ORIGINAL RESEARCH

Laparoscopic appendectomy by surgical trainees at a public teaching hospital in Cape Town, South Africa: A retrospective, observational study

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Abstract

Background

The uptake of laparoscopic appendectomy (LA) for acute appendicitis is variable in resource-limited settings despite an abundance of literature demonstrating associated improved patient outcomes. In South Africa, surgical trainees often perform most emergency operations unsupervised. This study's objectives were to describe the uptake and trainee supervision of LA at a teaching hospital in a resource-limited setting.

Methods

A retrospective, observational study analysing data from 1 January 2013 through 31 December 2015 was conducted at New Somerset Hospital, a public teaching hospital in Cape Town, South Africa. The study cohort comprised patients who underwent appendectomy for acute appendicitis. Factors associated with the choice of LA over open appendectomy (OA) among surgical trainees and surgical outcomes were analysed.

Results

Two hundred seventy-six appendectomies (62%) were attempted laparoscopically, with 225 (84%) completed as LA and 51 (19%) converted to OA. The proportion of cases completed laparoscopically increased significantly from 29% in 2013 to 68% in 2015 ($P<0.001$). Trainees were involved in all appendectomies, unsupervised in 85% of cases. Factors significantly associated with choosing OA included male gender, generalized peritonitis, elevated heart rate, and unsupervised trainees ($P<0.005$). The absence of trainee supervision was not associated with an increased duration of hospitalization ($P=0.352$) or conversion to OA ($P=0.506$).

Conclusions

LA was the most commonly performed operation for acute appendicitis, and the majority were conducted by unsupervised trainees in this setting. The establishment of an LA policy that employs a change management approach with support from all stakeholders is essential for scaling up LA at teaching hospitals, which may serve as a benchmark for the initiation of minimally invasive surgery in resource-limited settings.

Keywords: laparoscopy, appendicitis, appendectomy, trainee, supervision, low- and middle-income countries, South Africa

Introduction

Acute appendicitis (AA) is a common surgical emergency, with an incidence exceeding 100 cases per 100 000 person-years.[1] Although antibiotics may treat uncomplicated AA, surgical removal of the inflamed appendix remains the definitive management.[2] Surgical options include open appendectomy (OA) and laparoscopic appendectomy (LA).[3] LA is recognized as the preferred operation for AA when adequate equipment and surgical expertise are accessible.[4] LA has been shown to be associated with significantly fewer adverse clinical outcomes compared with OA, even in

complicated cases of appendicitis.[5]-[7] A Cochrane review highlighted reduced surgical site infections (SSIs), shorter in-hospital length of stay (LOS), and quicker return to work post-LA vs OA.[4]

Despite the well-documented clinical benefits, the adoption of LA has been inconsistent globally. In high-income countries, LA is the predominant surgical intervention for AA, with utilization rates reaching 80% in the United States and 86% in Germany.[8],[9] A comprehensive analysis of 4546 appendectomies across 52 countries revealed that in low- and middle-income countries (LMICs), LA was performed less frequently—11% compared with 55% in high-income countries.[10] Nonetheless, LA is becoming more prevalent in LMICs, as evidenced by single-centre studies underscoring its clinical advantages.[11]-[13]

The health system in South Africa, classified as an upper middle-income country, is encumbered by inequality.[14],[15] The public health sector, burdened by resource constraints and a limited health workforce, often depends on trainees to perform surgical procedures, typically with minimal supervision.[16] One study conducted in South Africa found that a mere 6% of appendectomies conducted by trainees were supervised.[17] Consequently, LA has seen limited adoption in the South African public health sector.[18],[19]

Several studies globally have investigated the safety of trainees performing LA and have found comparable outcomes in terms of LOS, mortality, and complication rates, including in emergency operations.[20]-[24] One study noted that trainees in 8 African countries performed more operations than their counterparts in the United States.[25] In South Africa, surgical trainees have opportunities to perform laparoscopic operations during their training, but there is a voiced need for more exposure to minimally invasive surgery.[26],[27] In the last decade, the South African Society of Endoscopic Surgeons have been advocating for increased laparoscopic training in the South African curriculum to address this deficit and have recommended that LA be integrated into standard training.[28]-[30]

Studies have demonstrated that LA is a beneficial initial step in laparoscopic training and can serve as an index procedure for surgical trainees.[20],[22] In South Africa, there is a lack of data regarding the frequency of LA performed by trainees and associated outcomes. This study investigated the adoption of LA at a teaching hospital in a resource-limited setting that has implemented a policy to encourage the use of LA. The primary objective of this study was to delineate the factors associated with the choice of LA over OA. The secondary objective was to assess the factors contributing to a longer LOS.

Methods

Study design and setting

This was a retrospective, observational study of patients who underwent appendectomy between 1 January 2013 and 31 December 2015 at the Department of Surgery of New Somerset Hospital (NSH). Patients with a primary diagnosis other than AA who underwent incidental appendectomy (right hemicolectomy for colon cancer, for example) were excluded. Children younger than 8 years old with AA were also excluded, as they were managed at the referral paediatric hospital.

NSH is a public second-level teaching hospital in Cape Town, South Africa, serving an estimated referral population of 500 000 people. Through a policy initiative initiated in early 2012, the Department of General Surgery at NSH has been promoting laparoscopy for all emergency abdominal operations, including for AA. A change management approach has been adopted, securing the cooperation of all stakeholders—including surgeons, anaesthetists, and nurses—in a phased manner. Initially, laparoscopic techniques were introduced for elective abdominal operations during regular working hours with senior surgeons in attendance. This allowed operating theatre nurses and anaesthesiologists to familiarize themselves with the specialized equipment and the routine of laparoscopic cases. With the initiation of emergency laparoscopic procedures, including LA, senior surgeons have been present and actively involved in all cases, thereby demonstrating the procedures' acceptable durations and complexity to all team members. Trainee surgeons are closely observed, trained, and evaluated by senior surgeons in LA cases during regular hours before being authorized to perform the operations independently. Senior surgeons remain readily available for guidance, technical advice, or direct supervision as required.

Data collection

Patients were identified through operating theatre registries. The following variables were collected from paper medical records and entered into an electronic database: type of operation, rank of primary surgeon, trainee surgeon supervision status, presence of intra-abdominal pus, appendiceal perforation status, and operative time. Handwritten medical records were reviewed for admission and outcome variables, including age, gender, heart rate, temperature, white blood cell count, LOS, SSI, and in-hospital mortality.

Definitions and measures

An appendectomy was defined as an operation to remove the appendix and was categorized as open OA, LA, or conversion. LA was typically performed using a 3-port technique, involving 1 camera port and 2 working ports. OA involved an appendectomy through either a limited right iliac fossa incision (McBurney-type or Lanz-type incision) or a midline laparotomy. Conversion was defined as an LA that was converted to OA.

Trainees included medical officers employed full-time in the Department of Surgery, as well as University of Cape Town general surgery residents at all stages of their training. Senior surgeons were general surgery specialists employed full-time at NSH.

The primary surgeon was identified as the operating surgeon who performed the key portions of the operation. The primary surgeon could be either a senior or trainee surgeon.

Senior surgeons provided trainees with management assistance and technical supervision when necessary. The terms 'supervised' and 'unsupervised' referred exclusively to the presence and absence, respectively, of in-person senior supervision intraoperatively. Intraoperative trainee supervision was defined as having a senior scrubbed in at any point of the operation, whether as the primary or assisting surgeon.

Intraabdominal pus was defined as the presence of pus in the abdomen identified intraoperatively. Appendiceal perforation was defined intraoperatively by the identification of macroscopic transmural perforation of the appendix. The Centers for Disease Control and Prevention's definition of SSI was used.[31] The in-hospital mortality rate was the proportion of patients who died during the respective admissions following their operations. LOS was defined as the number of days from operation to discharge.

Data analysis

All analyses were conducted using Stata 13 (StataCorp, College Station, TX, USA). Continuous data were assessed for normality using the Shapiro–Wilk test. Baseline characteristics were described using counts with percentages for categorical data, means with standard deviations for normally distributed continuous data, and medians with interquartile ranges for skewed continuous data. Comparisons were made using independent Student's t-tests or Wilcoxon rank-sum tests for continuous variables and chi-squared tests for categorical data.

LOS was used as a measure of clinical outcome. Multivariate logistic regression was used to determine factors associated with LOS, including preoperative factors, type of operation, and supervision. Multivariate analyses were also conducted to identify factors associated with choosing OA and conversion. Age and gender were included a priori. Factors with P values <0.10 in univariate analyses were incorporated into the multivariate model. All tests were considered significant at $P<0.05$.

Ethical considerations

The University of Cape Town Human Research Ethics Committee granted ethical approval for the study (HREC 758/2015).

Results

During the study period, 512 appendectomies were performed. Of these, 444 had complete records and were included in the analysis. The median age was 26 years (interquartile range, 19-34 years), with 50% of the patients being male. Two hundred seventy-six cases (62%) were attempted laparoscopically, of which 225 (84%) were completed successfully, and 51 (19%) of those initiated as LA were converted to OA. The proportion of cases successfully completing LA increased significantly from 29% in 2013 to 68% in 2015 ($P<0.001$).

Preoperative patient characteristics are presented in Table 1. Patients who underwent LA were younger (median, 26 vs 29 years), more likely to be female (66% vs 40%), and less likely to present with generalized peritonitis (4% vs 23%) compared with those who underwent OA. Patients requiring conversion to OA had higher median preoperative values for body temperature (37.4°C vs 37.0°C, $P=0.003$), heart rate (102 vs 88 beats per minute), and white blood cell count (16.2 vs 12.7 × 10^9/L), and they were more likely to have generalized peritonitis (14% vs 4%) than LA cases.

Trainee surgeons participated in all appendectomies either as the primary or assisting surgeons. They were unsupervised in 85% of cases (Table 2). Trainees were less likely to conduct LA (79%) unsupervised compared with OA (92%, $P=0.001$) and conversions (92%, $P=0.030$). The operation durations varied; LA procedures took a median of 65 minutes, compared with 56 minutes for OA ($P=0.010$). The median operative time for conversions was longer than that for LA (87 vs 65 minutes, $P<0.001$). Intraoperative pus was found more frequently in association with OA (52%, $P=0.009$) and conversion (71%, $P<0.001$) cases than in LA cases (39%). SSIs were less commonly associated with LA (4%) than with OA (11%, $P=0.010$) and conversions (26%, $P<0.001$). The median LOS was significantly shorter in association with LA (1 day) than with OA and conversions (3 days, $P<0.001$). There were 3 deaths in total, all occurring in the OA group.

Multivariate analysis revealed the following factors associated with opting for OA: male gender (odds ratio [OR], 2.33; $P<0.001$), generalized peritonitis (OR, 6.27; $P<0.001$), elevated heart rate (OR, 1.02; $P=0.006$), and unsupervised trainee surgeon (OR, 3.49; $P=0.001$) (Table 3). Factors contributing to an increased LOS were age (OR, 1.03; $P=0.010$), generalized peritonitis (OR, 3.38; $P=0.004$), OA or conversion (OR, 8.34; $P<0.001$), intraoperative pus (OR, 3.21; $P<0.001$), and SSI (OR, 4.54; $P=0.003$) (Table 4). Having unsupervised trainees perform appendectomies was not associated with a longer LOS (OR, 0.77; $P=0.352$). Moreover, there were no significant preoperative risk factors identified that were associated with the need for conversion (Supplementary File). An absence of supervision for trainee surgeons undertaking appendectomies was not associated with increased odds of conversion (OR, 2.08; $P=0.506$).

Discussion

The uptake of laparoscopic surgery, especially for emergency conditions, has been slow in resource-limited hospitals in LMICs. This study demonstrated that LA was regularly practised at a South African public hospital that implemented a policy to encourage the surgical treatment of AA laparoscopically. It showed that LA was attempted in nearly two-thirds of appendectomies, with half being successfully completed. Over the study period, the number of LA cases doubled. There were better patient outcomes associated with LA over OA, specifically decreased LOS and SSI, which is consistent with international experience; however, as these groups were not random, this is possibly an indication of selection bias.[4] Trainee surgeons completed most of the LA cases without senior supervision, similar to rates of unsupervised LA in the United Kingdom.[24]

Table 1. Preoperative characteristics of patients undergoing appendectomy by operation type at New Somerset Hospital, Cape Town, South Africa, 2013-2015

Characteristic	LA	OA	Conversion from LA to OA	Total
Number	225 (50.7)	168 (37.8)	51 (11.5)	444
Age, years	26 (19-32)	29 (21-37)	24 (16-31)	26 (19-34)
Males	98 (43.6)	101 (60.1)	23 (45.1)	222 (50.0)
Generalized peritonitis	10 (4.4)	39 (23.2)	7 (13.7)	56 (12.6)
Temperature, °C	37.0 (36.4-37.7)	37.0 (36.4-37.7)	37.4 (36.9-38.3)	37.0 (36.4-37.8)
Heart rate, bpm	88 (76-103)	96 (82-110)	102 (87-115)	93 (79-108)
WBC count, cells×10⁹/L	12.7 (9.9-16.3)	14.0 (10.6-17.4)	16.2 (12.9-20.2)	13.6 (10.3-17.1)

Continuous variables are reported as median (interquartile range). Categorical variables are reported as n (%). Due to rounding, the per cent totals may not sum to 100%

LA, laparoscopic appendectomy; OA, open appendectomy; bpm, beats per minute; WBC, white blood cell

Table 2. Operative characteristics and outcomes by appendectomy type at New Somerset Hospital, Cape Town, South Africa, 2013-2015

Characteristic or outcome	LA	OA	*P* value[a]	Conversion from LA to OA	*P* value[b]	Total
Number	225 (50.7)	168 (37.8)	–	51 (11.5)	–	444
Trainee surgeon unsupervised	178 (79.1)	154 (91.7)	0.001	47 (92.2)	0.03	379 (85.4)
Operation length, minutes	65 (50-80)	56 (43-75)	0.01	87 (70-103)	<0.001	64 (48-83)
Intraoperative pus	88 (39.1)	88 (52.4)	0.009	36 (70.6)	<0.001	212 (47.7)
Surgical site infections	10 (4.4)	19 (11.3)	0.01	13 (25.5)	<0.001	42 (9.5)
LOS, days	1 (1-2)	3 (2-4)	<0.001	3 (2-5)	<0.001	2 (1-3)
In-hospital mortality	0 (0.0)	3 (1.8)	0.04	0 (0.0)	–	3 (0.7)

Continuous variables are reported as median (interquartile range). Categorical variables are reported as n (%). Due to rounding, the percent totals may not sum to 100%.

[a]LA versus OA; [b]LA versus conversion

LA, laparoscopic appendectomy; OA, open appendectomy; LOS, length of stay

Table 3. Factors associated with the performance of open appendectomy for acute appendicitis at New Somerset Hospital, Cape Town, South Africa, 2013-2015

Open appendectomy[a]	Univariate			Multivariate		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Age, years	1.02	1.00-1.04	0.02	1.02	1.00-1.04	0.06
Male patient	1.95	1.30-2.93	0.001	2.33	1.48-3.65	<0.001
Generalized peritonitis	6.50	3.14-13.46	<0.001	6.27	2.84-13.81	<0.001
Temperature, °C	1.11	0.89-1.38	0.35	–	–	–
Heart rate, bpm	1.01	1.00-1.02	0.007	1.02	1.00-1.03	0.006
WBC count, cells×10⁹/L	1.03	0.99-1.08	0.12	–	–	–
Trainee surgeon unsupervised	2.90	1.54-5.48	0.001	3.49	1.72-7.09	0.001

Variables with *P*<0.1 in the univariate analysis were included in the multivariate analysis. Age and sex were included in the multivariate analysis *a priori*.

[a]Starting open appendectomy, reference group laparoscopic appendectomy

bpm, beats per minute; CI, confidence interval; OR, odds ratio; WBC, white blood cell

Table 4. Factors associated with length of stay after surgical appendectomy at New Somerset Hospital, Cape Town, South Africa, 2013-2015

Length of stay (>2 days)	Univariate			Multivariate		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Age, years	1.03	1.02-1.05	<0.001	1.03	1.01-1.05	0.01
Male patient	0.91	0.61-1.34	0.62	0.63	0.36-1.11	0.11
Generalized peritonitis	7.30	3.84-13.09	<0.001	3.38	1.49-7.65	0.004
Temperature, °C	1.26	1.03-1.56	0.03	1.05	0.77-1.42	0.78
Heart rate, bpm	1.02	1.01-1.03	<0.001	1.00	0.99-1.02	0.93
WBC count, cells×10^9/L	1.05	1.01-1.09	0.02	1.01	0.96-1.06	0.70
Open appendectomya	8.17	5.14-12.99	<0.001	8.34	4.63-15.01	<0.001
Trainee surgeon unsupervised	0.77	0.45-1.33	0.35			
Operation duration, minutes	1.01	1.01-1.02	<0.001	1.00	0.99-1.01	0.58
Intraoperative pus	5.22	3.39-8.02	<0.001	3.21	1.81-5.71	<0.001
Surgical site infections	6.32	3.08-12.98	<0.001	4.54	1.68-12.24	0.003

Variables with *P*<0.1 in the univariate analysis were included in the multivariate analysis. Age and sex were included in the multivariate analysis ***a priori***.

[a]Includes those converted from laparoscopic appendectomy as well as those started as open appendectomy

bpm, beats per minute; CI, confidence interval; WBC, white blood cell; OR, odds ratio

LA is recommended globally as the procedure of choice for AA.[4] Previous studies conducted in South Africa have shown an inconsistent uptake of LA as a routine operation, especially in public hospitals where most healthcare is delivered.[18],[19],[32],[33] In the context of this study, the increase in the adoption of LA arose from the implementation of a hospital policy that encouraged the use of laparoscopy for all emergency abdominal operations. This policy was implemented gradually and sought buy-in from all stakeholders, including nurses and anaesthesiologists. A change management approach achieved successful LA implementation, particularly by trainee surgeons, in this low-resource setting. A culture of change should be encouraged, with examples set by senior management. The use of a change management approach to introduce minimally invasive surgery in resource-limited settings should be explored further in other contexts.

While hospital policy encouraged LA, 38% of appendectomies were not initiated laparoscopically. Patients presenting with more severe symptoms, such as tachycardia and generalized peritonitis, more frequently underwent OA. Females, in whom the diagnosis might be less certain, were also more commonly approached laparoscopically. Additionally, an absence of senior supervision was associated with trainees opting not to attempt LA. Further investigation is warranted to explain this association; we hypothesize that trainees were hesitant to request in-person supervision and were more comfortable performing OA unsupervised. The potential of training tools to promote the adoption of LA should be further explored, including the use of laparoscopy trainers. Training tools, which can be easily constructed with boxes, basic instruments, and simple cameras, are cost-effective. Their use in resource-limited environments should be an integral component of any laparoscopic training programme.

Overall, trainee surgeons were unsupervised in the majority of appendectomies. However, the role of senior surgeons may be underrepresented due to the provision of telephonic advice and oversight during operations, even when senior surgeons are not physically scrubbed in. Notably, unsupervised trainee performance of an appendectomy was not associated with an extended LOS or an increased rate of conversion to open surgery. Given the low mortality and SSI rates, we were not able to evaluate their associations with the level of trainee supervision. However, the comparable LOS may be an early indicator that surgical trainees are capable of safely conducting appendectomies without senior oversight in our setting, aligning with findings from other countries.[20]-[24] To ensure the safe performance of LA by trainees without direct supervision, it is necessary to establish a context-specific minimum number of supervised operations.[34] Surgical trainees form a crucial component of the emergency healthcare system in South Africa.[26],[35],[36] They are eager to perform more laparoscopic surgery,[26],[27] and LA is internationally acknowledged as a fundamental procedure for laparoscopic training.[20],[22] To this end, LA should be actively supported at teaching hospitals in South Africa and other resource-constrained settings, ensuring adequate supervision is available when needed.

Limitations

This study was limited by its retrospective, nonrandomized design. There may have been other factors contributing to the uptake of LA that were not measured in this retrospective audit. Variables, such as preoperative duration of symptoms, delays in transfer to the operating theatre, and readmissions, were not captured, and these could have influenced the choice of surgical method. Data on 30-day outcomes for SSIs and postoperative mortality were not collected, and therefore, differences in long-term outcomes between operations or surgeon types remain unknown. Objective measures of the laparoscopic skills of the trainee surgeons were also not documented. The time of surgery (day vs night) was not analyzed, which might have provided further insights into the selection of the surgical approach. Further limitations, such as a lack of equipment (which is more expensive for LA), were not considered. Additionally, the nature and extent of the contributions of senior surgeons were not recorded, which could underestimate their input.

This study provided initial insights into LA uptake by trainee surgeons at a single institution, but further investigation is recommended on the topic, including (1) larger, longitudinal studies to assess outcomes, (2) qualitative research with surgical trainers and trainees to investigate ways to improve LA training and adoption, and (3) the establishment of robust minimally invasive surgery programmes in resource-limited settings that offer supervised training.

Conclusions

This study demonstrated that after a hospital policy was implemented to encourage the use of laparoscopic techniques, a high proportion of AA cases were completed laparoscopically. This is particularly relevant in low-resource settings, where there may still be barriers to LA uptake. The development of LA policies, using a change management approach and securing the commitment of all stakeholders, is critical for the expansion of LA capacity in teaching hospitals. Such policies could serve as a starting point for the broader establishment of minimally invasive surgery in resource-limited settings.

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References

1. 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. doi:10.1097/SLA.0000000000002188 [View Article] [PubMed]
2. Wilms IM, de Hoog DE, de Visser DC, Janzing HM. Appendectomy versus antibiotic treatment for acute appendicitis. *Cochrane Database Syst Rev*. 2011;(11):CD008359. doi:10.1002/14651858.CD008359.pub2 [View Article] [PubMed]
3. Di Saverio S, Podda M, De Simone B, et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. *World J Emerg Surg*. 2020;15(1):27. doi:10.1186/s13017-020-00306-3 [View Article] [PubMed]
4. Jaschinski T, Mosch CG, Eikermann M, Neugebauer EA, Sauerland S. Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database Syst Rev*. 2018;11(11):CD001546. doi:10.1002/14651858.CD001546.pub4 [View Article] [PubMed]
5. Quah GS, Eslick GD, Cox MR. Laparoscopic appendicectomy is superior to open surgery for complicated appendicitis. *Surg Endosc*. 2019;33(7):2072-2082. doi:10.1007/s00464-019-06746-6 [View Article] [PubMed]
6. Talha A, El-Haddad H, Ghazal AE, Shehata G. Laparoscopic versus open appendectomy for perforated appendicitis in adults: randomized clinical trial. *Surg Endosc*. 2020;34(2):907-914. doi:10.1007/s00464-019-06847-2 [View Article] [PubMed]
7. Low ZX, Bonney GK, So JBY, Loh DL, Ng JJ. Laparoscopic versus open appendectomy in pediatric patients with complicated appendicitis: a meta-analysis. *Surg Endosc*. 2019;33(12):4066-4077. doi:10.1007/s00464-019-06709-x [View Article] [PubMed]
8. Bliss LA, Yang CJ, Kent TS, Ng SC, Critchlow JF, Tseng JF. Appendicitis in the modern era: universal problem and variable treatment. *Surg Endosc*. 2015;29(7):1897-1902. doi:10.1007/s00464-014-3882-2 [View Article] [PubMed]
9. Sahm M, Koch A, Schmidt U, et al. [Acute appendicitis – clinical health-service research on the current surgical therapy]. Article in German. *Zentralbl Chir*. 2013;138(3):270-277. doi:10.1055/s-0031-1283947 [View Article] [PubMed]
10. GlobalSurg Collaborative. Laparoscopy in management of appendicitis in high-, middle-, and low-income countries: a multicenter, prospective, cohort study. *Surg Endosc*. 2018;32(8):3450-3466. doi:10.1007/s00464-018-6064-9 [View Article] [PubMed]
11. Mutlu S. Laparoscopic appendectomy is an appropriate initial way in acute appendicitis surgery. *Egypt J Surg*. 2020;39(4):1082-1087. doi:10.4103/ejs.ejs_185_20 [View Article]
12. El-Houseini EME, Abdelmoteleb HA, Ahmed MS. Is laparoscopic appendicectomy an acceptable approach in management of patients with acute appendicitis? *Egypt J Hosp Med*. 2019;77(6):5911-5921. doi:10.21608/ejhm.2019.65256 [View Article]
13. Hanspal S, Shah MY, Akhtar M. Laparoscopic versus open appendicectomy: a non-randomized comparative study. *Int Surg J*. 2020;7(6):1925-1929. doi:10.18203/2349-2902.isj20202407 [View Article]
14. Coovadia H, Jewkes R, Barron P, Sanders D, McIntyre D. The health and health system of South Africa: historical roots of current public health challenges. *Lancet*. 2009;374(9692):817-834. doi:10.1016/S0140-6736(09)60951-X [View Article] [PubMed]
15. Gini index – South Africa. The World Bank. 2002. Accessed 14 September 2022. https://data.worldbank.org/indicator/SI.POV.GINI?locations=ZA
16. Pohl L, Naidoo M, Rickard J, et al. Surgical trainee supervision during non-trauma emergency laparotomy in Rwanda and South Africa. *J Surg Educ*. 2021;78(6):1985-1992. doi:10.1016/j.jsurg.2021.05.013 [View Article] [PubMed]
17. Rogers AD, Hampton MI, Bunting M, Atherstone AK. Audit of appendicectomies at Frere Hospital, Eastern Cape. *S Afr J Surg*. 2008;46(3):74-77. [PubMed]
18. Zosimas D, Lykoudis PM, Pilavas A, et al. Open versus laparoscopic appendicectomy in acute appendicitis: results of a district general hospital. *S Afr J Surg*. 2018;56(2):59-62. doi:10.17159/2078-5151/2018/v56n2a2392 [View Article] [PubMed]
19. Ndofor B, Mokotedi S, Koto M. Comparing laparoscopic appendectomy to open appendectomy in managing generalised purulent peritonitis from complicated appendicitis: the uncharted path. *S Afr J Surg*. 2016;54(3):30-34. [PubMed]
20. Perry ZH, Netz U, Mizrahi S, Lantsberg L, Kirshtein B. Laparoscopic appendectomy as an initial step in independent laparoscopic surgery by surgical residents. *J Laparoendosc Adv Surg Tech A*. 2010;20(5):447-450. doi:10.1089/lap.2009.0430 [View Article] [PubMed]

21. Harivallavan N, Jayawardene MD, Piyarathne SA, et al. Is laparoscopic appendicectomy safe in the hands of junior trainees in surgery? *Sri Lanka J Surg*. 2020;38(2):1-5. doi:10.4038/sljs.v38i2.8686 [View Article]
22. Ussia A, Vaccari S, Gallo G, et al. Laparoscopic appendectomy as an index procedure for surgical trainees: clinical outcomes and learning curve. *Updates Surg*. 2021;73(1):187-195. doi:10.1007/s13304-020-00950-z [View Article] [PubMed]
23. Canal C, Scherer J, Birrer DL, Vehling MJ, Turina M, Neuhaus V. Appendectomy as teaching operation: no compromise in safety-an audit of 17,106 patients. *J Surg Educ*. 2021;78(2):570-578. doi:10.1016/j.jsurg.2020.08.006 [View Article] [PubMed]
24. Singh P, Turner EJ, Cornish J, Bhangu A; National Surgical Research Collaborative. Safety assessment of resident grade and supervision level during emergency appendectomy: analysis of a multicenter, prospective study. *Surgery*. 2014;156(1):28-38. doi:10.1016/j.surg.2014.04.007 [View Article] [PubMed]
25. Parker RK, Topazian HM, Ndegwa W, et al. Surgical training throughout Africa: a review of operative case volumes at multiple training centers. *World J Surg*. 2020;44(7):2100-2107. doi:10.1007/s00268-020-05463-9 [View Article] [PubMed]
26. Kruger D, Veller MG. Exposure to key surgical procedures during specialist general surgical training in South Africa. *S Afr J Surg*. 2014;52(4):96-100. doi:10.7196/sajs.2162 [View Article] [PubMed]
27. Patel N, Leusink AL, Singh N, Koto MZ, Luvhengo T. Registrar perceptions on general surgical training in South Africa: a report by the South African Society of Surgeons in Training (SASSiT). *S Afr J Surg*. 2018;56(2):10-14. doi:10.17159/2078-5151/2018/v56n2a2448 [View Article] [PubMed]
28. Koto Z. Laparoscopic surgery. Letter to SASES members. University of Limpopo Department of Surgery. 4 November 2014. Accessed 14 September 2022. https://www.sases.org/wp-content/uploads/2019/08/Laparoscopic-surgery-appx-endorsement-Koto.pdf
29. Panieri E. Re: laparoscopic surgery for appendicitis. Letter to Naidoo M. University of Cape Town Department of Surgery. 11 November 2014. Accessed 14 September 2022. https://www.sases.org/wp-content/uploads/2019/08/Appendicetomy-SASES-letter-Prof-Panieri.pdf
30. Training and fellowships. South African Society of Endoscopic Surgeons. 2022. Accessed 14 September 2022. https://www.sases.org/for-surgeons/training-and-fellowships/
31. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. *Infect Control Hosp Epidemiol*. 1992;13(10):606-608. doi:10.2307/30148464 [View Article] [PubMed]
32. Kong VY, Bulajic B, Allorto NL, Handley J, Clarke DL. Acute appendicitis in a developing country. *World J Surg*. 2012;36(9):2068-2073. doi:10.1007/s00268-012-1626-9 [View Article] [PubMed]
33. Yang E, Cook C, Kahn D. Acute appendicitis in the public and private sectors in Cape Town, South Africa. *World J Surg*. 2015;39(7):1700-1707. doi:10.1007/s00268-015-3002-z [View Article] [PubMed]
34. Parker RK, Topazian HM, Parker AS, et al. Operative case volume minimums necessary for surgical training throughout rural Africa. *World J Surg*. 2020;44(10):3245-3258. doi:10.1007/s00268-020-05609-9 [View Article] [PubMed]
35. Dell AJ, Kahn D. Where are general surgeons located in South Africa? *S Afr J Surg*. 2018;56(1):12-18. doi:10.17159/2078-5151/2018/v56n1a2393 [View Article] [PubMed]
36. Klopper JH, Rayamajhi S, Venter JJ, De Villiers DJ, Almgla N, Kloppers JC. Provision of acute and elective general surgical care at a tertiary facility in the era of subspecialisation. S Afr Med J. 2017;107(11):948-951. doi:10.7196/SAMJ.2017.v107i11.12335 [View Article] [PubMed]

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