)	94 (27%)	
MRI Abd/Pelvis	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		0 (0%)	0 (0%)	
Other	3 (1%)	0 (0%)	1 (1%)	0 (0%)	2 (2%)		2 (1%)	1 (<1%)	
A 32 year-old woman presents to the ED with 12 h of symptoms: periumbilical pain migrating to the RLQ, vomiting, RLQ tenderness, positive Rovsing's sign. She is afebrile and her WBC is 12. Beta-hcg is negative and her pelvic exam in normal. What is the first imaging study (if any) that you would request?									
None, I'm ready to treat the patient based on the information I already have	70 (14%)	7 (6%)	9 (7%)	25 (19%)	29 (22%)	<0.01	22 (15%)	44 (13%)	0.03
RLQ ultrasound	103 (20%)	17 (14%)	25 (21%)	25 (19%)	36 (27%)		40 (27%)	60 (17%)	
CT Abd/Pelvis	332 (65%)	99 (80%)	83 (69%)	84 (63%)	66 (49%)		82 (56%)	239 (69%)	
MRI Abd/Pelvis	1 (<1%)	0 (0%)	1 (1%)	0 (0%)	0 (0%)		1(1%)	0(0%)	
Other	5 (1%)	0 (0%)	3 (2%)	0 (0%)	2 (2%)		2 (1%)	3 (1%)	
A 74 year-old man presents to the ED with 12 h of symptoms: periumbilical pain migrating to the RLQ, vomiting, RLQ tenderness, positive Rovsing's sign. He is afebrile and his WBC is 12. What is the first imaging study (if any) that you would request?									
None, I'm ready to treat the patient based on the information I already have	56 (11%)	9 (7%)	14 (12%)	15 (11%)	18 (14%)	0.63	17 (12%)	37 (11%)	0.02
RLQ ultrasound	20 (4%)	3 (2%)	7 (6%)	4 (3%)	6 (5%)		10 (7%)	10 (3%)	
CT Abd/Pelvis	432 (85%)	111 (90%)	100 (83%)	113 (84%)	108 (81%)		117 (80%)	299 (86%)	
MRI Abd/Pelvis	1 (<1%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)		1(1%)	0(0%)	
Other	2 (<1%)	0 (0%)	0 (0%)	1 (1%)	1 (1%)		2(1%)	0(0%)	
							(n = 151)	(n = 369)	
When ordering a CT to evaluate for appendicitis, which of the following modalities of contrast do you routinely request (check all that apply)?									

(*continued on next page*)

Table 2 (*continued*)

	All (n = 518)	Years Since Completing Training					Home Call (n = 148)	Mandatory In-Hospital (n = 352)	P
		<5 (n = 124)	5–10 (n = 123)	11–20 (n = 137	>20 (n = 135)	P			
None	33 (6%)	4 (3%)	2 (2%)	12 (8%)	15 (11%)	0.01	13 (9%)	19 (5%)	0.14
oral (PO)	215 (38%)	45 (35%)	60 (46%)	54 (37%)	56 (40%)	0.33	73 (48%)	133 (36%)	0.01
rectal (PR)	14 (2%)	1 (1%)	3 (2%)	6 (4%)	4 (3%)	0.37	3 (2%)	9 (2%)	0.76
intravenous (IV)	457 (81%)	116 (91%)	113 (87%)	119 (83%)	109 (77%)	0.01	126 (83%)	314 (85%)	0.64

compare different treatment effects with sufficient statistical power.[18] When crafting a composite endpoint, it is important to assign relative weights to each of the individual components, as some are more important to the patient and clinician (ex: death) than others (ex: wound infection).[18] In our survey, the most important clinical outcomes, in decreasing order of percentage of surgeons who ranked it as important, were complications of treatment (75%), pain (65%), recurrence of appendicitis (55%), hospital length of stay (41%), and days of work missed (36%) (Fig. 1). Assuming that every patient and surgeon would rank mortality as important, it therefore would seem reasonable to create a composite endpoint with the following weighted components.

$$\begin{aligned} \textit{composite endpoint} = \; & 1.00 \times (\textit{mortality}) + 0.75 \\ & \times (\textit{treatment complications}) + 0.65 \\ & \times (\textit{pain}) + 0.55 \times (\textit{recurrence rate}) \\ & + 0.41 \times (\textit{hospital days}) + 0.36 \\ & \times (\textit{days of work missed}) \end{aligned}$$

Arguably, the most important findings in this survey may be the risk tolerance items at the end of the survey. We report, for the first time, how surgeons approach the decision-making process when deciding between surgical or medical treatment of appendicitis. Our findings suggest that surgeons would be willing to tolerate a median excess morbidity of 17% to avoid an operation for appendicitis, and that they would require a surgical treatment to have a median of 24% lower morbidity to consider the approach as superior to medical management. Future trials should consider using these or similar values as potential benchmarks to assess differences in intervention arms. This is important to increase surgeon adoption of new clinical criteria. While a study may show that a medical approach may be better than a surgical approach for appendicitis, if it does not reach the level of benefit deemed necessary to avoid the procedure among most surgeons, few may actually start practicing the new guidelines. For example, if it is estimated that the 1-year incidence of the primary composite medical endpoint (Fig. 1) will occur in approximately 30% of medically treated patients, then the 1-year incidence of the primary composite surgical endpoint (Fig. 1) cannot be higher than 47% (including 95% confidence intervals) in order to declare equivalence; to detect such a difference with 80% power a sample size of 250 (125 in each arm) is required. Similarly, the 1-year incidence of the primary composite surgical endpoint must be below 6% (including 95% CI) in order to declare that appendectomy is superior to medical therapy.

Limitations

Our survey study has several limitations, which must be acknowledged. First, the response rate was 34%, which is relatively low, and our results may be subject to selection bias. Second, although our survey was pilot tested with multiple surgeons experienced in treating appendicitis, the survey was not formally validated and this may have introduced unanticipated biases into the responses. Third, our population was restricted only to the membership of EAST, and thus there is potential for sampling bias. Compared to other organizations of surgeons who treat appendicitis (ex: American College of Surgeons), the EAST membership is relatively younger and has less experience. The majority of our respondents practice on the East Coast of the United States and we had relative under-representation from surgeons on the West Coast (5%) and Northwest (2%). Only 2% of our respondents were international. Additionally, the majority of our respondents practice at academic teaching facilities and two-thirds lived in urban settings. This potentially limits the generalizability of our findings. Furthermore, we did not ask any questions about the motivations driving the treatment preferences, for example financial incentives or time management. As with any self-report survey, our data validity is potentially threatened by *response biases,* which may be broadly defined as biases that influence the respondent to answer in an untruthful manner. Examples of response biases include *acquiescence bias* (tendency to agree to all questions), *extreme responding* (tendency to select only the most extreme options, for example, on a Likert scale), *question order bias* (tendency to answer questions differently depending upon the order in which they appear), and *social desirability bias* (tendency to answer according to what the respondent believes is socially desirable). Finally, for the equivalence/superiority/non-inferiority final question, 17% of the total respondents did not provide an answer, a much higher non-response rate than for other sections. We believe this is because of the complicated nature of the statistical concept, which likely deterred nearly one-fifth of our survey participants. Additionally, we noticed participation attrition across the survey sections. Participation was highest for the first section ("Demographics") and lowest for the final section ("Equivalence testing"); our response rate to this important question may have improved if we had placed it earlier in the survey.

Despite these limitations, we believe our findings are meaningful for several reasons. First, to our knowledge, there is no prior study that explores the surgeon's decision-making process when counseling a patient about treatment of different forms of appendicitis. In this modern era of shared decision-making, it is important to understand the attitudes and preferences of all stakeholders, including patients and surgeons. The relative importance of various outcomes provides guidance on how to weigh them in crafting a composite endpoint. Second, the responses to the treatment preferences reveal that some surgeons already prefer non-operative treatment of acute and perforated appendicitis and that open appendectomy is preferred by nearly nobody. Thus, the most highly cited recent randomized European trial, the APPAC trial, is not applicable to modern American practice. Finally, our study provides an estimate of the clinically meaningful effect size that would be required to change the practice of active surgeons and thus provides data for calculating sample sizes of future randomized trials on this contentious topic.

Table 3
Treatment.

	All (n = 495)	Years Since Completing Training					Home Call (n = 139)	Mandatory In-Hospital (n = 339)	P
		<5 (n = 123)	5–10 (n = 121)	11–20 (n = 132)	>20 (n = 134)	P			
Early acute non-perforated appendicitis in young, healthy man									
Laparoscopic appendectomy (with pre-operative antibiotics)	467 (94%)	114 (96%)	112 (96%)	126 (96%)	115 (90%)	0.30	132 (95%)	321 (95%)	0.34
Open appendectomy (with pre-operative antibiotics)	6 (1%)	0 (0%)	0 (0%)	2 (2%)	4 (3%)		2 (1%)	3 (1%)	
IV antibiotics only	15 (3%)	4 (3%)	4 (3%)	1 (1%)	6 (5%)		2 (1%)	12 (4%)	
PO antibiotics only	1 (<1%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)		0 (0%)	1 (<1%)	
Percutaneous drainage	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		0 (0%)	0 (0%)	
Other	6 (1%)	1 (1%)	1 (1%)	2 (2%)	2 (2%)		3 (2%)	2 (1%)	
If you chose medical/percutaneous therapy, and the initial treatment was successful:									
interval appendectomy	14 (93%)	4 (100%)	3 (75%)	1 (100%)	6 (100%)	0.40	2 (100%)	11 (92%)	0.67
no interval appendectomy	1 (7%)	0 (0%)	1(25%)	0 (0%)	0 (0%)		0 (0%)	1 (8%)	
							(n = 139)	(n = 338)	
Early acute, non-perforated appendicitis with appendicoliths in a young healthy man									
Laparoscopic appendectomy (with pre-operative antibiotics)	475 (96%)	118 (99%)	112 (97%)	127 (97%)	118 (92%)	0.09	131 (94%)	329 (97%)	0.01
Open appendectomy (with pre-operative antibiotics)	9 (2%)	0 (0%)	2 (2%)	2 (2%)	5 (4%)		5 (4%)	3 (1%)	
IV antibiotics only	6 (1%)	0 (0%)	2 (2%)	0 (0%)	4 (3%)		0 (0%)	6 (2%)	
PO antibiotics only	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		0 (0%)	0 (0%)	
Percutaneous drainage	1 (<1%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)		1 (1%)	0 (0%)	
Other (please specify)	3 (1%)	1 (1%)	0 (0%)	2 (2%)	0 (0%)		2 (1%)	0 (0%)	
If you chose medical/percutaneous therapy, and the initial treatment was successful:									
interval appendectomy	4 (67%)	N/A	2 (100%)	N/A	2 (50%)	0.22	0 (0%)	4 (80%)	0.12
no interval appendectomy	2 (33%)	N/A	0 (0%)	N/A	2 (50%)		1 (100%)	1 (20%)	
							(n = 139)	(n = 338)	
Appendicitis with phlegmon									
Laparoscopic appendectomy (with pre-operative antibiotics)	181 (36%)	46 (39%)	42 (36%)	47 (36%)	46 (36%)	<0.01	54 (39%)	122 (36%)	0.25
Open appendectomy (with pre-operative antibiotics)	12 (2%)	0 (0%)	2 (2%)	1 (1%)	9 (7%)		6 (4%)	6 (2%)	
IV antibiotics only	277 (56%)	65 (55%)	67 (58%)	77 (59%)	67 (52%)		75 (54%)	192 (57%)	
PO antibiotics only	3 (1%)	0 (0%)	0 (0%)	0 (0%)	3 (2%)		0 (0%)	2 (1%)	
Percutaneous drainage	16 (3%)	6 (5%)	4 (3%)	6 (5%)	0 (0%)		2 (1%)	14 (4%)	
Other	5 (1%)	1 (1%)	1 (1%)	0 (0%)	3 (2%)		2 (1%)	2 (1%)	
If you chose medical/percutaneous therapy, and the initial treatment was successful:									
interval appendectomy	118 (41%)	23 (32%)	32 (46%)	35 (43%)	28 (42%)	0.40	30 (40%)	84 (41%)	0.84
no interval appendectomy	171 (59%)	48 (68%)	38 (54%)	47 (57%)	38 (58%)		45 (60%)	119 (59%)	
							(n = 139)	(n = 338)	
Early acute non-perforated appendicitis in surgically challenging patient									
Laparoscopic appendectomy (with pre-operative antibiotics)	232 (47%)	62 (52%)	54 (47%)	63 (48%)	53 (41%)	<0.01	70 (50%)	155 (46%)	0.61
Open appendectomy (with pre-operative antibiotics)	75 (15%)	9 (8%)	11 (9%)	32 (24%)	23 (18%)		20 (14%)	52 (15%)	
IV antibiotics only	178 (36%)	46 (39%)	49 (42%)	36 (27%)	47 (37%)		46 (33%)	127 (38%)	
PO antibiotics only	1 (<1%)	0 (0%)	1 (1%)	0 (0%)	0 (0%)		0 (0%)	1 (<1%)	
Percutaneous drainage	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		0 (0%)	0 (0%)	
Other (please specify)	8 (2%)	2 (2%)	1 (1%)	0 (0%)	5 (4%)		3 (2%)	3 (1%)	
If you chose medical/percutaneous therapy, and the initial treatment was successful:									
interval appendectomy	156 (89%)	42 (91%)	41 (82%)	30 (88%)	43 (96%)	0.19	38 (84%)	114 (91%)	0.21
no interval appendectomy	19 (11%)	4 (9%)	9 (18%)	4 (12%)	2 (4%)		7 (16%)	11 (9%)	
							(n = 139)	(n = 338)	
Early acute non-perforated appendicitis in medically complex patient									
Laparoscopic appendectomy (with pre-operative antibiotics)	291 (59%)	73 (61%)	65 (56%)	81 (62%)	72 (56%)	0.77	70 (50%)	212 (63%)	0.02
Open appendectomy (with pre-operative antibiotics)	5 (1%)	1 (1%)	1 (1%)	2 (2%)	1 (1%)		3 (2%)	1 (<1%)	
IV antibiotics only	196 (40%)	44 (37%)	50 (43%)	48 (36%)	54 (42%)		65 (47%)	124 (37%)	
PO antibiotics only	1 (<1%)	1 (1%)	0 (0%)	0 (0%)	0 (0%)		0 (0%)	1 (<1%)	
Percutaneous drainage	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		0 (0%)	0 (0%)	
Other	1 (<1%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)		1 (1%)	0 (0%)	
If you chose medical/percutaneous therapy, and the initial treatment was successful:									
interval appendectomy	165 (86%)	41 (95%)	41 (82%)	36 (80%)	47 (89%)	0.14	51 (82%)	108 (89%)	0.24
no interval appendectomy	26 (14%)	2 (5%)	9 (18%)	9 (20%)	6 (11%)		11 (18%)	14 (11%)	
							(n = 138)	(n = 338)	
Perforated appendicitis, no drainable collection									
Laparoscopic appendectomy (with pre-operative antibiotics)	300 (61%)	71 (60%)	67 (58%)	85 (65%)	77 (60%)	0.01	89 (64%)	203 (60%)	0.24

(*continued on next page*)

Table 3 (*continued*)

	All (n = 495)	Years Since Completing Training					Home Call (n = 139)	Mandatory In-Hospital (n = 339)	P
		<5 (n = 123)	5–10 (n = 121)	11–20 (n = 132)	>20 (n = 134)	P			
Open appendectomy (with pre-operative antibiotics)	12 (2%)	0 (0%)	1 (1%)	2 (2%)	9 (7%)		5 (4%)	6 (2%)	
IV antibiotics only	175 (36%)	48 (40%)	48 (41%)	41 (32%)	38 (30%)		42 (30%)	126 (37%)	
PO antibiotics only	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		0 (0%)	0 (0%)	
Percutaneous drainage	5 (1%)	0 (0%)	0 (0%)	2 (2%)	3 (2%)		1 (1%)	3 (1%)	
Other (please specify)	1 (<1%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)		1 (1%)	0 (0%)	
If you chose medical/percutaneous therapy, and the initial treatment was successful:									
interval appendectomy	76 (45%)	23 (50%)	20 (44%)	19 (48%)	14 (36%)	0.60	16 (38%)	57 (47%)	0.31
no interval appendectomy	94 (55%)	23 (50%)	25 (56%)	21 (53%)	25 (64%)		26 (62%)	64 (53%)	
							(n = 138)	(n = 338)	
Perforated appendicitis with abscess									
Laparoscopic appendectomy (with pre-operative antibiotics)	68 (14%)	11 (9%)	10 (9%)	21 (16%)	26 (20%)	<0.01	29 (21%)	38 (11%)	0.01
Open appendectomy (with pre-operative antibiotics)	9 (2%)	0 (0%)	0 (0%)	1 (1%)	8 (6%)		4 (3%)	5 (1%)	
IV antibiotics only	41 (8%)	7 (6%)	8 (7%)	12 (9%)	14 (11%)		16 (12%)	25 (7%)	
PO antibiotics only	1 (<1%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)		0 (0%)	1 (<1%)	
Percutaneous drainage	369 (75%)	100 (84%)	97 (84%)	95 (73%)	77 (60%)		87 (63%)	268 (79%)	
Other	5 (1%)	1 (1%)	1 (1%)	0 (0%)	3 (2%)		2 (1%)	1 (<1%)	
If you chose medical/percutaneous therapy, and the initial treatment was successful:									
interval appendectomy	149 (36%)	39 (37%)	41 (39%)	40 (37%)	29 (32%)	0.80	34 (33%)	110 (38%)	0.45
no interval appendectomy	260 (64%)	67 (63%)	64 (61%)	68 (63%)	61 (68%)		68 (67%)	183 (63%)	

Conclusion

There is wide disparity in the approach to the treatment of appendicitis. Open appendectomy is no longer preferred amongst surgeon members of EAST. In order to be considered non-inferior, antibiotic (medical) therapy of appendicitis cannot have more than 17% excess morbidity in a 1-yr incidence of primary composite endpoint. In order to be considered superior, surgical treatment of appendicitis must have at least 24% lower morbidity in a 1-yr primary composite endpoint.

Conflicts of interest

None of the authors have any financial disclosures or conflicts of interest to report.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.amjsurg.2018.08.019.

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