The impact of an acute care surgery clinical care pathway for suspected appendicitis on the use of CT in the emergency department

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Background: The natural evolution of an acute care surgery (ACS) service is to develop disease-specific care pathways aimed at quality improvement. Our primary goal was to evaluate the implementation of an ACS pathway dedicated to suspected appendicitis on patient flow and the use of computed tomography (CT) in the emergency department (ED).

Methods: All adults within a large health care system (3 hospitals) with suspected appendicitis were analyzed during our study period, which included 3 time periods: pre- and postimplementation of the disease-specific pathway and at 12-month follow-up.

Results: Of the 1168 consultations for appendicitis that took place during our study period, 349 occurred preimplementation, 392 occurred postimplementation, and 427 were follow-up visits. In all, 877 (75%) patients were admitted to the ACS service. Overall, 83% of patients underwent surgery within 6 hours. The mean wait time from CT request to obtaining the CT scan decreased with pathway implementation at all sites (197 v. 143 min, $p < 0.001$). This improvement was sustained at 12-month follow-up (131 min, $p < 0.001$). The pathway increased the number of CTs completed in under 2 hours from 3% to 42% ($p < 0.001$). No decrease in the total number of CTs or the pattern of ultrasonography was noted ($p = 0.42$). Wait times from ED triage to surgery were shortened (665 min preimplementation, 633 min postimplementation, 631 min at the 12-month follow-up, $p = 0.040$).

Conclusion: A clinical care pathway dedicated to suspected appendicitis can decrease times to both CT scan and surgical intervention.

Contexte : L'évolution naturelle d'un service de chirurgie d'urgence (SCU) consiste à mettre au point des plans d'intervention spécifiques aux maladies dans le but d'améliorer la qualité des soins. Notre objectif principal était d'évaluer l'impact de l'instauration au SCU d'un plan d'intervention spécifique à l'appendicite présumée sur le roulement des patients et sur l'utilisation de la tomomodensitométrie (TDM) à l'urgence.

Méthodes : Les dossiers de tous les patients adultes d'un important réseau de santé (3 hôpitaux) s'étant présentés pour une appendicite présumée ont été analysés durant la période de notre étude qui incluait 3 étapes : avant et après la mise en œuvre du plan d'intervention spécifique, puis suivi à 12 mois.

Résultats : Sur les 1168 consultations pour appendicite qui ont eu lieu durant notre étude, 349 se sont déroulées avant la mise en œuvre du service, 392, après sa mise en œuvre, et 427 étaient des visites de suivi. En tout, 877 patients (75 %) ont été admis au SCU. Globalement, 83 % des patients ont subi une chirurgie dans les 6 heures. Le temps d'attente moyen entre la demande de TDM et sa réalisation a diminué après l'application du plan d'intervention pour tous les sites (197 c. 143 min, $p < 0,001$). Cette amélioration se maintenait toujours au suivi de 12 mois (131 min, $p < 0,001$). Le plan d'intervention a permis de faire passer le nombre de TDM réalisées en moins de 2 heures de 3 % à 42 % ($p < 0,001$). On n'a noté aucune diminution du nombre total de TDM ou des tendances de l'échographie ($p = 0,42$). Les temps d'attente entre le triage et l'appendicectomie ont diminué (665 min avant et 633 min après l'application du plan d'intervention, 631 min au suivi de 12 mois, $p = 0.040$).

Conclusion : Un plan d'intervention spécifique à l'appendicite peut réduire les temps d'attente pour la TDM et l'intervention chirurgicale.

Acute care surgery (ACS) refers to a specific surgical service dedicated to the urgent assessment and treatment of patients with general surgical emergencies.¹ In Canada, this model of health care delivery most often focuses on optimizing the treatment of patients with non-trauma, intra-abdominal crises.^{1,2} Although the local delivery and structure of an ACS service typically varies from hospital to hospital in both Canada and the United States, a mature ACS program should incorporate a focused academic and clinical interest in patients with surgical emergencies, a fellowship training program specific to this subspecialty and evidence-based research centred on improving outcomes.¹

The age- and sex-adjusted incidence of appendicitis in North America ranges from 70 to 100 cases per 100 000, with even higher incidence noted in young people.³⁻⁵ As a result, appendicitis carries a lifetime risk of affecting 1 in 15 people.⁶ Despite the widespread use of minimally invasive techniques, appendicitis continues to generate morbidity, mortality and substantial costs to all health care systems.⁶ This risk is particularly high in the 35% of patients who present to hospital with a perforation.³ As appendectomy is the most frequent operation performed in developed nations, the annual cost of appendicitis-related hospital admissions in the United States now approaches \$3 billion.⁴

In addition to the immense value of a detailed patient history and physical examination, the noninvasive gold standard imaging modality for acute appendicitis remains computed tomography (CT) with contrast medium. While CT is not isolated to diagnosing appendicitis, its use for ACS patients with suspected intra-abdominal pathology has increased tremendously. In 1980, approximately 3 million CT scans were obtained in the United States, and this number had risen to 62 million in 2006.⁷⁻¹² This change has also led to a nearly 6-fold increase in the per capita radiation exposure from medical imaging.¹³⁻¹⁶

The primary goal of this study was therefore to evaluate the impact of implementing an ACS clinical care pathway dedicated to suspected appendicitis on the timing and use of CT and on patient flow through the emergency department (ED). The secondary objective was to compare patient-related variables among 3 ACS-equipped medical centres within the Calgary region of Alberta Health Services.

METHODS

The Calgary region of Alberta Health Services is a centrally organized system that cares for all patients in a geographically diverse area with a population of more than 1 million. This centralized structure has allowed for the development of ACS services at each of our adult medical centres that share dominant guiding principles as well as the acquisition of truly population-based data. The Calgary ACS service (Acute Care Emergency Surgery Service [ACCESS]) was established on Feb. 1, 2004. Although all 3 Calgary centres (Foothills Medical Centre [FMC], Peter Lougheed Centre [PLC], Rocky-

view General Hospital [RGH]) share similar ACS-related principles (dedicated ACCESS surgeon for a 7-d interval), each centre delivers ACCESS care in a slightly different manner. Specifically, the ACCESS surgeon provides all postoperative care for any patient initially admitted to the ACCESS service at 2 centres. The third centre assigns postoperative patients to the surgeon of record, even if the surgeon has rotated off the ACCESS service. General surgery residents are the dominant house staff for 2 of 3 services, whereas off-service residents provide the most coverage at the third hospital. This hospital also has the benefit of a dedicated ACCESS ward to cluster all inpatients. Finally, only 2 centres have protected operating theatre time for ACCESS patients. More specifically, the operating theatre is used in the morning (8 am to 11 am) by a non-ACCESS surgeon for short, elective cases, followed by an afternoon of ACCESS patient operations.

The local/regional concerns for the flow and care of patients with suspected appendicitis originated from 2 dominant issues: a focused desire to improve efficiency in the care of all patients with acute general surgical conditions (i.e., ACS service) and a response to a highly publicized death of a patient with appendicitis.

Data for all patients with suspected appendicitis presenting to the ED at each of the 3 hospitals during 3 time courses (preimplementation of the disease-specific pathway [Nov. 1, 2008, to Jan. 31, 2009], postimplementation [Aug. 1, 2009, to Oct. 31, 2009], and 12-month follow-up [May 1, 2010, to July 31, 2010]) was obtained using the Regional Emergency Department Information System (REDIS). The ACS clinical care pathway for suspected appendicitis (Fig. 1) was initiated on May 1, 2009. The emergency medicine doctor (EMD) formal assessment (Fig. 1) involves a complete history and physical examination with specific reference to gynecological and genitourinary causes of abdominal pain. The ED nurse typically administers oral contrast immediately following the initial EMD assessment. Diagnostic codes (ICD 10 K350-K7) were used as screening tools. Patient identifiers, hospital site, disposition, admitting service and ED time stamps (Emergency department physician [ERP] assessment, ACCESS request, hospital admission request and ED discharge) were examined. Start times for operating room (OR) procedures were provided by the Operating Room Information System. We reviewed the health record chart to confirm REDIS data (9% of data elements were incorrect).

Calculated wait times included time from ED triage to ERP assessment, ERP assessment to ACCESS request, ACCESS request to initial consultation, consultation to admission request, admission request to ED discharge, and total ED triage to ED discharge.

Statistical analysis

We performed our analysis using Stata software version 12.0 (Stata Corp.). Data are reported as means when normally distributed or medians when non-normally distributed. We

compared means using the Student *t* test and medians using the Mann–Whitney *U* test. Differences in proportions among categorical data were assessed using the Fisher exact test. We considered results to be significant at $p < 0.05$.

RESULTS

During the study period, 1168 adult patients were referred for assessment and/or care by the ACCESS team for suspected appendicitis (322 at FMC, 392 at PLC, 454 at RGH). In all, 349 referrals (30%) occurred preimplementation, 392 (34%) occurred postimplementation, and 427 (37%) were follow-up visits. Overall, 877 patients (75%) were admitted by the ACCESS service; the other patients were either discharged (24%) or left against medical advice (1%).

The mean wait times for each stage of a patient's journey through the ED are described in Table 1. The overall mean wait time from CT scan request to obtaining the CT scan was significantly reduced following implementation of the pathway at all sites (197 v. 143 min, $p < 0.001$). This improvement

was sustained at the 12-month follow-up (131 min, $p < 0.001$). As a result, there was a significant increase in the number of patients who underwent CT within 2 hours of ordering (3% v. 42%; $p < 0.001$). This was sustained at the 1-year follow-up (37%; $p < 0.001$), and was consistent across all centres. No significant change in the overall total number of CT scans ordered as a single study was identified (53% preimplementation, 54% postimplementation, 52% at the 12-month follow-up). This equivalence is echoed when ultrasonography was included (i.e., CT alone or in combination with ultrasonography; 62% preimplementation, 61% postimplementation, 59% at the 12-month follow-up). Similar findings were noted for ultrasonography alone (7% preimplementation, 12% postimplementation, 9% at the 12-month follow-up). The percentage of daylight (8 am to 4 pm) ultrasound examinations was also unchanged (58% preimplementation, 48% postimplementation, 61% at the 12-month follow-up).

The overall wait time from ED triage to request for admission was statistically unchanged at all time points (499 min preimplementation v. 444 min postimplementation [$p = 0.38$])

Fig. 1. Acute care surgery suspected appendicitis care map/pathway. CBC = complete blood count; CT = computed tomography; EMD = emergency medical doctor; IV = intravenous; RLQ = right lower quadrant.

v. 432 min at the 12-month follow-up [$p = 0.17$]). At 1 site (FMC) however, we noted an improvement in wait times (579 min preimplementation v. 502 min postimplementation [$p = 0.08$] v. 482 min at the 12-month follow-up [$p = 0.021$]). We noted no difference in the wait from admission request to surgery with the initiation of the care pathway at any site (210 min preimplementation, 246 min postimplementation, 221 min at the 12-month follow-up). The ratio of patients receiving surgery within 6 hours of the admission request was unchanged (86% preimplementation, 78% postimplementation, 84% at the 12-month follow-up; $p = 0.09$).

Upon compilation, overall wait times from ED triage to surgery decreased with the implementation of the appendicitis pathway (665 min preimplementation, 633 min postimplementation, 631 min at the 12-month follow-up, $p = 0.040$).

DISCUSSION

The emergence of acute care surgery as a specific entity is aimed at improving the care and experience of surgically ill patients.^{1,2} Much like the widespread adoption of trauma systems more than 40 years ago, ACCESS-type services must be able to streamline care and enhance hospital efficiencies.¹⁷ Beyond the initial creation of an ACS service, its natural evolution is the development of specific and dedicated care pathways for individual diseases of clinical and resource importance. Given the frequency of appendicitis, and therefore its resource requirements, an ACS-derived clinical care pathway specific to suspected appendicitis is a needed endeavour. The Calgary ACS appendicitis care pathway had 5 specific goals: to reduce wait times from CT request to obtaining the CT scan, to reduce the total number of CT scans ordered, to

increase the number of ultrasound examinations ordered during daylight hours, to reduce the wait times between ED triage and the decision to admit to less than 6 hours and to reduce the wait time from admission request to surgery to less than 6 hours. As a result, this pathway can be summarized as an attempt at streamlining the flow of patients from the ED to the operating theatre. This is particularly topical given the increasingly common experience of ED overcrowding and its “emerging threat to patient safety and public health”.^{18–21} There is also recent suggestion that implementation of ACS services decrease ED length of stay for patients with appendicitis^{22,23} and other general surgical diagnoses.^{17,21}

Upon review of the mature, multi-institutional Calgary ACS/ACCESS experience with its first clinical care pathway, it became evident that the wait time between ordering and obtaining the CT scan was dramatically reduced. As a result, there was an absolute increase of 39% in the number of patients achieving rapid cross-sectional imaging. Furthermore, this improvement was sustained at the 12-month follow-up. The biggest reason for this dramatic change was the reduction of the wait time between oral contrast ingestion and CT imaging to less than 2 hours.

Unfortunately, the overall number of CT scans ordered was not reduced with the implementation of the appendicitis pathway. Similarly, the number of ultrasound investigations during daylight hours (i.e., to spare the effective radiation dose associated with CT²⁴) was unchanged before and after initiation of the pathway. This is not overly surprising given the success of this goal relies on education and awareness. This compares to the observed reduction in wait times for CT for which a specific physical intervention (reduced delay after oral contrast ingestion) was targeted. As a result, one

Table 1. Mean wait times for patients with suspected appendicitis

Period; centre	Mean wait time, min							
	Time from ED triage to EDP assessment	Time from EDP assess to CT order	Time from CT order to CT scan	Time from ED triage to admission request	Time from CT scan to admission request	Time from admission request to discharge	Time from admission request to surgery	Total time from ED triage to surgery
Preimplementation								
Foothills Medical Centre, $n = 95$	182	163	236	579	148	132	198	771
Peter Lougheed Centre, $n = 122$	182	132	174	466	145	147	264	709
Rockyview General Hospital, $n = 132$	145	112	185	469	145	96	170	634
All centres, $n = 349$	168	134	197	499	146	124	210	697
Postimplementation								
Foothills Medical Centre, $n = 116$	187	136	163	502	148	90	211	715
Peter Lougheed Centre, $n = 125$	156	110	127	427	144	131	277	706
Rockyview General Hospital, $n = 151$	113	99	140	408	161	143	247	656
All centres, $n = 392$	149	113	143	444	152	122	246	691
Follow-up								
Foothills Medical Centre, $n = 111$	153	198	129	482	144	94	193	681
Peter Lougheed Centre, $n = 145$	140	167	115	403	139	114	249	635
Rockyview General Hospital, $n = 171$	117	111	142	425	160	137	215	623
All centres, $n = 427$	134	153	131	432	149	118	221	642

CT = computed tomography; ED = emergency department; EDP = emergency department physician.

wonders if this improvement was based on the reliance of nursing care to shorten a time-based interval as opposed to expecting physician-based changes in practice/behaviour (i.e., alteration in ordering habits).

Interestingly, only 1 site (FMC) significantly reduced its delay from ED triage to request for admission. We suspect this is a direct result of the unacceptably long initial wait time, and therefore substantial room for improvement, at the start of the study. More specifically, the FMC wait times from ED triage to admission request were nearly 2 hours longer than those at the other hospitals (579 min at FMC, 466 min at PLC, 469 min at RGH). Furthermore, the wait times from the decision to admit to actual appendectomy also did not decrease with the pathway. Again, room for improvement was minimal, given that 86% of all patients received surgery within 6 hours of admission before implementation of the appendicitis care pathway.

When taken as a whole, overall wait times from ED triage to surgery decreased with the implementation of the appendicitis care pathway; the main reason is the dramatically shorter wait times between ordering and obtaining the CT scan. This algorithmic and protocolized component of the pathway is under nearly complete control of the radiology technician and bedside nurse.

Limitations

This study has several potential limitations. Comparisons between Calgary centres are limited by a lack of patient comorbidity data. Furthermore, despite similar times from admission to surgery across centres, we were not able to evaluate the specific time of day these procedures were completed. This variable may have a substantial impact on economic costs, patient experience and operating room efficiencies that we cannot comment on.

CONCLUSION

Introduction of the Calgary ACS suspected appendicitis care pathway resulted in overall shorter wait times from ED triage to appendectomy. This was likely a result of reducing the delay between contrast medium ingestion and CT imaging. Future quality improvement will require additional interventions at other time points (e.g., more rapid access to the operating room). Attempts at altering physician diagnostic imaging ordering behaviour via education and suggestion were unsuccessful.

Competing interests: G. Kaplan has received compensation from Jansen and Abbvie and has received speaker fees or grants from Abbvie, Shire and Merck; however, these fees were unrelated to the topic of the present article. No other competing interests declared.

Contributors: C.G. Ball, E. Dixon, A.R. MacLean, L. Nicholson and F.R. Sutherland designed the study. C.G. Ball, L. Nicholson and F.R. Sutherland acquired and analyzed the data, which G.G. Kaplan also analyzed. C.G. Ball and L. Nicholson wrote the article, which all authors reviewed and approved for publication.

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