Outcomes of appendicectomy in an acute care surgery model

Robert C Gandy, Phillip G Truskett, Shing W Wong, Sanchia Smith, Michael H Bennett and Andrew D Parasyn

ABSTRACT

Objective: To assess the outcomes of appendicectomy in an acute care surgery (ACS) model compared with a traditional on-call (Trad) model.

Design: Retrospective historical control study comparing appendicectomy outcomes in the Trad period (April 2004 to March 2005) with outcomes in the ACS period (April 2006 to March 2007).

Setting: The Prince of Wales Public Hospital, a metropolitan tertiary referral centre in Sydney.

Patients: All adult patients undergoing appendicectomy during 1-year periods before and after the introduction of the ACS model.

Intervention: The introduction of an ACS model for managing all emergency general surgical presentations.

Main outcome measure: Complication rate.

Results: A total of 402 appendicectomies were performed, 176 during the Trad period and 226 during the ACS period. There was no perioperative mortality. The complication rate was lower in the ACS period than the Trad period (9.3% v 17.0%; $P = 0.02$). After the intervention, there was no significant change in the time from presentation to arrival in theatre or in length of stay, but the proportion of operations performed at night (24:00–08:00) was reduced from 26.1% to 15.0% ($P = 0.006$). The proportion of negative appendicectomies was reduced from 22.7% to 17.3%, but the change was not statistically significant ($P = 0.08$). There was no difference in perforation rate before and after the intervention (13.6% v 13.3%; $P = 0.86$).

Conclusion: The ACS model provides a safe surgical environment for patients and is associated with a reduced complication rate. Under the ACS model, there was an increase in the number of patients treated conservatively overnight, but this did not lead to an overall increase in perforation rate or length of stay.

MJA 2010; 193: 281–284

An acute care surgery (ACS) service[1] was introduced at Prince of Wales Public Hospital (POWH), Sydney, in September 2005 (Box 1). The primary aim of introducing an ACS was to provide a consultant-led service to improve the efficiency and the predictability of the emergency surgery service. This was achieved by separating the elective and emergency workloads and placing control of the emergency theatre under the acute care general surgeon. Control of the emergency operating theatre allowed for planning of the semi-urgent caseload. The duty acute care surgeon remained on site during the working day, with no other commitments other than the ACS service. Patients whose surgical care had not been completed by the end of the duty period were handed on to the next acute care duty surgeon for definitive care. The introduction of the ACS service at our institution coincided with the formalised referral of surgical patients from a second emergency department within the area network. There were no changes in the clinical guidelines for patient care.

Appendicectomy is the most commonly performed emergency intra-abdominal procedure in Australia. On this basis, we chose to review the management of acute appendicitis to assess whether there were any improvements in patient outcomes and patient flow with implementation of the ACS model.

METHODS

We conducted a retrospective historical control study using the medical records of all patients who had undergone appendicectomy over two 1-year periods: 1 April 2004 to 31 March 2005 (the traditional on-call [Trad] model), and 1 April 2006 to 31 March 2007 (the ACS model). Patients who underwent appendicectomy during the 6 months before and the 6 months after introduction of the ACS (in October 2005) were not included, as this was a transitional period during which the ACS model was piloted.

The inclusion criteria were patients undergoing operations at POWH with the following ORMIS (Operating Room Management Information System; iSOFT, Banbury, UK) codes:

- 30571 (open appendicectomy); and
- 30572 (laparoscopic appendicectomy).

Patients admitted for elective interval appendicectomy were excluded.

Patient medical records, operation reports, times and discharge summaries were examined. Patient demographics, time and date of presentation and operation, operative findings, type of procedure (open or laparoscopic), histology of the appendix, morbidities, length of stay, preoperative use of imaging (ultrasound or computed tomography) and preoperative consultant review were recorded. Operation times were divided into three groups for the purposes of analysis: day (08:00–17:00), evening (17:00–24:00) and night (24:00–08:00). Histological reports were retrieved from the hospital pathology server. Morbidities were recorded and grouped into operation-specific and general complications. Operation-specific complications included wound complications, intra-abdominal collections, small bowel obstructions and readmissions. General complications included cardiac, respiratory and thromboembolic complications and urinary tract infections.

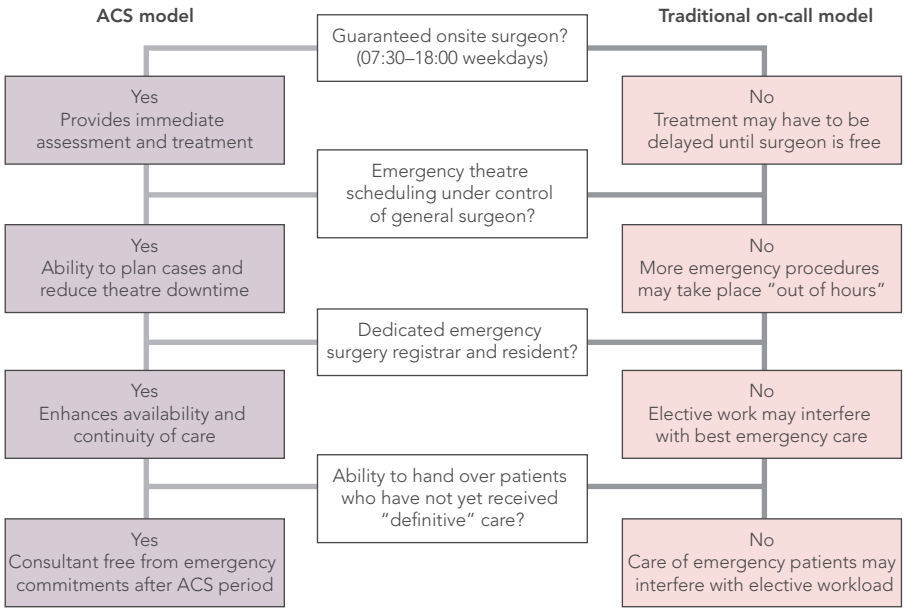
The null hypothesis was that there was no difference in post-appendicectomy outcomes between the Trad and ACS systems. Outcomes analysed were time to operation, time to discharge, morbidity, perforation rate and negative appendicectomy rate. Time of day of appendicectomy was compared between the systems. Morbidity, perforation rate and negative appendicectomy rate were also analysed according to time of day.

Data were analysed using SPSS software, version 17.0 (SPSS Inc, Chicago, Ill, USA). χ^2 tests were performed to evaluate binomial data and Mann–Whitney *U* tests were used to evaluate categorical data.

Ethics approval

Our study was approved by the Human Research Ethics Committee of the South Eastern Sydney and Illawarra Area Health Service.

1 Essential differences between the traditional on-call model for emergency appendicectomy and the acute care surgery (ACS) model



ACS model

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
ACS surgeon 1 07:30–17:30			ACS surgeon 2 07:30–17:30		Surgeon 3 (on call from Friday 18:00 to Monday 07:30)	
Acute care registrar and resident 07:30–17:30					Weekend registrar 07:30–08:00	Weekend registrar 07:30–08:00
On-call registrar 17:00–08:00	On-call registrar 17:00–08:00	On-call registrar 17:00–08:00	On-call registrar 17:00–08:00	On-call registrar 17:00–08:00		

Traditional on-call model

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Consultant 1	Consultant 2	Consultant 3	Consultant 4	Consultant 5	Consultant 6	
Consultant Team registrar 07:30–08:00	Consultant Team registrar 07:30–08:00	Consultant Team registrar 07:30–08:00	Consultant Team registrar 07:30–08:00	Consultant Team registrar 07:30–08:00	Weekend registrar 07:30–08:00	Weekend registrar 07:30–08:00

RESULTS

Of 402 patients who underwent appendicectomy for suspected acute appendicitis during the study period, 176 had the operation during the Trad period and 226 during the ACS period. There were no statistically significant differences in the demographics or insurance status of the two groups (Box 2), and there were no deaths in either group. Patients in the ACS group were more likely to have a documented preoperative review by a consultant surgeon and to undergo ultrasound and computed tomography. There was no significant difference between groups in the histological perforation rate or negative appendicectomy rate, but there was weak evidence that the ACS model reduced the latter.

There was no difference between the two groups in median length of time from emergency department presentation to arrival in the operating theatre (10 h 27 min [Trad] v 9 h 36 min [ACS]; $P = 0.29$). Forty per cent of appendicectomies were completed laparoscopically in the ACS group compared with 11% in the Trad group ($P < 0.001$). There was no significant difference in conversion rate.

A significantly higher proportion of operations took place during the day in the ACS period (47.8% v 34.1%; $P = 0.006$), and a significantly lower proportion of operations were performed at night in the ACS period (15.0% v 26.1%; $P = 0.006$). The proportion of operations performed in the evening did not differ significantly between the Trad and ACS groups (Box 3).

The overall complication rate was significantly lower in the ACS period than the Trad period (9.3% v 17.0%; $P = 0.02$) (Box 4), and the complication rate during daytime hours (08:00–17:00) was also significantly lower in the ACS group than the Trad group (9.3% v 21.7%; $P = 0.02$) (Box 3). The complication rate for non-perforated appendicitis was significantly lower in the ACS group (4.6% v 12.5%; $P = 0.009$).

The negative appendicectomy rate was significantly lower in the ACS group than the Trad group at night ($P < 0.05$) but not at other times (Box 3). There was no overall change in the appendiceal perforation rate. There was also no significant difference between groups in the perforation rates when analysed according to time of day (P [day] = 0.10; P [evening] = 0.33; P [night] = 0.31).

DISCUSSION

The ACS model is consultant-led. This is demonstrated by a significant increase in preoperative patient review by a consultant (from 38.1% to 54.9%) and in supervision of junior surgeons in the operating theatre (from 32.4% to 46.9%). While these proportions appear low, they must be taken in the context of the acute care surgeon being on site for 50 hours of the 168-hour week (ie, 29.8% of the time). The increase in consultant supervision reduces adverse outcomes without compromising registrar training opportunities. A 28% increase in appendicectomy workload, from 176 (Trad group) to 226 (ACS group), was observed. The increase may be due to referrals from a second emergency department.

Patient–consultant interaction before an operation is likely to reinforce patients' confidence in their care. Consultants were not encouraged to ensure documentation with the advent of ACS, so it is assumed that the ratio of documented to undocumented reviews was equal across both groups. Prospective data (not included in this study) suggest that all emergency general surgical patients are reviewed by the ACS surgeon within 24 hours of admission.

Our study specifically investigated the treatment of patients with appendicitis, rather than those with right iliac fossa pain. However, the presence of an on-site acute care surgeon can have a major impact in all areas. A previous study conducted at POWH showed that 40% of all general surgical presentations are saved from

2 Patient demographics, investigations and outcomes*

	Traditional on-call model ($n = 176$)	Acute care surgery model ($n = 226$)	P
Mean age (years)	33.6	32.8	0.57
Female	93 (52.8%)	104 (46.0%)	0.24
Privately insured	58 (33.0%)	60 (26.5%)	0.4
Ultrasound scan	11 (6.3%)	37 (16.4%)	0.001
Computed tomography scan	20 (11.4%)	53 (23.5%)	0.002
Documented consultant review	67 (38.1%)	124 (54.9%)	0.001
Perforated appendicitis	24 (13.6%)	30 (13.3%)	0.86
Negative appendicectomy	40 (22.7%)	39 (17.3%)	0.08
Complications	30 (17.0%)	21 (9.3%)	0.02
Laparoscopic complication rate	7 of 20	7 of 90	0.004
Consultant first operator	56 (31.8%)	77 (34.1%)	0.67
Consultant present at operation	57 (32.4%)	106 (46.9%)	0.004
Median length of stay in days (range)	2 (1–17)	3 (1–13)	0.92
Median time to arrival in theatre (h:min)	10:27	09:36	0.29

* Data are number of patients (%) unless otherwise specified. ◆

3 Outcomes, by time of day of operation

	08:00–17:00 (day)		17:00–24:00 (evening)		24:00–08:00 (night)		Overall	
Outcome	Trad	ACS	Trad	ACS	Trad	ACS	Trad	ACS
Proportion of total operations	34.1%	47.8%*	39.8%	37.2%	26.1%*	15.0%	100%	100%
Perforation rate	18.3%	10.2%	12.9%	16.7%	8.7%	14.7%	13.6%	13.3%
Negative appendicectomy rate	23.3%	21.3%	14.3%	11.9%	34.8%†	17.7%	22.7%	17.3%
Complication rate	21.7%†	9.3%	14.3%	7.1%	15.2%	14.7%	17.0%†	9.3%

ACS = acute care surgery model. Trad = traditional on-call model. * $P < 0.01$. † $P < 0.05$. ◆

4 Complications of appendicectomy

Complication	Trad ($n = 176$)*	ACS ($n = 226$)*	P
Operation-specific			
Wound infection or haematoma	10 (5.7%)	6 (2.7%)	0.13
Pelvic collection	5 (2.8%)	3 (1.3%)	0.30
Small bowel obstruction	2 (1.1%)	3 (1.3%)	0.86
Readmission with bowel obstruction	2 (1.1%)	1 (0.4%)	0.42
Readmission with pain	3 (1.7%)	1 (0.4%)	0.21
Subtotal	22 (12.5%)	14 (7.1%)	0.04
General			
Respiratory	4 (2.3%)	3 (1.3%)	0.47
Deep vein thrombosis or pulmonary embolism	2 (1.1%)	1 (0.4%)	0.42
Cardiac	2 (1.1%)	1 (0.4%)	0.42
Urinary tract infection	0	2 (0.8%)	0.21
Subtotal	8 (4.5%)	7 (3.1%)	0.60
Total	*30 (17.0%)*	*21 (9.3%)*	*0.02*

ACS = acute care surgery model. Trad = traditional on-call model. * Data are number of patients (%). ◆

admission by the presence of an on-site acute care surgeon.[1]

We did not observe any significant improvement in patient flow in terms of time to theatre or length of stay. A previous study of patients undergoing appendicectomy showed that the introduction of acute care surgery was associated with a reduced time to theatre and reduced length of stay.[2] However, this was achieved against a background of an increased proportion of appendicectomies being carried out after midnight. Control of the emergency operating theatre gave the acute care surgeon the ability to intentionally delay non-urgent appendicectomy during the night until the following day. With this conservative approach, there was no increase in perforation rate, the complication rate was reduced and there was no increase in length of stay.

The increasing use of preoperative imaging and laparoscopic techniques are two confounders. The greater use of preoperative imaging during the ACS period compared with the Trad period could potentially have reduced the negative appendicectomy rate, but our results did not show this. Meta-analyses have also failed to consistently show a decrease in the overall rate of complications when comparing conventional with laparoscopic appendicectomy.[3-7] Laparoscopic appendicectomy has been shown to reduce the rate of wound infection, but is associated with a higher incidence of intra-abdominal collection. Reduced postoperative pain scores in patients undergoing laparoscopic appendicectomy may also reduce the incidence of cardiorespiratory complications, but this was not demonstrated in our study.[4-7]

Over the period of our study, laparoscopic appendicectomy became more widely used, and we accept that this change may have had a bearing on our results in terms of a learning curve. Subgroup analysis of the complications of laparoscopic appendicectomy shows a significantly lower complication rate in the ACS period.

Introduction of the ACS system facilitated a reduction in the number of appendicectomies being performed "out of hours". There was an increase in appendicectomies carried out during office hours (from 34.1% to 47.8%) and a reduction in operations performed after midnight (from 26.1% to 15.0%). Patients undergoing appendicectomy after midnight were more likely to have perforation and significantly less likely to have a normal appendix in the ACS period than in the Trad period. In the ACS model, patients presenting with perforated

appendicitis were still operated on after midnight. Having the acute care surgeon in control of the emergency operating theatre allows operations for patients with non-perforated appendicitis to be scheduled for the following morning.

An increase in the number of patients treated conservatively overnight did not lead to an overall increase in perforation rate. Other surgical studies and the findings of the National Confidential Enquiry into Peri-Operative Deaths in the United Kingdom suggest that it is safe to delay surgery for non-perforated appendicitis and that surgery after midnight may be associated with increased morbidity and mortality.[8-12] Prospective studies have reported that delay in presentation, rather than in-hospital delay, account for most of the perforations in patients with appendicitis.[13-16]

We have demonstrated that delaying operations for uncomplicated appendicitis reduced the complication rate and did not alter length of stay. Other studies have confirmed that a 12–24-hour delay before surgery is acceptable.[14,17,18] The potential to perform appropriately timed appendicectomy is achieved by providing the duty surgeon with control of access to the emergency theatre during the day. Greater input and supervision from senior clinicians with respect to diagnosis, management and timeliness of intervention enhance the safety of a surgical service.

By implementing a consultant-led system and a culture in which emergency surgery is prioritised and separated from the elective surgical stream, complications and unnecessary operations after midnight can be reduced.

COMPETING INTERESTS

None identified.

AUTHOR DETAILS

Robert C Gandy, MB ChB, MRCS, Surgical Registrar
Phillip G Truskett, MB BS, FRACS, General/Upper Gastrointestinal Surgeon
Shing W Wong, MB BS, MS, FRACS, Colorectal Surgeon
Sanchia Smith, MB BS, Surgical Intern
Michael H Bennett, MB BS, MD, FANZCA, Director of Hyperbaric Medicine
Andrew D Parasyn, MB BS, FRACS, Oncological Surgeon
Department of General Surgery, Prince of Wales Hospital, University of New South Wales, Sydney, NSW.
Correspondence:
robert.gandy@sesiahs.health.nsw.gov.au

REFERENCES

1 Parasyn AD, Truskett PG, Bennett M, et al. An acute care surgical service — a change in culture. *ANZ J Surg* 2009; 79: 12-18.
2 Earley AS, Pryor JP, Kim PK, et al. An acute care surgery model improves outcomes in patients with appendicitis. *Ann Surg* 2006; 244: 498-504.
3 Meynaud-Kraemer L, Colin C, Vergnon P, et al. Wound infection in open versus laparoscopic appendectomy. A meta-analysis. *Int J Technol Assess Health Care* 1999; 15: 380-391.
4 Chung RS, Rowland DY, Li P, et al. A meta-analysis of randomized controlled trials of laparoscopic versus conventional appendectomy. *Am J Surg* 1999; 177: 250-256.
5 Golub R, Siddiqui F, Pohl D. Laparoscopic versus open appendectomy: a metaanalysis. *J Am Coll Surg* 1998; 186: 545-553.
6 Sauerland S, Lefering R, Holthausen U, et al. Laparoscopic vs conventional appendectomy — a meta-analysis of randomised controlled trials. *Langenbecks Arch Surg* 1998; 383: 289-295.
7 Styrud J, Eriksson S, Nilsson I, et al. Appendicectomy versus antibiotic treatment in acute appendicitis: a prospective multicenter randomized controlled trial. *World J Surg* 2006; 30: 1033-1037.
8 Yardeni D, Hirschl RB, Drongowski RA, et al. Delayed versus immediate surgery in acute appendicitis: do we need to operate during the night? *J Pediatr Surg* 2004; 39: 464-469.
9 Eldar S, Nash E, Sabo E, et al. Delay of surgery in acute appendicitis. *Am J Surg* 1997; 173: 194-198.
10 Paterson HM, Qadan M, de Luca SM, et al. Changing trends in surgery for acute appendicitis. *Br J Surg* 2008; 95: 363-368.
11 Cullinane M, Gray AJ, Hargraves CM, et al. Who operates when? II. The 2003 report of the National Confidential Enquiry into Perioperative Deaths. Section 8. London: NCEPOD, 2003: 69-76.
12 Temple CL, Huchcroft SA, Temple WJ. The natural history of appendicitis in adults: a prospective study. *Ann Surg* 1995; 221: 278-281.
13 Maroju NK, Robinson Smile S, Sistla SC, et al. Delay in surgery for acute appendicitis. *ANZ J Surg* 2004; 74: 773-776.
14 Stahlfeld K, Hower J, Homitsky S, et al. Is acute appendicitis a surgical emergency? *Am Surg* 2007; 73: 626-629.
15 Kearney D, Cahill RA, O'Brien E, et al. Influence of delays on perforation risk in adults with acute appendicitis. *Dis Colon Rectum* 2008; 51: 1823-1827.
16 Wong SW, Haxhimolla H, Grieve DA, et al. Insurance and the risk of ruptured appendix in the adult. *Aust N Z J Surg* 1999; 69: 31-33.
17 Abou-Nukta F, Bakhos C, Arroyo K, et al. Effects of delaying appendectomy for acute appendicitis for 12–24 h. *Arch Surg* 2006; 141: 504-507.
18 Clyde C, Bax T, Merg A, et al. Timing of intervention does not affect outcome in acute appendicitis in a large community practice. *Am J Surg* 2008; 195: 590-592.

(Received 9 Jun 2009, accepted 11 Feb 2010) ❑