

Appendicitis is a Severe Disease in Elderly Patients: A Twenty-Year Audit

Marthe Weinandt, MD, Gaelle Godiris-Petit, MD, Fabrice Menegaux, MD, Nathalie Chereau, MD, Renato Micelli Lupinacci, MD, PhD

ABSTRACT

Background and Objectives: Life expectancy has increased substantially. Elderly patients currently represent a large part of patients requiring emergency abdominal surgery. The aim of this study was to evaluate the post-operative outcomes of elderly patients who underwent appendectomy in a single French tertiary center.

Methods: We retrospectively reviewed the medical records of all patients who underwent appendectomy for acute appendicitis between January 1, 1994 and December 31, 2014. We used the French threshold of ≥ 75 y-old to define elderly patients. Hence, elderly patients who underwent appendectomy were compared to the younger group.

Results: During the study period, 2,060 consecutive patients underwent appendectomy for acute appendicitis. Laparoscopic appendectomy was performed in 52% of cases. Similar rates of laparoscopic approach were recorded in both groups, but conversion to open surgery was six times more frequent in elderly patients (17% vs. 3%; $P < .0001$). A higher incidence of complicated appendicitis was observed in the elderly group (63% vs. 13.6%; $P < .0001$). Complications occurred more frequently in the elderly group (46% vs. 8%; $P < .0001$). 30-d mortality was 0.15% for patients < 75 y and 6.15% for elderly patients ($P < .0001$). Unsuspected presence of an

appendiceal neoplasm was higher (7.7%) in the elderly population.

Conclusion: This study highlights the fact that appendicitis in the elderly is associated with a higher rate of complicated appendicitis, morbidity, and mortality.

Key Words: Abscess, Acute appendicitis, Elderly, Peritonitis, Mortality.

INTRODUCTION

Life expectancy in Europe has increased greatly.¹ The proportion of the elderly population requiring surgery has increased even faster than the rate of population aging, and elderly patients currently account for a non-negligible part of surgical practices.² The incidence of appendicitis remains constant in most Western countries³ and forms a substantial economic burden due to the large number of patients.⁴ Surgeons ordinarily think of appendectomy as a simple procedure from which patients recover quickly. Although this is frequently the case for most adult patients, caution should be used when extrapolating this belief to the care of geriatric patients, especially during the management of the more complex situation of perforated appendicitis and peritonitis. Indeed, elderly patients were found to have higher incidence of complicated appendicitis with reported rates of perforation as high as 70%⁵ and of morbidity as high as 48%.⁶

The aim of the present study was to evaluate the outcome of appendectomy for acute appendicitis in patients 75 y of age and older. We performed a 20-y audit from a single tertiary center in Paris, France. The analysis of more than 2,000 patients operated on consecutively allowed a reliable evaluation of both short-term morbidity and mortality as well as the identification of risk factors for poor outcomes in the elderly population.

MATERIALS AND METHODS

We reviewed the medical records of all patients who underwent appendectomy for acute appendicitis between January 1, 1994 and December 31, 2014. All patients with

Department of Digestive and Endocrine Surgery, Hôpital Pitié-Salpêtrière (all authors).

Department of Digestive and Oncologic Surgery, Hôpital Ambroise Paré (Dr Lupinacci).

Conflicts of Interest: none.

Funding: none.

Informed consent: Dr. Lupinacci declares that written informed consent was obtained from the patient/s for publication of this study/report and any accompanying images.

Address correspondence to: Dr. Renato Micelli Lupinacci, Department of Digestive and Oncologic Surgery, Hôpital Ambroise Paré, AP-HP, Paris-Saclay University, Boulogne-Billancourt, France. 9, avenue Charles de Gaulle – 92104 Boulogne-Billancourt, France. Tel: +33 1 49 09 47 82, Fax: +33 1 44 09 58 69, E-mail: rlupinacci@gmail.com.

DOI: 10.4293/JSLS.2020.00046

© 2020 by JSLS, Journal of the Society of Laparoscopic & Robotic Surgeons. Published by the Society of Laparoendoscopic & Robotic Surgeons, Inc.

a diagnosis of appendicitis underwent surgery because the nonoperative management, which may be an alternative for uncomplicated appendicitis,⁷ has never been adopted at our institution. The following data were obtained for each patient: age, sex, body temperature on admission, white blood cell count, level of C-reactive protein, lower right abdominal tenderness, mental confusion and/or disorientation prior to surgery, associated illnesses, American Society of Anesthesiologists (ASA) classification, imaging prior to surgery, surgery type, operative findings, intraoperative complications, postoperative complications, the need for postoperative intensive care unit admission, pathology results, and length of postoperative hospital stay. This retrospective study was approved by the institutional review board.

All procedures were performed in the emergency department by the chief resident or under the supervision of the attending surgeon. We considered appendicitis as complicated when the surgeon described the presence of a gangrenous or perforated appendix as well as an intra-abdominal abscess. In cases of pelvic abscess or localized peritonitis antibiotics were continued for 3 to 5 d. Postoperative complications were defined as any deviation from the normal postoperative course during the first 30 postoperative days. Postoperative complications were graded as related or unrelated to surgical site. Mortality refers to 30-d or in-hospital mortality. Postoperative infections were classified as wound infection, intra-abdominal infection, pulmonary infection, or septicemia. The age-adjusted Charlson comorbidity index was retrospectively calculated for patients ≥ 75 y-old.^{8,9}

Data Analysis

For this study, we used the French threshold of ≥ 75 y-old to define elderly patients.^{10,11} Then we analyzed the study variables twice. First, elderly patients (≥ 75 y) who underwent appendectomy were compared to the younger group (< 75 y). For the second analysis, elderly patients were divided by age: younger than 85 y or 85 y or more, based on a previous report for major colorectal surgery.¹²

Statistical Analysis

Quantitative variables are expressed as means and standard deviation or median and range; qualitative variables are presented as total number of events and percentage. Continuous variables were compared between groups with Student's t test or Wilcoxon-Mann-Whitney test, as appropriate. Categorical variables were compared with χ^2 or Fisher exact test. A *P* value of < 0.05 was considered

significant. Statistical analyses were performed using SPSS version 21 (SPSS Inc., Chicago, IL).

RESULTS

During the study period 2,060 consecutive patients underwent appendectomy for acute appendicitis in our department. Median age was 30 y (range 10–93); 55.4% were males. Stratification by age yielded 65 elderly patients (3.2%) and 27 patients aged ≥ 85 y (1.3%). Both groups had a significant female predominance. Preoperative patient data are presented in **Table 1**.

Over the 20-y period, the mean number of appendectomies performed by year was the same but the proportion of patients beyond 65 y-old gradually increased. Laparoscopic appendectomy was performed in 52% of cases. Surgical practices have gradually evolved during the study period and laparoscopy became the standard approach in 2006. Similar rates for the use of a laparoscopic approach were recorded in all groups (52% vs. 46%; *P* = .21). However, between-group conversion rates differed significantly: laparoscopy was converted to open appendectomy in 17% of the elderly group compared to 3% of the nonelderly group (*P* < .0001).

A significantly higher incidence of complicated appendicitis was observed in the elderly group (63% vs. 13.6%; *P* < .0001) (**Figure 1**). Overall morbidity was 9.3%, but complications occurred more frequently in the elderly group compared with the younger group (46% vs. 8%; *P* < .0001). The rate of infectious complications was higher in the elderly group (23% vs. 5.4%; *P* < .0001) and it was mainly related to a higher rate of wound infection. Seven patients died after appendectomy. Overall 30-d mortality was 0.1% for patients younger than 75 y and 6.1% for elderly patients (*P* < .0001). Acute peritonitis resulting in multiple organ failure was the cause of the two deaths observed in the younger group. Five elderly patients died after appendectomy during the study period, two of them presented generalized acute peritonitis whereas the other three developed cardiac arrhythmia after surgery and died from cardiovascular collapse. Finally, the unsuspected presence of an appendiceal neoplasm was considerably higher in the elderly population (7.7% vs. 0.9%; *P* = .001), among whom 3.1% were adenocarcinomas. **Table 1** summarizes intraoperative characteristics and postoperative outcomes.

Subgroup Analysis of Patients Older than 75 y

Results of logistic regression show that the incidence of complications was not dependent on coexistent illness

Table 1.
Patients' Demographics, Operation Method, Presence of Neoplasia, Short-term Complications, and Mortality

	Patients < 75 y (n = 1995)	Patients ≥ 75 y (n = 65)	P
Sex, woman, n (%)	902 (45.1%)	37 (56.9%)	0.040
Age, median (range)	29.5 (10–74.6)	83 (75–93)	
ASA score, n (%)			
1 or 2	1836 (92%)	40 (62%)	< 0.0001
≥3	159	22	< 0.0001
Laparoscopy	1040 (52%)	30 (46%)	0.210
Conversion rate (%)	60 (3%)	11 (17%)	< 0.0001
Complicated appendicitis, n (%)	259 (13%)	41 (63%)	< 0.0001
Presence of neoplasm on histology, n (%)	19 (1%)	5 (8%)	0.001
Adenocarcinoma	3 (0.15%)	2 (3.1%)	0.01
Neuroendocrine tumor	13 (0.65%)	0	
Morbidity, n (%)			
Overall	161 (8%)	30 (46%)	< 0.0001
Related to surgical site	128 (6.4%)	21 (32.4%)	< 0.0001
Unrelated to surgical site	49 (2.5%)	15 (23.1%)	< 0.0001
Postoperative infection, n (%)			
Overall	107 (5.4%)	15 (23.1%)	< 0.0001
Wound infection	52 (2.6%)	10 (15.4%)	< 0.0001
Intra abdominal abscess	35 (1.8%)	3 (4.6%)	0.112
Pulmonary	9 (0.5%)	1 (1.5%)	0.271
Septicemia	11 (0.6%)	1 (1.5%)	0.316
Need for ICU after surgery, n (%)	18 (0.9%)	14 (21.5%)	< 0.0001
30-d mortality, n (%)	3 (0.2%)	4 (6.2%)	< 0.0001

ASA, American Society of Anesthesiologists; ICU, intensive care unit.

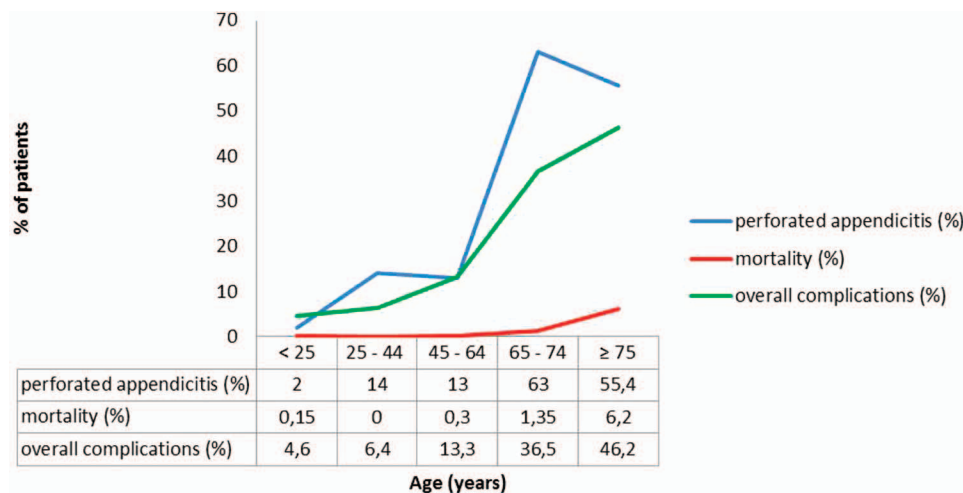


Figure 1. Percentage of perforated appendicitis, overall complication rate and mortality by age.

but significantly related with the open surgical approach (odds ratio (OR) 9.3 [95% CI, 1.77 – 48.9]; $P = .008$) and surgery for complicated appendicitis (OR 6.9 [95% CI, 1.45 – 34.3]; $P = .015$).

Surgical delay and coexistent illness did not influence the rate of complicated appendicitis, while the only factor independently related to complicated appendicitis in the elderly group was the presence of abdominal tenderness at admission (OR 8.3 [95% CI, 1.64 – 42.3]; $P = .011$) (Table 2).

Comparative analysis of patients between 75 and 84 y old and those older than 85 y is summarized in Table 3. There were significantly more women in the group ≥ 85 y old (77.7% vs. 42%; $P = .004$), but no differences in clinical presentation at admission. There was no significant difference between the two groups with respect to the overall morbidity rate, surgical complications, and mortality rate.

DISCUSSION

This study evaluated the outcomes of 2,060 consecutive appendectomies performed in a single tertiary center over a 20 y period. Postoperative complications were more frequently observed in the elderly group (≥ 75 y). This morbidity can be partially explained by a higher rate

(5-times more frequently) of complicated appendicitis in this group. Multivariate analysis showed that the age over 75 y and an ASA score of ≥ 3 are independent risk factors for complicated appendicitis. Furthermore, mortality after appendectomy in the elderly was not a rare event (6.15%).

Delay for surgery after the onset of symptoms is considered to be an important prognostic factor in the management of acute appendicitis. In our study, 14% of elderly patients had a surgical delay ≥ 10 d. Although it is possible that the time taken for key decisions is longer in these patients, we could not raise conclusions with retrospective data. We found surgical delay and coexistent illness did not influence the rate of complicated appendicitis, whereas the presence of abdominal tenderness at admission did.

Some authors reported the use of score systems to be useful in distinguishing uncomplicated from complicated acute appendicitis based on clinical and imaging features,¹³ while others have shown that score systems are not able to differentiate complicated from uncomplicated appendicitis in the elderly population.¹⁴ Omari et al. recently found that the patient's prehospital time delay was the most important risk factor for perforation and postoperative complications although it was not dependent on

Table 2. Factors Related to Complicated Appendicitis in the Elderly Group (≥ 75). Univariate and Multivariate analysis

	Univariate Analysis			Multivariate Analysis ^b	
	Complicated Appendicitis (n = 41)	Uncomplicated Appendicitis (n = 20)	P	OR [95% CI]	P
Sex, woman (n, %)	25 (61%)	12 (60%)	0.579		
ASA score ≥ 3 (n, %)	16 (39%)	5 (25%)	0.212		
Charlson score ≥ 3 (n, %)	13 (32%)	12 (60%)	0.034	0.18 [0.04–0.78]	0.022
Symptoms on admission (n, %)					
Confusion	5 (12%)	1 (5%)	0.351		
Abdominal tenderness	30 (73%)	11 (55%)	0.039	8.33 [1.6–42.3]	0.011
Fever	22 (54%)	11 (55%)	0.481		
Surgical delay ^a (n, %)					
> 2 d	26 (63%)	11 (55%)	0.194	2.72 [0.6–11.3]	0.168
> 5 d	10 (24%)	4 (20%)	0.402		
> 10 d	5 (12%)	4 (20%)	0.388		

OR, odds ration; ASA, American Society of Anesthesiologists.

^aDuration of symptoms before appendectomy.

^bIncluded all factors with $P < 0.2$ in univariate analysis.

Table 3.
Comparative Analysis Between Patients Older than 85 Years and Aged Between ≥ 75 Years and < 85 Years

	≥ 75 to < 85 years (n = 38)	Patients ≥ 85 years (n = 27)	P
Sex, woman, n (%)	16 (42%)	21 (77.7%)	0.004
ASA score, n (%)			
1 or 2	19 (50%)	21 (77.7%)	
≥ 3	19 (50%)	6 (22.2%)	0.003
Charlson score, n (%)			
3 or 4	18 (47.4%)	7 (25.9%)	0.065
≥ 5	18 (47.4%)	17 (63%)	0.256
Symptoms on admission, n (%)			
Confusion	3 (7.9%)	3 (11.1%)	0.489
Abdominal tenderness	26 (68.4%)	15 (55.5%)	0.070
Fever	22 (57.9%)	11 (40.7%)	0.054
Surgical delay ^a n (%)			
> 2 d	18 (47.4%)	19 (70.4%)	0.065
> 5 d	6 (15.8%)	8 (29.6%)	0.175
> 10 d	4 (10.5%)	5 (18.5%)	0.316
Complicated appendicitis, n (%)	25 (65.8%)	16 (59.3%)	0.431
Length of hospital stay, d (mean)	9.6	7.5	0.886
Morbidity, n (%)			
Overall	20 (52.6%)	10 (37%)	0.161
Related to surgical site	12 (31.6%)	3 (11%)	0.043
Unrelated to surgical site	13 (34.2%)	8 (29.6%)	0.454
Need for ICU after surgery, n (%)	12 (31.6%)	2 (7.4%)	0.014
ICU length of stay, day	3	0.2	0.014
30-day Mortality, n (%)	3 (7.9%)	1 (3.7%)	0.445

ASA, American Society of Anesthesiologists; ICU, intensive care unit.

^aDuration of symptoms before appendectomy.

the presence of comorbid diseases or in-hospital time delay.¹⁵ Nonetheless, acute abdominal pain in elderly patients is still considered to be challenging to diagnose and treat. Delay prior to correct treatment, due to an incorrect preliminary diagnosis from an emergency department consequent to low symptom specificity, has been shown to lead to increased morbidity.^{16,17} The preoperative distinction between uncomplicated and complicated disease is challenging¹³ and it is particularly true in elderly patients.¹⁴ Thus, physicians who evaluate elderly patients with suspicion of acute abdominal pain must be well aware that their clinical impression of surgical illness is of greater importance than laboratory tests in the decision to request radiological assessment or surgical consultation.¹⁸

In this study, wound infection represented the main cause of morbidity in both groups. We have never used delayed primary closure as an option for contaminated surgical wounds. Although, it was considered to be a strategy to reduce the rate of surgical site infection, recent high-quality studies have not shown any significant benefit to using this strategy.^{19,20} Moreover, delayed primary wound closure has its own disadvantages including pain from routine dressing, necessity for later wound suturing, and increase cost of treatments.

Our results and others have demonstrated that perforation worsens the condition dramatically resulting in higher rates of morbidity and mortality.^{15,21} Some authors pro-

pose the early use of computed tomography (CT) scan to facilitate prompt diagnosis where presentation is more equivocal, which may eventually lead to improved surgical outcomes.^{13,15,21–23}

We observed that laparoscopy has become the surgical approach of choice since 2006. The utility and benefits of laparoscopic appendectomy were not well established in the surgical literature of the 1990s and early 2000s because some studies have demonstrated an increased risk of intra-abdominal infectious complications.^{24,25} However, recent studies have shown that laparoscopic appendectomy is as safe as open appendectomy and provides the benefits of minimally invasive surgery.^{26,27} Also, it was shown that hospital stay increases with age and is significantly longer for open versus minimally invasive appendectomy.⁴

Interestingly, age at time of procedure of greater than 85 y does not seem to correlate to worse postoperative outcomes. Patients over 85 y had significantly fewer comorbidities and lower complications rate. The only death observed in this group was related to a previous cardiovascular condition instead of septic complications or multivisceral failure. This can be partially explained by the fact that people living this long are generally healthier, with no self-reported diseases or functional impairment.²⁸

Several trials have shown that acute appendicitis can be treated with antibiotics.^{7,29–32} Thus, in the face of the important rate of morbidity and mortality observed in elderly patients, one may be tempted to propose non-operative management of acute appendicitis. However, initial trials were weakened by several design limitations,^{29,31,32} and two recent randomized control trials failed to show noninferiority of antibiotic treatment for uncomplicated appendicitis.^{7,30} These trials were designed for uncomplicated appendicitis, but the incidence of appendiceal perforation in acute appendicitis increases in patients above 60 y of age to reach 32%–72%.^{5,15,21,33–36} (63% in the present study). Moreover, Vons et al. show that despite CT-scan assessment, 18% of patients were unexpectedly identified at surgery to have complicated appendicitis with peritonitis.⁷ Thus, we believe there is not enough evidence in the current literature to support nonoperative management in the elderly.

Our study has the usual limitations of a retrospective review. First, the number of patients above 75 y is relatively small. Also, treatment choices were made at the surgeon's discretion, with no consistent criteria for assign-

ment of patients to laparoscopy or specific therapeutic courses. Finally, in order to highlight the risk factors leading to appendiceal perforation one would ideally collect clinical data before and not after perforation occurred. However, this study highlights the fact that appendicitis is not a pathology exclusively observed in young people and, in the elderly, is associated with a higher rate of complicated appendicitis, morbidity, and mortality.

CONCLUSIONS

Management of emergency surgical disease in the elderly requires that the surgeon combine everyday surgical practice with geriatrics. The elderly have specific characteristics that must be considered from the outset, both before and after surgery and until the end of hospital care. This study highlights the fact that appendicitis in the elderly is associated with a higher rate of complicated forms, morbidity, and mortality, as well as a higher presence of unsuspected appendiceal neoplasms. Geriatric comanagement programs have been associated with improved postoperative results after surgery, such as shorter length of stay, less mortality, and lower readmission rate.^{37,38} Therefore, researchers should seek to develop management strategies tailored specifically to the elderly population.

References:

1. Mackenbach JP. Convergence and divergence of life expectancy in Europe: a centennial view. *Eur J Epidemiol.* 2013;28(3):229–240.
2. Klopfenstein CE, Herrmann FR, Michel JP, Clergue F, Forster A. The influence of an aging surgical population on the anesthesia workload: a ten-year survey. *Anesth Analg.* 1998;86(6):1165–1170.
3. Ferris M, Quan S, Kaplan BS, et al. The global incidence of appendicitis: a systematic review of population-based studies. *Ann Surg.* 2017;266(2):237–241.
4. de Wijckerslooth EML, van den Boom AL, Wijnhoven BPL. Disease burden of appendectomy for appendicitis: a population-based cohort study. *Surg Endosc.* 2020;34(1):116–125.
5. Yamini D, Vargas H, Bongard F, Klein S, Stamos MJ. Perforated appendicitis: is it truly a surgical urgency? *Am Surg.* 1998;64(10):970–975.
6. Franz MG, Norman J, Fabri PJ. Increased morbidity of appendicitis with advancing age. *Am Surg.* 1995;61(1):40–44.
7. Vons C, Barry C, Maitre S, et al. Amoxicillin plus clavulanic acid versus appendectomy for treatment of acute uncompli-

- cated appendicitis: an open-label, non-inferiority, randomised controlled trial. *Lancet*. 2011;377(9777):1573–1579.
8. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373–383.
 9. St-Louis E, Iqbal S, Feldman LS, et al. Using the age-adjusted Charlson comorbidity index to predict outcomes in emergency general surgery. *J Trauma Acute Care Surg*. 2015;78(2):318–323.
 10. Legrain PS. Consommation Médicamenteuse chez le Sujet Agé. Published online 2005;16. Available at: http://has-sante.fr/upload/docs/application/pdf/pmsa_synth_biblio_2006_08_28_16_44_51_580.pdf.
 11. Haute Autorité de Santé - Comment améliorer la qualité et la sécurité des prescriptions de médicaments chez la personne âgée? Accessed September 24, 2018. Available at: https://www.has-sante.fr/jcms/c_1771468/fr/comment-ameliorer-la-qualite-et-la-securite-des-prescriptions-de-medicaments-chez-la-personne-agee.
 12. Duron J-J, Duron E, Dugue T, et al. Risk factors for mortality in major digestive surgery in the elderly: a multicenter prospective study. *Ann Surg*. 2011;254(2):375–382.
 13. Atema JJ, van Rossem CC, Leeuwenburgh MM, Stoker J, Boermeester MA. Scoring system to distinguish uncomplicated from complicated acute appendicitis. *Br J Surg*. 2015;102(8):979–990.
 14. Deiters A, Drozd A, Parikh P, Markert R, Shim JK. Use of the Alvarado score in elderly patients with complicated and uncomplicated appendicitis. *Am Surg*. 2019;85(4):397–402.
 15. Omari AH, Khammash MR, Qasaimeh GR, Shammari AK, Yaseen MKB, Hammori SK. Acute appendicitis in the elderly: risk factors for perforation. *World J Emerg Surg*. 2014;9(1):6.
 16. Kizer KW, Vassar MJ. Emergency department diagnosis of abdominal disorders in the elderly. *Am J Emerg Med*. 1998;16(4):357–362.
 17. Laurell H, Hansson L-E, Gunnarsson U. Acute abdominal pain among elderly patients. *Gerontology*. 2006;52(6):339–344.
 18. Parker JS, Vukov LF, Wollan PC. Abdominal pain in the elderly: use of temperature and laboratory testing to screen for surgical disease. *Fam Med*. 1996;28(3):193–197.
 19. Siribumrungwong B, Noorit P, Wilasrusmee C, Thakkinstian A. A systematic review and meta-analysis of randomised controlled trials of delayed primary wound closure in contaminated abdominal wounds. *World J Emerg Surg*. 2014;9(1):49.
 20. Siribumrungwong B, Chantip A, Noorit P, et al. Comparison of superficial surgical site infection between delayed primary versus primary wound closure in complicated appendicitis: a randomized controlled trial. *Ann Surg*. 2018;267(4):631–637.
 21. Lee JF, Leow CK, Lau WY. Appendicitis in the elderly. *Aust N Z J Surg*. 2000;70(8):593–596.
 22. Ong M, Guang TY, Yang TK. Impact of surgical delay on outcomes in elderly patients undergoing emergency surgery: A single center experience. *World J Gastrointest Surg*. 2015;7(9):208–213.
 23. Kim HY, Park JH, Lee YJ, Lee SS, Jeon J-J, Lee KH. Systematic review and meta-analysis of CT features for differentiating complicated and uncomplicated appendicitis. *Radiology*. 2018;287(1):104–115.
 24. Paik PS, Towson JA, Anthonie GJ, Ortega AE, Simons AJ, Beart RW. Intra-abdominal abscesses following laparoscopic and open appendectomies. *J Gastrointest Surg*. 1(2):188–192, 1997; discussion 192–193.
 25. Krisher SL, Browne A, Dibbins A, Tkacz N, Curci M. Intra-abdominal abscess after laparoscopic appendectomy for perforated appendicitis. *Arch Surg*. 2001;136(4):438–441.
 26. Kirshtein B, Perry ZH, Mizrahi S, Lantsberg L. Value of laparoscopic appendectomy in the elderly patient. *World Journal of Surgery*. 2009;33(5):918–922.
 27. Ukai T, Shikata S, Takeda H, et al. Evidence of surgical outcomes fluctuates over time: results from a cumulative meta-analysis of laparoscopic versus open appendectomy for acute appendicitis. *BMC Gastroenterol*. 2016;16:37.
 28. Ailshire JA, Beltrán-Sánchez H, Crimmins EM. Becoming centenarians: disease and functioning trajectories of older US Adults as they survive to 100. *J Gerontol A Biol Sci Med Sci*. 2015;70(2):193–201.
 29. Varadhan KK, Humes DJ, Neal KR, Lobo DN. Antibiotic therapy versus appendectomy for acute appendicitis: a meta-analysis. *World J Surg*. 2010;34(2):199–209.
 30. Salminen P, Paaanen H, Rautio T, et al. Antibiotic therapy vs appendectomy for treatment of uncomplicated acute appendicitis: the APPAC randomized clinical trial. *JAMA*. 2015;313(23):2340–2348.
 31. Styrd J, Eriksson S, Nilsson I, et al. Appendectomy versus antibiotic treatment in acute appendicitis. a prospective multicenter randomized controlled trial. *World J Surg*. 2006;30(6):1033–1037.
 32. Hansson J, Körner U, Khorram-Manesh A, Solberg A, Lundholm K. Randomized clinical trial of antibiotic therapy versus appendectomy as primary treatment of acute appendicitis in unselected patients. *Br J Surg*. 2009;96(5):473–481.
 33. Rydén CI, Grunditz T, Janzon L. Acute appendicitis in patients above and below 60 years of age. incidence rate and clinical course. *Acta Chir Scand*. 1983;149(2):165–170.

34. Paajanen H, Kettunen J, Kostiainen S. Emergency appendectomies in patients over 80 years. *Am Surg.* 1994;60(12): 950–953.
35. Temple CL, Huchcroft SA, Temple WJ. The natural history of appendicitis in adults. a prospective study. *Ann Surg.* 1995; 221(3):278–281.
36. Lunca S, Bouras G, Romedea NS. Acute appendicitis in the elderly patient: diagnostic problems, prognostic factors and outcomes. *Rom J Gastroenterol.* 2004;13(4):299–303.
37. Van Grootven B, Mendelson DA, Deschodt M. Impact of geriatric co-management programmes on outcomes in older surgical patients: update of recent evidence. *Curr Opin Anaesthesiol.* 2020;33(1):114–121.
38. Eamer G, Taheri A, Chen SS, et al. Comprehensive geriatric assessment for older people admitted to a surgical service. *Cochrane Database Syst Rev.* 2018;1:CD012485.