Quick Looks Into the Acute Abdomen- Findings from A 1 Year Audit of Asian Emergency Department Ct Scans

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Abstract

Background

Much of the literature regarding Emergency Department CT scan usage for abdominal pain has been in American and European settings, and less so in the rest of the world. We performed an audit for this in our Southeast Asian hospital to see how we compare with international data, also to glean some insights into optimising its use locally.

Results – An anonymised de-identified electronic database of all ED patients had been set up since 2020 with the aim of capturing 10 years of ED retrospective data for audit of our clinical performance. From this master database, a subset of all CTAPs done in 2020 was created and then extracted for analysis. Costs, length of stay in the ED and wards, CT reports, disposal from ED, and other data were captured for study. A description was made of the common conditions found, with a subgroup analysis of the elderly, and disposal outcomes from the ED. Specific analysis was done for appendicitis using Mann-Whitney U tests. For 2020, 1860 patients (56% male, and ages 14 to 99 years) had ED CTAPs done. Top indications included right upper and lower quadrant pains, flank pains, persistent abdominal pain despite analgesia, and suspicion for intestinal obstruction. Acute appendicitis, biliary tract disease, renal stones, ovarian disease, and bowel disease were the common diagnoses. 16.2% of CTAPs revealed no abnormality. Malignancies were uncommon diagnoses. For the patients that were discharged from the ED after a negative CTAP, no patient returned within 72 hours nor were there any adverse outcomes. When analysed using Mann-Whitney U tests, patients who had ED CTAPs done for appendicitis had significantly faster time to CT and surgery than those with inpatient imaging, with lower inpatient costs and lengths of stay.

Conclusion – CT scans in the ED for appendicitis patients reduces costs, time to surgery, and lengths of stay. Generally, ED CTAPs allows better siting and disposition of patients. Presence of RLQ pain increases the likelihood of a positive scan. Our negative scan rate of 16.2% is comparable to other studies. Protocols and senior inputs can improve accuracy of this important ED resource.

Introduction

Computed tomography (CT) scan usage is increasingly important in the management of patients with acute abdomen at the emergency department (ED) in Asia. However, most of the literature about its usage is from Western sources, where it is already an established practice in public and private health care settings. The value of this approach remains unknown in most Asian public hospitals due to lack of data. As healthcare is often heavily subsidised in such hospitals, there are valid concerns whether ED CT imaging is a viable and sustainable strategy.

We carry out a retrospective study on a year's usage of CT abdomen and pelvis (CTAP) for non-traumatic abdominal pain, to prove this is feasible. The main objectives are:

- defining clinical indications for ED CTAP scans

- quantifying costs & impact on lengths of stay
- determining its appropriateness for acute appendicitis as a proxy for ED CTAP
- establishing a baseline reference for negative CTAP scans

Methods

The study institution is a public teaching hospital in Eastern Singapore providing acute and elective care to the population. The daily average ED attendance is 430 patients, and ED care is heavily subsidised by the government.

An anonymised de-identified electronic database of all ED patients had been set up since 2020 with the aim of capturing 10 years of ED retrospective data for audit of our clinical performance. From this master database, a subset of all ED CTAPs done in 2020 was created and then extracted for analysis. We excluded CTAP for trauma, CT aortograms and CT intravenous urograms, as these were scans indicated for specific conditions (such as abdominal aortic aneurysms or urolithiasis). CTAP scans ordered in the ED must be approved by a specialist Emergency Physician (EP). ED CTAPs were done with intravenous contrast and read by the radiology department within 2 hours (can be faster for life-threatening conditions), and the diagnosis of the radiologist(s) is taken as final. Costs, length of stay in the ED and wards, CT reports, disposal from ED, and other data were captured for study.

For purposes of comparison for costs and time taken to surgery for patients who had their CTAP done in the wards, we decided to use acute appendicitis for this comparison, as it is a common condition for which surgery is often done and data easily obtained. Additionally, the ED has clear protocols for ordering ED CTAP based on the Alvarado score. The time to surgery (starting from ward admission), as well as the length of stay were measured for both populations, as also gross bill sizes.

As the data was obtained from our anonymised database without patient identifiers, a waiver of consent was applied for and given by the research ethics committee for the study.

Results

For the year of study in 2020, 1860 patients (56% male) had CTAPs done in the ED for non-traumatic abdominal pain. Their ages ranged from 14 to 99 years, with a median of 48 years (average 50). Three hundred and sixty-five patients were aged 70 years and more (19.6%), while only nine patients (0.5%) were between 14–16 years. Our patients' stay in the ED ranged from 1.37 to 26.83 hours, with a median of 4.82 hours and mean of 5.2 hours.

When we analysed the indications for ordering a CTAP (Table 1), the top 6 included right upper and lower quadrant pains, flank pains, left lower quadrant pain, persistent abdominal pain despite analgesia, and suspicion for intestinal obstruction (clinical and/or on plain abdominal radiograph).

Table 1
– Indications for CTAP and the common diagnoses and disposal outcomes in ED patients (total 1860 patients)

Top 6 indications	**1. Right lower quadrant pain**	**811 (43.6%)**
	2. Right or left-sided flank pains (renal stones not suspected)	**240 (12.9%)**
	3. Right upper quadrant pain	**164 (8.9%)**
	4. Left lower quadrant pain	**127 (6.8%)**
	5. Persistent abdominal pain despite analgesia	**104 (5.6%)**
	6. Suspicion of intestinal obstruction (clinical and/or on plain abdominal radiograph)	**68 (3.6%)**
Top 10 diagnoses after ED CTAP	1. Acute appendicitis, with or without perforation	305 (16.4%)
	2. Nonspecific abdominal pain with normal or minor CTAP findings#	259 (13.9%)
	3. Biliary tract disease (cholecystitis, cholangitis, cholelithiasis)	132 (7.1%)
	4. Urolithiasis/renal colic, with or without obstruction	113 (6.1%)
	5. Diverticulitis, with or without perforation	98 (5.2%)
	6. Ovarian cysts/accidents/malignancies	86 (4.6%)
	7. Gastroenteritis with lower quadrant pain/colitis/inflammatory bowel disease	71 (3.8%)
	8. Intestinal obstruction (volvulus, ileus, intussusception)	67 (3.6%)
	9. Pyelonephritis/perinephric abscesses	65 (3.5%)
	10. Sepsis of unidentified source with abdominal symptoms#	43 (2.3%)

Top 10 ED CTAP diagnoses in elderly (70 years or more)	365 CTAPs done (19.6% of 1860 CTAPs)	55/132 (41.6%)
	1. Biliary tract disease (cholecystitis, cholangitis, cholelithiasis)	49/259 (18.9%)
	2. Nonspecific abdominal pain with normal or minor CTAP findings	40/98 (40.8%)
	3. Diverticulitis, with or without perforation	24/315 (7.6%)
	4. Acute appendicitis, with or without perforation	23/43 (53.4%)
	5. Sepsis of unidentified source with abdominal symptoms	19/71 (26.8%)
	6. Gastroenteritis with lower quadrant pain/colitis/inflammatory bowel disease	15/23 (65.2%)
	7. Basal pneumonia / lower respiratory tract infections	13/65 (20.0%)
	8. Pyelonephritis/perinephric abscesses	9/22 (40.9%)
	9. Bowel perforation not from appendicitis or diverticulitis	8/14 (57.1%)
	10. Obstructive uropathy without concurrent infection	
#Negative scans	Total number of negative scans (16.2%)	Total 302/1860
	1. Nonspecific abdominal pain with normal or minor CTAP findings	259 (13.9%)
	2. Sepsis of unidentified source with abdominal symptoms	43 (2.3%)
Malignancies (56 cases or 3%)	1. Large and small bowel malignancies	19
	2. Gynaecological malignancies	15
	3. Hepatobiliary malignancies	8
	4. Metastatic cancer of unidentified primary	7
	5. Lymphomas	3
	6. Sarcomas	2
	7. Urological malignancy	1
	8. Breast cancer with liver metastases	1

Disposal	1. Admitted to inpatient wards.	1300 (69.8%)
	2. Referred to specialist outpatient clinics (same hospital)	254 (13.6%)
	3. Referred to maternity hospital emergency clinic	121 (6.5%)
	4. Treated and discharged.	63 (3.4%)
	5. Discharged against medical advice.	49 (2.6%)
	6. Referred to primary care providers	40 (2.2%)
	7. Admitted to 23 hours ED short stay unit.	32 (1.7%)

The top 10 ED diagnosis after CTAP for all ages are listed in Table 1, and unsurprisingly, acute appendicitis, biliary tract disease, renal stones, ovarian disease, and bowel disease were the common conditions. 16.2% of CTAPs revealed no abnormality to account for the symptoms (nonspecific abdominal pain, and sepsis of unidentified source with abdominal symptoms)

When we analysed in a similar way the geriatric group (≥ 70 years), the spectrum was similar, but 15 unsuspected basal pneumonia cases were seen on the upper sections of the CTAP, out of 23 basal pneumonias diagnosed this way. This is not surprising as basal pneumonia patients can present with upper abdominal pains.

Malignancies were uncommon diagnoses (Table 1) forming only 3%, with bowel, gynaecological and hepatobiliary malignancies being the most prevalent. Metastatic cancers of unidentified primary sources, lymphomas and sarcomas found were in the single digit number of cases.

Almost 70% was admitted to inpatient wards, while 6.5% were referred to a partner maternity hospital emergency clinic, and 3.4% were discharged after a negative CTAP. The last group had neither re-attendances within 72 hours nor any adverse outcomes.

In Tables 2 and 3, the time to CTAP, surgery, lengths of stay and gross bill sizes for patients admitted with appendicitis are shown. When analysed using Mann-Whitney U test, patients who had ED CTAPs done had significantly faster time to a scan and surgery, lower bill sizes and lengths of stay. This was after adjusting for confounding comorbidities that led to prolonged stays.

Table 2
– ED admissions with appendicitis seen on CTAP done in different settings

	Group A (CTAP scan done in ED)	Group B (CTAP scan done in ward)	Total
Number of Patients	305	153	458
Number requesting discharge against advise or transfer (after CTAP)	10	7	17
Number with surgery after admission	279	139	418
Number which did not undergo surgery the same admission (resolved with antibiotics, or had abscess/phlegmon with percutaneous drainage or later elective surgery)	16	7	23
Patients who had prolonged stay due to comorbidities (dementia, myocardial infarction, heart failure, renal failure, chronic pulmonary disease)	16	2	18

Table 3
– Timings to CT and to surgery

		Group A	Group B
		(n = 305)	**(n = 153)**
Time to CT scan (hrs)	Range	30mins to 6 hrs	2hrs to 3 days
	Median	2 hrs	4 hrs
Difference is Statistically Significant. P-value = 2.23846e-11, (p(x ≤ Z) = 1.11923e-11) Z + -6.689557 U = 13300.00			
Time to surgery from admission to ward(hrs)*		**(n = 279)**	**(n = 139)**
	Range	1 hr to 6 days 13 hrs	2hrs to 7 days
	Median	7 hrs 14 mins	10 hrs
Difference is Statistically Significant 6.71685e-14, (p(x ≤ Z) = 3.35842e-14) Z equals − 7.494833 U = 10161.00			
***Only 418 out of 441 patients had surgery after admission			

Table 4
– Comparisons of bill sizes and lengths of stay of appendectomy patients (excluding 18 prolonged stay patients due to co-morbidities)

		Group A (n = 263)	Group A (n = 137)
Bill size (gross) in SGD	Range	$4,154-$19,308	$4,806-$34,488
	Median	$6,241	$6,592
Difference is Statistically Significant p-value = 0.0234940, ($p(x \leq Z) = 0.0117470$). Z = -2.265304 U = 15768.00			
Length of Stay (days)	Range	1–10 days	1–24 days
	Median	2.1	2.5
Difference is Statistically Significant P value = 0.0238079, ($p(x \leq Z) = 0.0119040$) Z = -2.260214 U = 15836.50			

We could only confirm some medical causes of abdominal pain after a negative CTAP scan. Confirmed examples included 13 patients with basal pneumonia, 8 with diabetic ketoacidosis, 8 with mesenteric lymphadenitis and 1 with dengue (Table 1).

Discussion

Our example of a cost-recovery model for ED CTAP

Our ED installed a CT scanner initially for assessing poly-trauma and stroke patients. Later, the EPs (sometimes with the surgeons' inputs) began to order CTAPs for patients with acute abdomen. Initially, the costs of performing CTAPs in the ED were absorbed by the hospital, under the flat fee of SGD140 for each emergency attendance (SGD80 paid by patient and SGD60 from government subvention). This meant a loss for the hospital as each CTAP costs about SGD700 (without subvention).

After 2015, patients were asked to pay for ED CTAPs themselves, if they are not admitted. It was charged at SGD350 (after 50% subvention). Should the CTAP show a condition that necessitated emergency admission, then the cost would be rolled over and included into the inpatient bill instead of the ED charges. Patients could choose to pay part or all of their hospitalisation bills with own savings, private insurance or from Medisave (national health savings scheme). Patients could choose to have their CTAPs

done in the ED or ward, and some preferred it done as an inpatient so as to utilise insurance or Medisave funds.

Making a confident diagnosis that allows appropriate pain relief and safer disposal of patients

Several past papers from Western and Japanese settings [1,2,3,4], have shown that CT for abdominal pain changes the leading diagnosis, increases diagnostic certainty, and facilitates management decisions. In haemodynamically stable patients with acute severe and generalized abdominal pain, CTAP is now the preferred imaging test and gives invaluable diagnostic information. Even for unstable patients after adequate resuscitation [5, 6], Paolantonio[5] has shown examples of safely diagnosing acute pancreatitis, gastrointestinal perforation, ruptured aneurysm and acute mesenteric ischemia.

In another survey by Kirsch [7] in an American setting, the adult CTAP utilization rate ranged from 11.3% (95% CI 11.2–11.4%) at age 20–29 years to 24.6% (95% CI 24.5–24.8%) for those over 65. The CT utilization rate was 9.3% (95% CI 9.2–9.4%) in EDs with < 20,000 annual visits and increased to 17.8% (95% CI 17.7–17.9%) in EDs with volumes of > 40,000 annual visits.

For our patient population that was discharged from the ED after a negative CTAP, none returned within 72 hours nor had any adverse outcomes. Though analgesic use was not studied, it was generally acknowledged that our emergency physicians and surgeons were more comfortable in allowing the use of opioid analgesics for pain relief in patients undergoing CTAPs.

Effect of early CT on length of hospital stay and need for additional inpatient imaging.

Using appendicitis as a proxy, our results showed benefits for admitted. Our department uses the Alvarado score to help define indications for ED CTAP in the RLQ as part of a suspected appendicitis protocol. It is similar to Sala's [3] study, which found that the average hospital stay was almost 1 day (22 hours) shorter for patients in the CT group than for those in the control group, but that was statistically not significant. However, in that British study, the CTAPs were done after admission, and not in the ED. Patients in Sala's CTAP group had significantly fewer additional inpatient radiological investigations.

Mitigating transit time through the ED

There are valid arguments that performing CT scans in the ED could worsen transit time through the ED, causing choke points in the ED. The counter-argument is that with more access block, usage of CT scans could reduce unnecessary admissions and freeing up badly-needed beds. In our hospital, where the daily average bed occupancy often hovers above 95%, we favour the latter argument. To mitigate the CTAP becoming a choke point for patients flowing through the ED, our senior EPs used a system of decision making similar to that described by Wang [8] in Toronto. When studying the flow of ED patients having CTAPs for acute abdomens, they found 3 unique patterns of ED disposition:

A. disposition after initial imaging report - the most common pattern is where CTAP is performed and interpreted before the disposition decision (83% of their patients)
B. disposition before report – this represents the sequence of events where a disposition decision has been made before the availability of the first radiology report but after the scan has been performed (for instance when the Alvarado score for appendicitis is high enough to warrant admission, and the scan is to differentiate between appendicitis or ovarian abscess and hence admission to surgery or OBGYN)
C. disposition before CT – when during the ED visit where the disposition decision was made before the start of the CTAP (for instance when plain films showed obstructed bowel resulting in a decision to admit before a CTAP is ordered)

With adoption of pattern **B** (7%) and **C** (6%), the Toronto team found that the ED length of stay (LOS) for pattern **A** (mean 10.4 hours) is statistically significantly longer than those for pattern **B** (mean 8.1 hours) and pattern **C** (mean 6.9 hours). In our study, we did not manage to collect the actual numbers and hours for each pattern, but our EPs practiced the three patterns in a similar way. Our patients' stay in the ED ranged from 1.37 to 26.83 hours (can be prolonged by access block), with a median of 4.82 hours and mean of 5.2 hours.

Monitoring utilization of CT scans in the ED

With baseline data, it is possible that monitoring of the trends in the usage of CT scans can help avoid abuse and misuse, though it may seem likely that increase usage may be inevitable with time. At the Mayo Clinic, Bellolio [9] performed a cross-sectional study of all ED visits in which a CT scan was obtained between 2003 and 2012 at an academic, tertiary-care setting. Overall, CT use per 1000 ED visits increased from 142.0 in 2003 to 169.2 in 2012 ($p < 0.001$), while the number of annual ED visits remained stable. The authors found that patients without a primary care provider were more likely to have a CT performed in the ED.

Closer adherence to guidelines and protocols reduces unnecessary CT scans. Gans and co-authors[10] (in a multi-specialty Dutch collaboration) aimed to develop an evidence-based guideline for the diagnostic pathway of patients with non-traumatic abdominal pain in the ED. All available international literature on patients with acute abdominal pain was identified and close to 50 were selected. In their guidelines, CTAP leads to the highest sensitivity and specificity in patients with acute abdominal pain, when complemented with thorough history taking and physical findings, supplemented with relevant laboratory investigations and ultrasound.

Understandably, positive CT results are a predictor for hospital admission/transfer, and Modahl [6] found predictive clinical indicators include paediatric age, leucocytosis, and a specified pre-CT diagnosis. Choy and Yoon[11] came up with a study to predict negative scans. Three hundred ED patients aged 60 or younger were studied after ED CTAP. Their model predicted that a female patient under 36 years, with a

normal white count, and no peritoneal findings on exam is 70.8% less likely to have a significant positive finding on CT than the average patient.

CTAP role in assessing the Geriatric acute abdomen

Older patients often present with vague symptoms, unreliable physical findings, and laboratory values may be altered by chronic organ disease. The morbidity and mortality associated with elderly abdominal pathologic conditions are more significant[13]. Gardner [12] found in an American retrospective study of 464 patients (> 80 years) that CTAPs were positive in 55%, while ours was 19.6%. Their disease spectrum was similar to ours in the top 10 conditions found. 43% of their diagnoses were clinically unsuspected prior to CT and had a significant influence on clinical management and disposition. A similar conclusion was reached by Millet at al[13] in Europe who had 30.3% acute unsuspected pathologies.

Defining clinical indications for ordering CTAPs

Table 1 show that the top six indications are by sites of pain, persistence of abdominal pain despite analgesia, and suspicion for intestinal obstruction. These indications may also be influenced by clinical acumen, scoring systems (for instance the Alvarado score for suspected appendicitis), laboratory results (e.g. hyper-amylasemia), or preliminary imaging (e.g. dilated bowel on plain films).

The approach for ordering CTAPs as guided by quadrant pain aided by relevant investigations is intuitively logical, as well as attractive to a busy ED physician. Pickhardt and Nelson[14] studied 1000 patients who had CT scans in the ED. When analysed by quadrant pain, a positive CT diagnosis was provided in 47.3% (473/1000) of all patients, and was highest for LLQ (58.8%) and RLQ (58.0%) symptoms, including diverticulitis and appendicitis in 23.6% and 24.8% cases, respectively. CT positivity was lower for the LUQ (34.4%) and RUQ (38.0%). Lameris[15] also studied 11 imaging strategies, and in one strategy driven by location of pain, they found that this approach by location had a sensitivity of 89% and a specificity of 78% for urgent diagnoses.

How much of a negative scan rate is acceptable?

In our study, 16.2% of CTAPs revealed no abnormality to account for the symptoms (259 patients with normal findings, and 43 patients with sepsis and abdominal symptoms but normal CTAP). A negative CTAP is reassuring to both patient and EPs. Medical causes of acute abdominal pain (e.g. diabetic ketoacidosis, dengue) were also confirmed after a surgical abdomen was safely excluded.

When we looked at the literature, we could not find many suitable similar retrospective studies for comparing negative scan rates for CTAPs of the entire abdomen. One comparable study by Pickhardt and Nelson[14] had a negative CT diagnosis in 52.7% of all patients. Lameris' study[15] had 183 out of 1021 patients (18%) with a negative scan.

For specific regions, Wertz[16] found 15% (7 out of 48 patients) of patients with RUQ pains were negative on CT. For RLQ pains, Woo[17] found a negative ED CTAP rate of 60% for 107 patients, while Stengel[18] had

a negative CT rate of 77% for 2283 patients.

Limitations

We do not have inpatient data of the time of the decision to order the CTAP, nor the seniority of the doctor who made this decison. Reasons such as delayed development of physical signs, atypical presentations, patient preferences for financial payment reasons, possible contrast allergy or risk of contrast-induced nephropathy, etc., could be present. All these were gaps in data which we cannot adjust for.

Conclusion

CT scans in the ED for acute abdomen allows accurate and faster diagnosis with significant impact on bill sizes, speed of surgery, and lengths of stay for acute appendicitis patients. It also allows better siting and disposition of patients from the ED. Presence of RUQ and RHC pains increases the likelihood of a positive scan, as does increasing age. Our negative scan rate of 16.2% is comparable to other studies. Protocols and senior inputs can improve accuracy of this important ED resource.

Declarations

Ethics approval and consent to participate – As the data was obtained from our anonymised database without patient identifiers, a waiver of consent was applied for and given by the institutional research ethics committee for the study. (CIRB Ref: 2020/2030 dated 14 Jan 2020)

Consent for publication – Not applicable

Availability of data and material - The datasets generated during and/or analysed during the current study are not publicly available due this being an anonymised patient database but are available from the corresponding author on reasonable request.

Competing interests – None

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Authors' contributions – Drs SH Goh, Calvin Goh and Tiah Ling had conceptualised the audit study and identified data points and analysed the data from the audit. Drs Oh and Venkataraman had helped in directing and setting up the anonymised database and extracting data.

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Supplementary Files

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