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# Imaging Approach to the Diagnosis of Acute Appendicitis in a Group of Teaching Hospitals With 24/7 In-house Availability of Ultrasound Technologist: Effect of Timing of Request on Imaging Modality

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## Abstract

**Purpose:** The study sought determine effect of requisition timing on the initial-choice imaging modality in appendicitis evaluation.

**Methods:** This was an institutional review board–approved retrospective study, encompassing 3 University of Toronto teaching hospitals, offering 24/7 radiology coverage. All surgically proven appendicitis cases, from 2012-2014, were included and presurgical ultrasound (US) or computed tomography (CT) reports were analysed. Examinations were all requested by the emergency department, performed by the same technologists and reviewed or finalized by the same radiology group (residents fellows or attending). Two coverage categories, namely regular hours (8 AM-5 PM, Monday-Friday) or after hours (5 PM-8 AM, Monday-Friday and weekends) were compared. The percentage of the starting modality (US or CT), the rate of CT following an indeterminate US, and the sensitivity of each modality was compared between the 2 categories, utilising Mann-Whitney *U* and chi-square tests.

**Results:** Presurgical US or CT studies of 494 patients, from February 2012-August 2014, were evaluated. Regular-hours and after-hours coverage demonstrated 174 (89:85 women:men) and 320 (141:179 women:men;  $P < .04$ ) patients. The average age,  $37.9 \pm 17.1$  women versus  $35.2 \pm 13.7$  men was not statistically different ( $P = .8$ ). Regular hours included 89 of 174 (51.1%) of US-only examinations, 50 of 174 (29%) of CT-only examinations, and 35 of 174 (20%) of US examinations followed by CT examinations. After hours included 147 of 320 (46%) of US-only examinations, 147 of 320 (46%) of CT-only examinations, and 26 of 320 (8%) of US examinations followed by CT examinations ( $P < .001$ ). The total diagnostic sensitivities for US and CT were 86% (81% regular hours, 90% after hours;  $P = .041$ ) and 99.2% (100% regular hours, 99% after hours;  $P > .05$ ), respectively.

**Conclusions:** US was less utilised in acute appendicitis detection after hours, although its diagnostic sensitivity was better than regular-hours coverage.

## Résumé

**Objet :** La présente étude cherche à déterminer dans quelle mesure l'heure de la demande influe sur la modalité d'imagerie choisie pour l'évaluation de l'appendicite.

**Méthodes :** Cette étude rétrospective approuvée par le comité d'examen de l'établissement englobe trois hôpitaux d'enseignement de la University of Toronto qui offrent des services de radiologie en tout temps. Tous les cas d'appendicite confirmés par chirurgie de 2012 à 2014 ont été inclus, et les rapports des examens préchirurgicaux par échographie et tomographie ont été analysés. Les examens avaient été demandés par le service d'urgence, exécutés par les mêmes radiologistes et passés en revue ou finalisés par le même groupe de radiologistes (résidents, étudiants postdoctoraux ou traitants). La comparaison portait sur deux plages horaires, soit pendant les heures d'ouverture normales (du lundi au vendredi de 8 h à 17 h) et après les heures d'ouverture normales (du lundi au vendredi de 17 h à 8 h et les fins de semaine). Plus précisément, le pourcentage d'examens initiaux par échographie ou tomographie, le taux d'examens par tomographie effectués après une échographie aux résultats indéterminés ainsi que la sensibilité de chaque modalité ont été comparés entre les deux plages horaires au moyen de tests *U* de Mann-Whitney et de tests du khi carré.

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**Résultats :** Les conclusions des examens préchirurgicaux par échographie ou par tomodensitométrie réalisés sur 494 patients de février 2012 à août 2014 ont été analysées. Cette analyse a révélé que 174 patients (89 femmes, 85 hommes) ont subi un examen pendant les heures d'ouverture normales et 320 patients (141 femmes, 179 hommes;  $P < .04$ ) après les heures d'ouverture normales. La moyenne d'âge, soit  $37,9 \pm 17,1$  pour les femmes contre  $35,2 \pm 13,7$  pour les hommes, était semblable sur le plan statistique ( $P = 0,8$ ). Pendant les heures d'ouverture normales, 174 examens ont été effectués dont 89 (51,1 %) examens par échographie seulement, 50 (29 %) examens par tomodensitométrie seulement et 35 (20 %) examens par échographie suivis d'un examen par tomodensitométrie. Après les heures d'ouverture, 320 examens ont été effectués dont 147 (46 %) examens par échographie seulement, 147 (46 %) examens par tomodensitométrie seulement et 26 (8 %) examens par échographie suivis d'un examen par tomodensitométrie. La sensibilité diagnostique totale des examens par échographie et par tomodensitométrie s'élevait respectivement à 86 % (81 % pendant les heures normales, 90 % après les heures normales;  $P = .041$ ) et à 99,2 % (100 % pendant les heures normales, 99 % après les heures normales;  $P > .05$ ).

**Conclusion :** L'échographie a été moins utilisée après les heures d'ouverture normales pour diagnostiquer l'appendicite aiguë, même si la sensibilité diagnostique de cette modalité s'est révélée supérieure à celle enregistrée durant les heures d'ouverture normales.

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*Key Words:* Ultrasound; Computed tomography; Initial modality; After hours; Appendicitis

Both ultrasound (US) and computed tomography (CT) are utilised in evaluation of the cause of acute right lower quadrant pain, such as detection of acute appendicitis [1–4]. Ultrasound is considered operator dependent, thus potentially impacting its diagnostic accuracy. A 2006 meta-analysis on diagnostic performance of US and CT demonstrated an overall sensitivity and specificity of 83% and 93% for US and that of 94% and 94% for CT, respectively [5]. Based on the current literature, US, as the initial imaging modality, markedly reduces the evaluation costs (>6-fold; \$547 vs \$88 per patient, respectively) [6]. This is a crucial consideration, particularly given ever-rising health care costs and scarcity of medical resources. Furthermore, it reduces the exposure to ionizing radiation and potential short and long term associated negative impacts. To our knowledge, no previous study has compared utilisation and performance of US during the regular hours and on-call after-hours coverage. We hypothesized that the rate of utilisation of CT is higher during when on call as opposed to regular hours.

## Materials and Methods

The Joint Department of Medical Imaging at the University of Toronto has provided 24/7 in-house US service by our technologists at the 3 University of Toronto institutions since 1996.

This is a research ethics board-approved multicentre retrospective study of consecutive patients, between February 2012 and August 2014, with surgically established diagnosis of acute appendicitis, following CT or US diagnosis. The patients were identified searching the pathology databases of the 3 hospitals. Acquisition of consent was waived. No patient was excluded from the study analysis after meeting the initial inclusion criteria. All US technologists in these institutions are American Institute of Ultrasound in Medicine certified, are exposed to the evaluation of appendicitis, and have joint departmental bimonthly continuing medical education sessions. All technologists applied a similar technique in their sonographic examination of the right lower quadrant, including graded

appendiceal compressions. Examination in the left decubitus position was performed at the discretion of the sonographer. The US findings were reported through a standardized reporting template. All examinations were requested by the same emergency physicians. The same emergency physicians work during regular hours and on call. Regular-hours examinations are performed based on emergency physician requests. On-call examinations are approved after discussion with the on-call resident. All US examinations were performed using 1 of 2 US machines, an Aplio 500 (Toshiba Medical Systems, Tustin, CA) and a 2-6-Hz transducer or an IU22 (Philips Ultrasound, Bothell, WA) with a 1-5-MHz transducer. CTs were performed on an Aquilion 64 or 320 Toshiba scanner (Toshiba Medical Systems, Tustin, CA) from the top of diaphragm to ischial tuberosity, if CT was performed first, and from the top of L2 to the top of symphysis pubis, if CT followed US to reduce radiation exposure [7]. Patients received 100 cm<sup>3</sup> of Visipaque 320 injected at 3 cm<sup>3</sup>/s and scan was obtained with 70-second delay after contrast administration. Data collected from the official reports by one of the authors (H.A.) included the imaging approach during regular hours (between 8 AM and 5 PM on working days) and on call (after 5 PM on working days and during weekends and holidays) to evaluate for the right lower quadrant pain. Patients had US only, CT only, or US followed by CT. Demographic data included age, sex, length of pain, and perforated versus nonperforated appendix. Given the infrequent clinical documentation of the body mass index (BMI) in our cohort, BMI was not used in our subgroup cohort analysis. Pathology results were collected from the official pathology reports. Ultrasound examinations were all initiated by a technologist and reviewed by a staff radiologist (2–25 years of experience in abdominal imaging) or abdominal imaging fellow during regular hours and by a resident or fellow or staff radiologist during on-call hour. All trainee reports were reviewed and finalized by a staff radiologist. All technologists who take call work during regular hours but some senior technologists who work during regular hours do not take call.

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