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 vs. 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 tomodensitométrie (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.
A
cute care surgery (ACS) refers to a specific surgical
service dedicated to the urgent assessment and treat-
ment of patients with general surgical emergencies. In Canada, this model of health care delivery most often
focuses on optimizing the treatment of patients with non-
trauma, intra-abdominal crises. 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 fel-
chship training program specific to this subspecialty and
evidence-based research centered on improving outcomes. 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. As a
result, appendicitis carries a lifetime risk of affecting 1 in
15 people. Despite the widespread use of minimally invasive
techniques, appendicitis continues to generate morbidity,
mortality and substantial costs to all health care systems. This risk is particularly high in the 35% of patients who pre-
sent to hospital with a perforation. 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.

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. This change has also led to a nearly 6-fold increase in the per capita radiation exposure from medical imaging.

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 geograph-
ically 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 Medi-
cal 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. Moreover, the oper-
ating 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 con-
ditions (i.e., ACS service) and a response to a highly pub-
licized death of a patient with appendicitis.

Data for all patients with suspected appendicitis present-
ing 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 dis-
charge) were examined. Start times for operating room (OR)
procedures were provided by the Operating Room Informa-
tion 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 ACESS 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 ACESS 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.
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 CT\(^{24}\)) 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**

<table>
<thead>
<tr>
<th>Period; centre</th>
<th>Mean wait time, min</th>
<th>Time from ED triage to EDP assessment</th>
<th>Time from EDP assess to CT order</th>
<th>Time from CT order to CT scan</th>
<th>Time from ED triage to admission request</th>
<th>Time from CT scan to admission request</th>
<th>Time from admission request to discharge</th>
<th>Time from admission request to surgery</th>
<th>Total time from ED triage to surgery</th>
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<td>Preimplementation</td>
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</table>

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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