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## Retrospective Study

## Computed tomography scan imaging in diagnosing acute uncomplicated pancreatitis: Usefulness vs cost

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## Abstract

## BACKGROUND

Literature has suggested that imaging is over-utilized in the diagnosis of pancreatitis. If the diagnosis of acute pancreatitis (AP) is established with abdominal pain and increased serum amylase or lipase activity without systemic signs of severe disease, computed tomography (CT) imaging may not be necessary. We hypothesize that among patients with uncomplicated acute pancreatitis (AUP), there is a significant number of unwarranted CT imaging studies. This imposes increased expenditure and cost in our healthcare system and does not improve hospital stay or management of AUP.

## AIM

To assess the overutilization and associated cost of CT imaging among patients meeting diagnostic criteria for AUP.

## METHODS

In this Institutional Review Board-approved retrospective, single-center study, we identified all adult patients admitted with AP from January 1, 2012 through October 1, 2017. Patients were identified via International Classification of Diseases (ICD-9) code for AP (577.0) and ICD-10 codes for different etiological AP (K85.9 unspecified, K85.0 idiopathic, K85.1 biliary, K85.2 alcohol-induced, K85.3 drug-induced, and K85.8 other). Diagnosis was confirmed by chart review using established non-imaging diagnostic criteria (presence of typical abdominal pain and elevated lipase or amylase greater than 3 times upper limit of normal). Ranson criteria and BISAP scores on presentation were calculated and patients that met scores less than or equal to 2 for both were included to suggest AUP. The utilization and cost of imaging in these patients were recorded.

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## RESULTS

Between January 2012 and October 2017, 1305 patients presented to the emergency department with AP, and 405 patients (31%) met our inclusion criteria for AUP (201 males, 204 females; mean age 49 years, range 18-98). Of those, 210 patients (51.85%) underwent CT imaging. One patient (0.47%) had evidence of pancreatic necrosis, one patient had cyst formation (0.47%), and the remaining 208 patients (99.05%) had either normal CT scan imaging or findings consistent with mild AP without necrosis. The average cost of CT scan imaging was \$4510 with a total cost of \$947056. Median length of hospitalization stay was 3 d among both groups. Combining Ranson's Criteria and BISAP score identified AUP in our patient population with an accuracy of 99.5%.

## CONCLUSION

CT imaging is unnecessary when AUP is diagnosed clinically and biochemically. Reducing overuse of diagnostic CT scans will decrease healthcare expenditure and radiation exposure to patients.

**Key words:** Acute pancreatitis; Diagnostic criteria; Computed tomography imaging utilization; Quality improvement; Healthcare expenditure; Emergency department

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**Core tip:** Guidelines indicate that routine use of imaging is unwarranted in patients with acute uncomplicated pancreatitis presenting with abdominal pain and increased serum amylase or lipase levels without signs of severe disease. This retrospective, single center study found that 51.85% of the study cohort underwent computed tomography imaging in the emergency department after having clinical and biochemical evidence of pancreatitis. The image findings did not impact hospital length of stay, and resulted in \$947056 health expenditure. Quality improvement initiatives targeting overutilization of early imaging are needed to increase guideline adherence, reduce healthcare cost, and ultimately improve patient care.

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## INTRODUCTION

Acute pancreatitis (AP) is one of the leading gastroenterologic causes for hospitalization in the United States with more than 220000 annual admissions and healthcare costs of approximately 2.6 billion dollars<sup>[1,2]</sup>. The diagnosis of AP is made by the presence of two of the three following criteria: (1) abdominal pain typical for AP (acute, constant, epigastric abdominal pain or right upper quadrant pain radiating to upper back); (2) serum amylase and/or lipase level greater than three times the upper limit of normal; and/or (3) characteristic findings on abdominal imaging<sup>[3]</sup>.

AP has varying etiologies with an overall mortality of approximately 2%<sup>[4]</sup>. The majority of cases (80%-90%) are mild and self-limited while 10%-20% lead to severe complications such as pancreatic necrosis and multi-organ failure<sup>[4,5]</sup>. Given the adverse prognosis and increased mortality with necrotizing pancreatitis, a number of scoring systems combining clinical and laboratory parameters have been designed to assess the severity of AP.

Ranson's Criteria was published in 1974 as one of the first prognostic tools established to help clinicians identify severity of AP<sup>[6]</sup>. A Ranson score of 2 or less is associated with a mortality rate of 0-3%<sup>[4]</sup>. Ranson's Criteria continues to be used today given its ease of use, however, in recent years, its prognostic accuracy was brought into question. The primary concern surrounding the Ranson score is the significant false positive rate upon initial evaluation and the need for a 48-h follow-up<sup>[7,8]</sup>. Alternatively, the Bedside Index for Severity in Acute Pancreatitis (BISAP) was developed in 2008 and has been shown to be a more accurate prognostic tool<sup>[7,9]</sup>. The

BISAP scoring index is to be used in the first 24 h of presentation and consists of 5 parts: blood urea nitrogen (BUN) level > 25 mg/dL, impaired mental status, development of systemic inflammatory response syndrome (SIRS), age > 60 years, and presence of pleural effusion ranging from 0-5 score<sup>[9]</sup>. Multiple studies have validated the performance of the BISAP and pooled estimates demonstrate its accuracy in predicting acute pancreatitis severity<sup>[10]</sup>.

The primary role of imaging during initial presentation of AP is to validate the diagnosis when uncertain or detect for possible pancreatic complications when there is no clinical improvement within the first 48 to 72 h of admission<sup>[11]</sup>. Utilization of computed tomography (CT) imaging has been an integral part of evaluating patients with AP, however its necessity and use has been questioned in those who meet the clinical and laboratory diagnosis<sup>[3]</sup>. Numerous studies have shown that early imaging is low-yield in that it has no measurable impact on the management or clinical outcomes of AP and is inaccurate in detecting pancreatic necrosis<sup>[12,13]</sup>.

The aim of this study is to assess the utilization and associated cost of CT imaging in patients presenting to our institution's emergency department (ED) with acute uncomplicated pancreatitis (AUP) that have low severity scores and meet the clinical and biochemical diagnostic criteria. We anticipate that CT imaging is unnecessarily ordered in the ED for patients who match the criteria of an initial episode of AUP at presentation and will incur excess cost and not impact hospitalization course.

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## MATERIALS AND METHODS

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### **Study population**

This IRB-approved retrospective, single-center study reviewed all adult patients admitted to our quaternary care facility with a diagnosis of AP between January 1, 2012 and October 1, 2017. Patients were initially identified via International Classification of Diseases (ICD-9) code for AP (577.0) and ICD-10 codes for different etiological AP (K85.9 unspecified, K85.0 idiopathic, K85.1 biliary, K85.2 alcohol-induced, K85.3 drug-induced, and K85.8 other). Inclusion criteria included abdominal pain suspicious for

pancreatitis and either an initial lipase or amylase level greater than three times the upper limit of normal, which at our institution was  $\geq 1179$  units/L and  $\geq 345$  units/L, respectively. The BISAP score and Ranson's Criteria at admission were used to classify pancreatitis severity (Tables 1 and 2)<sup>[6,14]</sup>. Patients with a BISAP and Ranson's score of 2 or less were included. Exclusion criteria included patients with BISAP and Ranson's score 3 or greater, those admitted to the intensive care unit, or those with documented history of recurrent or chronic pancreatitis.

### **Data Collection**

Patient demographics, laboratory data, radiographic history, and clinical data were retrospectively reviewed using our electronic medical record system. Data was collected and stored in a secure platform known as Redcap™. Patient's admission and discharges dates were collected for prognostic purposes. Patient demographics include age and gender. Laboratory data was limited to lipase, amylase, WBC, blood glucose, AST, LDH, and BUN. Vitals were reviewed to assess if patients met SIRS criteria. Clinical data such as history of present illness and physical examination were reviewed from the ED documentation. Etiology was determined from imaging and clinical documentation and was classified as either biliary/gallstone, alcohol, idiopathic, drug-induced, hypertriglyceridemia, ERCP-related, trauma, autoimmune, or unknown. CT imaging ordered within the ED, after clinical picture and laboratory results were obtained, was reviewed and further classified into the specific type of imaging. Patient specific financial information pertaining to imaging cost was obtained from the Financial Decision Support Department within our institution using the patient's medical record number.

### **Statistical analysis**

Data collected from Redcap™ was exported to SAS® Version 9.4 for further analysis using descriptive statistics. The mean and standard deviation for CT imaging cost and patient age were calculated using standard formulas. Categorical data was recorded and reviewed as final summations.

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## RESULTS

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### **Study cohort and clinical characteristics**

**Table 1 Ranson's criteria at admission estimates severity and mortality of patients with acute pancreatitis based on initial lab values**

Ranson criteria at admission	
White blood cell count > 16000	1 point
Age > 55 years of age	1 point
Blood glucose > 200 mg/dL	1 point
Aspartate transaminase > 250	1 point
Lactate dehydrogease > 350	1 point

Scores  $\leq 2$  indicate mortality of 0-3%. Patients with scores of 2 or less were included in the study cohort.

Between January 2012 and October 2017, 1305 patients were admitted with AP. The study cohort included total of 405 patients that met the clinical and biochemical diagnosis for AUP based on the inclusion criteria (201 males (49.63%), 204 females (50.37%); mean age  $49.30 \pm 17.42$  years, range 18-98 years) (Table 3). The etiologies for AUP included biliary/gallstones (149 patients, 36.79%), alcohol (142 patients, 35.06%), idiopathic (68 patients, 16.79%), drug-induced (17 patients, 4.20%), hypertriglyceridemia (4 patients, 0.98%), ERCP related (1 patient, 0.25%), trauma (1 patient, 0.25%), autoimmune (1 patient, 0.25%), unknown (22 patients, 5.43%) (Table 3).

### Use and cost of early CT imaging

Of the 405 patients that met the non-imaging clinical diagnostic criteria for AUP, 210 patients (51.85%) underwent CT imaging in the ED after having clinical and biochemical evidence of pancreatitis. The type of CT imaging ordered included abdomen/pelvis with contrast (122; 58.1%), abdomen/pelvis without contrast (62; 29.52%), abdomen/pelvis with and without contrast (9; 4.29%), abdomen only with contrast (10; 4.76%), abdomen only without contrast (1; 0.48%), abdomen only with and without contrast (5; 2.38%), and chest/abdomen/pelvis without contrast (1; 0.48%) (Table 4). CT imaging demonstrated normal imaging or uncomplicated AP in 208 patients (99.05%), AP with cyst formation in 1 patient (0.48%), and AP with necrosis in 1 patient (0.48%). The number of CT imaging per year varied with 47 in 2012, 36 in 2013, 43 in 2014, 23 in 2015, 34 in 2016, and 27 in 2017. The average cost of the CT imaging ordered was  $\$4450.38 \pm \$1185.98$  with a total cost of  $\$947056$  spent on CT imaging (Table 4). The median length of stay among those that received no CT imaging was 3.00 d (IQR 2.00-4.00) and among those that received CT imaging was also 3.00 d (IQR 2.00-5.00).

## DISCUSSION

In this single-center, retrospective descriptive cohort study, we determine the overutilization and associated cost of CT imaging within emergency department patients presenting with AUP from January 1, 2012 to October 1, 2017. First, we demonstrate that over half our cohort (51.85%) underwent CT imaging within the ED even though the diagnosis of AP had been established by non-imaging diagnostic criteria. Second, early imaging did not change the patient hospital course as there was no change in median length of hospitalization between those that received early CT imaging compared to those that did not. Third, this overutilization of CT imaging incurred in an excess cost close to \$1 million.

Our study findings correlate with multiple other studies and demonstrate suboptimal adherence to current recommendations of reserving early imaging for when the diagnosis is unclear or patients to fail to clinically improve after 2 to 3 d<sup>[11,15-17]</sup>. There is no literary evidence supporting any association of imaging within the ED and improvement of clinical outcomes. A recent time trend analysis within the U.S. EDs showed that utilization of CT and MRI imaging is actually rising in patients presenting with acute pancreatitis<sup>[18]</sup>. Another study found a 2.5-fold increase in utilization of CT imaging in patients with acute pancreatitis without measurable improvement in patient outcomes<sup>[19]</sup>. This is consistent with our study as there was no change in median length of hospitalization or outcome among patients who underwent imaging and those who did not. With complications such as necrosis typically requiring 3 to 4 d before appearing on imaging, studies have shown that early imaging did not typically lead to alternative treatment or length of stay<sup>[20]</sup>. Our study showed that in only 1 of 405 patients with acute uncomplicated pancreatitis,

**Table 2 BISAP score predicts the mortality risk in acute pancreatitis based on the data within the first 24 h**

BISAP score for pancreatitis mortality	
Blood urea nitrogen > 25 mg/dL	1 point
Impaired mental status (disorientation, lethargy, somnolence, coma, stupor)	1 point
≥ 2 Systemic Inflammatory Response Syndrome (SIRS) Criteria (temperature > 38 °C or < 36 °C, heart rate > 90, respiratory rate > 20 or PaCO <sub>2</sub> < 32 mmHg, white blood cell count > 120000/mm <sup>3</sup> or < 4000/mm <sup>3</sup> or > 10% bands)	1 point
Age ≥ 60 years old	1 point
Pleural effusion present on imaging	1 point

Score of 0 has < 1% and scores ≤ 2 have 1.9% mortality risk, respectively. Patients with scores of 2 or less were included in the study cohort.

early imaging showed necrosis. This is consistent with previous studies showing rates of 1%-2%<sup>[19]</sup>. Therefore, use of CT imaging in management of AP would be more appropriate if symptoms persist 4-7 d after admission or in case of persistent organ failure, sepsis, or decline in clinical status.

While the invention of CT imaging has pushed forward medical advancement, CT imaging carries its own risks and hazards. Estimated 2% of all cancer diagnoses in the United States is a result from radiation due to CT scan use<sup>[21]</sup>. This is partially attributed to the 600-fold increase in radiation exposure from CT imaging over the past 20 years, with an annual growth rate of 10% annually<sup>[21,22]</sup>. Appropriate and safe use of CT imaging can help reduce overall radiation exposure.

Unnecessary imaging additionally results in increased healthcare expenditure. Raghav *et al*<sup>[23]</sup> evaluated the potential cost savings of CT scan in gallstone pancreatitis at two county hospitals in Los Angeles and New York in 2010, and found that almost half of the patients received unnecessary CT scans, resulting in \$72288 excess health expenditure at that institution. Another study aimed to examine regional variation in national healthcare expenditure for management of AP and found the mean cost per hospitalization to be \$12446.48 within that year<sup>[24]</sup>. Decreasing excess imaging will not only reduce radiology costs, but also eliminate avoidable tests, consultations, and resources.

The size of the patient cohort is the main strength of this study. The large sample size that was analyzed based on inclusion and exclusion criteria provided a unique population that has not been specifically evaluated in prior literature. Exclusion of patients requiring imaging for diagnosis other than AP permitted for more accurate representation of imaging utilization. In addition, exclusion of recurrent, chronic, and severe pancreatitis focused our patient population on the utilization of imaging in uncomplicated pancreatitis with less external distortion.

To ensure patients with acute pancreatitis were uncomplicated, we used two scoring metrics for severity - both the BISAP score and Ranson's Criteria. Given that recent literature has suggested the Ranson's criteria tends to exaggerate the severity of acute pancreatitis, using this criteria reduced the risk that patients in our population cohort were falsely identified as AUP. Combining these two prognostic tools identified AUP with an accuracy of 99.5%.

Limitations of this study include the retrospective nature of the design. While the diagnosis of AP was analyzed on individual basis confirming two out of three diagnostic criteria, actual patients were not interviewed. Therefore, the diagnostic criteria of epigastric abdominal pain typical of AP was interpreted through documentation of the emergency department. In addition, since our study was conducted at a single center, it limits the generalization of our findings to other institutions or populations with different resources.

This study demonstrates that CT imaging in the emergency department does not provide new information or change hospital length of stay in patients that are clinically and biochemically diagnosed with AUP. Due to increased risk of radiation exposure, excess healthcare costs, and the lack of evidence for clinical benefit, early routine CT imaging should be discouraged. Our research findings emphasize the importance of further education and awareness among providers regarding high value cost conscious care to reduce excess imaging, eliminate unnecessary costs, minimize potential patient harm, and ultimately improve patient care. Future multi-disciplinary quality improvement initiatives among other departments should be implemented to enhance recognition and adherence to standard quality of care imaging guidelines.

**Table 3 Characteristics of patients admitted with acute uncomplicated pancreatitis (*n* = 405) *n* (%)**

Characteristic	Number / %
mean age (range)	49.30 ± 17.42 yr (18-98 yr)
Gender	
Male	201 (49.63)
Female	204 (50.37)
Etiology	
Biliary/gallstone	149 (36.79)
Alcohol	142 (35.06)
Idiopathic	68 (16.79)
Drug-induced	17 (4.20)
Hypertriglyceridemia	4 (0.98)
Endoscopic retrograde cholangiopancreatography-related	1 (0.25)
Trauma	1 (0.25)
Autoimmune	1 (0.25)
Unknown	22 (5.43)

**Table 4 Computed tomography imaging utilization, findings, and cost *n* (%)**

Use of computed tomography imaging	Value
Underwent computed tomography imaging	210 (51.85)
Did not undergo computed tomography imaging	195 (48.15)
<b>Type of computed tomography imaging (<i>n</i> = 210)</b>	
Computed Tomography abdomen/pelvis with contrast	122 (58.10)
Computed Tomography abdomen/pelvis without contrast	62 (29.52)
Computed Tomography abdomen/pelvis with and without contrast	9 (4.29)
Computed tomography abdomen with contrast	10 (4.76)
Computed tomography abdomen without contrast	1 (0.48)
Computed tomography abdomen with and without contrast	5 (2.38)
Computed tomography chest/abdomen/pelvis without contrast	1 (0.48)
<b>Image findings</b>	
Normal imaging or uncomplicated acute pancreatitis	208 (99.05)
Acute pancreatitis with cyst formation	1 (0.48)
Acute pancreatitis with necrosis	1 (0.48)
<b>Cost of computed tomography imaging</b>	
Average per computed tomography scan	\$4450.38 ± \$1185.98
Total cost	\$947056

## ARTICLE HIGHLIGHTS

### Research background

Literature has shown that use of imaging in patients with acute pancreatitis (AP) is rarely required for the diagnosis of AP and does not change the management or outcome in such patients. Guidelines suggest that diagnosis of AP can be done without imaging if the patient meets the clinical and biochemical diagnosis. Unwarranted imaging can lead to preventable radiation exposure, excessive healthcare resources, and unjustifiable healthcare costs.

### Research motivation

Reducing healthcare costs associated with tests that do not improve patient care and add to healthcare costs is of the utmost importance. This study was conducted to further characterize, in dollar amounts, the impact of ordering unwarranted imaging. More studies need to be conducted to further characterize clinical practice concerning acute uncomplicated pancreatitis and the utility of computed tomography (CT) imaging.

### Research objectives

This study aimed to evaluate how many unwarranted CT scans are performed in patients with

acute uncomplicated pancreatitis (AUP) meeting the diagnostic criteria of clinical symptoms and abnormal lab values at our institution. In addition, the study determined if the need of imaging impacted hospital length of stay and how much overall expenditure the hospital spent on the use of unnecessary CT imaging. This study emphasizes the importance of guideline adherence and educating providers on the importance of high value cost conscious care to ultimately improve potential healthcare cost savings and patient care.

### Research methods

A retrospective single center study was performed evaluating the use of CT imaging among patients with acute uncomplicated pancreatitis. Patients were selected from our quaternary referral center, Advocate Christ Medical Center in Oak Lawn, Illinois, USA from January 1, 2012 to October 1, 2017. Patients with acute pancreatitis were included if they had a BISAP and Ranson score of 2 or less, classifying them with uncomplicated pancreatitis. Each patient's electronic medical record was reviewed to evaluate whether the patient met the clinical and biochemical diagnosis for acute pancreatitis and if they underwent CT imaging. Additional demographic information was collected along with the suspected etiology of a patient's pancreatitis.

### Research results

A total of 1305 patients presented to the emergency department with AP; of these, 405 patients (31%) met our inclusion criteria for AUP and were included in the study (201 males, 204 females; mean age 49 years, range 18-98). The utilization of CT imaging was seen in 210 patients (51.85%) that met the clinical and biochemical evidence of AUP upon presentation. One patient (0.47%) had evidence of pancreatic necrosis, one patient had cyst formation (0.47%), and the remaining 208 patients (99.05%) had either normal CT scan imaging or findings consistent with mild AP without necrosis. The use of CT imaging incurred a total cost of \$947056, with average cost of \$4510. Median length of hospitalization stay did not differ among those that underwent CT imaging compared to those that did not.

### Research conclusions

Our study showed that CT imaging among patients that meet the diagnostic criteria for acute uncomplicated pancreatitis has significant healthcare costs. In the study time period, almost \$1 million was spent on CT imaging that did not improve patient care in regards to hospital length of stay or clinical management. This is especially the case if contrast is used, which can worsen acute pancreatitis. Efforts need to be made to educate providers about acute uncomplicated pancreatitis and the utility of CT imaging in regards to clinical management.

### Research perspectives

A large multi-centered study should be conducted to confirm our results and investigate whether this CT imaging practice is performed at other hospitals. A future study could involve education to the Emergency Department regarding the utility of CT imaging among patients with acute uncomplicated pancreatitis and evaluating whether this reduced the number of CT imaging studies performed.

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