A Clinical and Economic Analysis of Emergency Physician-Performed Ultrasonography in the Setting of Cholecystitis

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Abstract (300 words)

**Context:** Emergency Physician ultrasound has recently emerged as a potential method for the clinical identification of acute cholecystitis. **Objective:** To determine the accuracy and cost-savings of Emergency Physician ultrasound performed by RDMS certified personnel in the detection of acute cholecystitis. **Design, Setting, and Participants:** Retrospective analysis of quality assurance data from 37 patients that presented to the emergency department (ED) of an academic, tertiary care hospital with ‘positive’ ED ultrasounds of the RUQ from June 1, 2005 to February 30, 2006. **Main Outcome Measure:** Positive predictive value (PPV) for ED ultrasound to detect acute cholecystitis with subsequently confirmed surgical pathology. Secondary outcomes were the hypothetical cost-savings achieved with singular use of ED ultrasound, without additional radiographic modalities, to identify and diagnose cholecystitis as extrapolated to the hospital, state, and national level. **Results:** Thirty-seven patients were studied. Five patients were excluded due to prior diagnosis of cholecystitis, flight, or inoperative status. Thirty-two patients, 15 males (47%) and 17 females (53%), exhibited new-onset RUQ pain with an ED ultrasound significant for cholecystitis. Eight (25%) patients received no further radiographic tests and all exhibited positive surgical pathology. Twenty-six (75%) patients had additional scans (radiology-performed ultrasound, DISIDA scan, both), of which 24 (92%) showed positive surgical pathology. The PPV for ED ultrasound to detect acute cholecystitis with surgical pathology was 94%. Based upon Medicare compensation indices, an opportunity cost of $6885.34 was incurred at our institution over 6 months as a result of additional scans. Using conservative estimates of the prevalence of gallstones and US population distribution, this can be extrapolated to a $83 million potential cost-saving at the national level. **Conclusions:** ED ultrasounds performed by RDMS certified physicians are accurate and cost-efficient at identifying acute cholecystitis. Larger, prospective studies are needed to more accurately determine the health-care costs associated with this phenomenon.
Introduction

According to the CDC’s National Center for Health Care Statistics there are approximately 20 cholecystectomies performed annually per 10,000 people in the United States\(^1\). Based on current population estimates this translates into 591,468 cholecystectomies performed each year. It is unknown what percentage of these surgical patients present to Emergency Departments for evaluation and admission. However, national Emergency Department census data suggests that abdominal pain accounts for roughly 10% of all visits. There are 113.9 million emergency department visits annually and, on average, 14% of these are admitted.

The standard evaluation of patients presenting with right upper quadrant pain consists of a history and physical examination, laboratory analysis, and radiological investigation. Isolated clinical, hematological, and biochemical findings are neither sensitive nor specific in the setting of acute cholecystitis\(^2\). Ultrasound diagnosis of cholecystitis is determined by presence of cholelithiasis\(^3,4\), a sonographic Murphys sign\(^5\), a thickened gallbladder wall\(^6,7\) and percholecystic fluid. There is significant debate in the literature regarding the initial radiological study of choice in these cases. This is largely due to the consistently higher sensitivity and specificity of scintigraphy balanced against the convenience and expedience of right upper quadrant ultrasound\(^8,9\). While this debate continues, the American College of Radiology (ACR) Appropriateness Criteria for evaluation of acute right upper quadrant pain, published in 2001, states that ultrasound is the most appropriate initial study in this setting with a quoted sensitivity and specificity of 91% and 79% respectively. The ACR guidelines recommend dual analysis with ultrasound and scintigraphy on a case-by-case basis or in the scenario where an initially inconclusive ultrasound or scintigraphic scan requires a corroborative study. Literature review yields a wide range of sensitivity with ultrasound, spanning from 48-100% in studies performed over the last 20 years\(^10\). However, the majority of current surgical and gastroentological literature also recommends ultrasound as the initial study of choice for acute cholecystitis\(^11,12\). Of note, Ralls et. al, in their study of 497 patients, found a 92% positive predictive value for ultrasound in patients with gallstones and a positive sonographic Murphys sign or gallbladder wall thickening. Current surgical literature suggests that expedient management of cholecystitis decreases complications and the conversion rate from laparoscopic to open cholecystectomy\(^13,14\). Expedient diagnosis, therefore, is of even greater importance in these cases.

A growing proportion of Emergency Physicians are performing their own ultrasound examinations. This growth has been driven largely by clinical curiosity, frustration with delays in obtaining emergent studies, and the desire to improve patient care. However, curiosity is not sufficient to justify change. Evidence based practice mandates the need to prove the emergency physician’s aptitude for performing and interpreting a given study before standardizing its application. This is a difficult task as the spectrum of ultrasound experience reflected in the existing emergency medicine data is broad. It is clear that Emergency Medicine residents and practitioners with moderate levels of training can successfully identify cholelithiasis with a sensitivity of 92-96%\(^15,16\). In one study of emergency physicians who performed right upper quadrant ultrasounds, the combination of cholelithiasis and a positive murphy’s sign yielded a 91% sensitivity\(^17\). These results are consistent with those found in the radiology literature\(^18\). This growing body of evidence has led to the incorporation of basic ultrasound training...
into core Emergency Medicine residency curricula across the country. While recommendations have been made regarding requisite ultrasound experience for emergency medicine residents, it is not clear how these residents are meant to apply this knowledge in their personal practice once graduated. Should ultrasound be used simply as a guide for choice of the most appropriate radiological study? To satisfy personal clinical curiosity but without influencing clinical decision making? Or as a definitive study that needs no follow up investigation?

In the current medical climate the evaluation of any change in medical practice should be accompanied by an economic analysis of its impact. The judicious use of medical resources, especially in regards to Medicare dollars, is an unappealing but necessary factor in medical decision making. Ideally the adjustments to medical practice that improve patient outcomes and quality of care while eliminating redundancy in expenditure are more easily accepted and implemented than those that compromise patient care.

The aim of this study was to evaluate a group of emergency physicians with Registered Diagnostic Medical Sonographer (RDMS) certification and fellowship training who utilize their ultrasound diagnosis in routine clinical care. While this level of training is likely to be higher than what should be required of most emergency physicians for routine focused ultrasonography, it is an ideal population to evaluate the potential for emergency physicians with a competency in ultrasound. Cholecystitis was chosen as the ultrasound study to investigate because it is a common disease process that presents emergently, is largely reliant on radiological diagnosis, and benefits from expedient management. The following questions are addressed in this study.

In the setting of cholecystitis, what is the positive predictive value of ultrasound performed by RDMS certified/eligible sonographers in the Emergency Department? At our academic institution (I would only put the name of our institution in the methods, but that’s up to you), what additional radiological studies are these patients undergoing prior to surgery, ERCP, or discharge? Finally, what would be the potential economic impact if our surgical and GI colleagues could rely on a focused Emergency Department ultrasound alone to guide their management?

Methods

Subjects:

All patients with ‘positive’ ED ultrasounds of the RUQ performed by RDMS certified/eligible ED physicians over the period from June 01, 2005 to February 30, 2006 were evaluated. ‘Positive’ was defined as the presence of anterior gallbladder wall thickening or edema and/or peri-cholecystic fluid. Patients were excluded if there was a known diagnosis of cholecystitis prior to the emergency department study, if the patient left prior to completion of treatment (against medical advice), or if the patient was not a surgical candidate due to co-morbidity.

Study Design:

This is a retrospective analysis of quality assurance data from the emergency department at North Shore University Hospital, an academic tertiary care referral hospital in Manhasset, New York. The Emergency Department has a 65k annual volume. All
Emergency Department Ultrasounds performed by RDMS certified/eligible Emergency Medicine physicians were evaluated. RDMS certified/eligible was defined as those physicians with RDMS certification or those who have completed or are enrolled in an emergency medicine ultrasound fellowship with greater than 800 ultrasound examinations of experience. This study was approved by the Institutional Review Board. Interpretations of the Emergency physician ultrasounds were obtained from the quality assurance log sheets completed at the time the study was performed. Radiology performed study reports and pathology data were obtained from the hospital’s medical record database and maintained in a de-identified manner in accordance with HIPAA regulation. ‘Positive’ surgical pathology was defined as evidence of acute and/or chronic cholecystitis. Chart review was performed in cases where pathology data was not available or clinical course was inconsistent with admitting diagnosis.

Results

Patient characteristics:
A total of 37 patients were studied. 5 patients were subsequently excluded. Three of these were excluded on the basis that the Emergency Department sonographer was aware of the diagnosis prior to performing an ultrasound. These exams were performed as part of resident education. One patient was excluded on the basis that they left against medical advice despite the surgical services recommendation for cholecystectomy. One patient was excluded on the basis that they were deemed a non-operative candidate by joint decision of the health care proxy and the surgical team.

Of the remaining 32 patients studied, there were 15 males (47%) and 17 females (53%). The age range was 30-90 with a mean age of 58. All patients by selection criteria had a positive Emergency Department Ultrasound.

Clinical Outcomes: (See Figure 1)
Eight patients in the study group had no further radiological investigation and went on to have positive surgical pathology. Five patients went on to have a DISIDA scan performed. Of these, all were positive scans and the patient continued on to have positive surgical pathology. Four patients went on to have a radiology-performed ultrasound. Of these, 3 cases were positive. All three continued on to have positive surgical pathology. In the fourth case the radiology-performed ultrasound was read as a diffusely thickened gallbladder wall in the setting of congestive heart failure. Review of this patient chart revealed documentation by the performing Emergency physician stating the diagnosis of an edematous gallbladder in the setting of CHF consistent with the radiology interpretation. Due to an error in the documentation on the quality assurance log as per the study design this case was included in the false positive category.
The remaining 15 patients went on to have both a radiology-performed ultrasound and a DISIDA scan. One of these patients had an indeterminate ultrasound by radiology, followed by a negative DISIDA scan. They were observed in the hospital for 24 hours due to an elevated white blood cell count and total bilirubin. Repeat lab evaluation was normal and the patient had a second radiology ultrasound that was also interpreted as normal. This patient was included in the false positive category. Another patient in this group had a negative radiology ultrasound, a negative DISIDA scan and surgical pathology consistent with acute cholecystitis. A third patient’s ultrasound and DISIDA scans were interpreted as indeterminate. Surgical pathology was consistent with acute cholecystitis in this case as well. Of the 12 remaining patients, all had positive and/or indeterminate radiology studies followed by positive surgical pathology.

**Clinical Discussion**

This study evaluates the clinical course of patients with a diagnosis of cholecystitis on ultrasound as performed and interpreted by RDMS certified/eligible emergency physicians. It further evaluates the economic implications of this data had these ultrasounds been used in isolation or in conjunction with corroborative studies for the disposition of patients with suspected cholecystitis. The results of this study suggest that the ultrasound examinations performed by these physicians have a 94% positive predictive value. This is consistent with the positive predictive value found in the radiology study performed by Ralls et al. previously mentioned in this article. Further investigation of the two cases that did not have surgical pathology reveals that the management of these cases could have been directed solely by the emergency department study without a change in their clinical outcome.

This study is limited by the fact that it is retrospective and provides only a positive predictive value. The study design was retrospective in order to evaluate these cases in vivo. Prospective evaluation would introduce the influence known as the Hawthorne effect, that is the alteration in subject (physician) practice when the subject knows they are under observation. The absence of a Hawthorne effect is vital to our investigation, as we sought to evaluate clinical practice rather than a single diagnostic modality in isolation. Additionally, this highlights a crucial difference between clinical and technician performed ultrasounds. The Emergency Physicians performing these ultrasounds were subject to selection bias in that their knowledge of the patient’s clinical and chemical parameters may have affected their decision to diagnose cholecystitis on ultrasound. The authors of this study maintain that this lends itself to the strength of this data rather than detracts from it as the emergency physicians interest lies with patient diagnosis and disposition and not the result of the test in isolation.

The use of positive predictive value will also prompt the criticism that without knowledge of the prevalence of disease, the positive predictive value of the test is less reliable. This is true when extrapolating this data to other patient populations. However, the prevalence of gallstones in the United States has consistently been reported as 10-15%. The lack of a known prevalence does not argue for the redundancy of testing, especially with a positive predictive value of 94% and the projected cost of those potentially redundant tests as determined by this study. That being said, the extrapolation of this data is limited by this fact.
Economic Discussion

The objective of our economic analysis of the data is to define a measure of the cost of ‘additional’ radiographic studies for our sample and then to extrapolate this measure across the nation, given the plausible and conservative assumptions outlined below.

“Additional radiological studies,” in this analysis, refers to studies that may, in the future, be avoidable with reliable emergency medicine ultrasound examinations. It is not meant to imply that the radiology studies ordered in this set of data were not indicated at the time of their being ordered. The intent is to translate the cost of the ‘additional’ testing observed in this study to a national level using nationally interpretable values, here the use of Medicare dollars and relative value units. The authors do not suggest that the clinical practice of one institution reflects that of most institutions in the United States, or that the positive predictive value of Emergency physician ultrasounds would remain constant across the nation. The analysis and extrapolation of this data is performed solely to highlight the crucial point that our medical decision-making process is associated with a real and considerable cost.

Define the opportunity cost of an economic event such as ordering an unnecessary test as what has been given up to get that test performed\(^\text{19}\). Economists attempt to quantify and monetize the foregone opportunities through cost-benefit and cost-effectiveness analysis, and through direct extrapolation, as in this study. A textbook example is: if a city decides to build a hospital on vacant land that it owns, the opportunity cost is the value of some other thing that might have been done with the land and construction funds instead. In building the hospital, the city has forgone the opportunity to build a sporting center on that land, or a parking lot, or the ability to sell the land to reduce the city's debt, and so on\(^\text{20}\). Returning to our study, regardless of whether any Medicare reimbursement was actually received by our hospital for the tests performed, a second test being done imposes a cost on the system, which we can quantify in this case using the cost assigned to these studies by the Medicare Resource Based Relative Value Scale (RBRVS)\(^\text{21,22}\). This scale allows for the precise quantification of physician (professional) and resource (technical) cost for a given test or procedure. In assessing economic versus simple accounting costs, our methodology was simple: the appropriate direct opportunity costs (i.e. costs borne by the healthcare system itself) of the ordering of additional studies are the fees as measured in geographically-compensated relative value units for the professional and technical components of the extraneous test administered. As reported above, in the 32 cases where a positive ED ultrasound was obtained, a further radiological study followed in 86% of the cases. Here, we ask the question ‘how much would have been saved if these tests were not performed’?

It is important from a methodological standpoint that the steps taken and the assumptions made in the analysis and extrapolation are transparent. We began by finding the Medicare compensation in terms of Relative Value Units (RVUs) and Geographical Practice Cost Index (GPCI) for “New York City Suburbs/Long Island”, at the CMS website, \url{http://www.cms.hhs.gov/apps/pfslookup/}. This information is summarized in Table 1. The GPCI is a modifier value assigned to a region, which account for geographical variations in resource and physician cost. The RVUs for a given test or procedure can be broken down into professional (26) and technical (TC) components.
Table 2 presents an explanation of these components. Once the RVU’s are determined the value is multiplied by a conversion factor (CF), which converts the Relative value units to a dollar amount. This conversion factor is adjusted annually. Each of the estimates were then obtained by applying the following formula:

\[ \text{Medicare Fee} = \left[ (\text{Work RVU} \times \text{Work RVU GPCI Adjustment}) + (\text{Facility PE RVU} \times \text{PE RVU GPCI Adjustment}) + (\text{MP RVU} \times \text{MP RVU GPCI Adjustment}) \right] \times \text{CF} \]

RVU = relative value unit, GPCI = Geographical Practice index, PE = practice expense, MP = malpractice

As example calculation, when one wants to calculate the dollar amount a hospital in the same region as NorthShore University Hospital (regional code 80302) would receive for Hepatobiliary imaging, one obtains the CPT code for the procedure (78223), associated with which is a set of weights for the procedure’s costing for professional services rendered, non-facility expenses, and physician malpractice insurance; in this case, respectively: 0.84, 3.95, and 0.23. The geographic/regional cost price modifiers for each RVU weight (1.05, 1.28 and 1.79, respectively) is multiplied through all of these, and the conversion factor, 37.90, revised annually, is applied, giving a dollar remuneration of

\[ [(0.84\times1.05) + (1.28\times3.95)+(0.23\times1.79)] \times 37.90 = \$240.65. \]

Once the relevant RVU set and conversion factors were obtained, it was necessary to calculate the opportunity cost arising from the duplication of ultrasound examinations and the addition of a HIDA scan in certain cases. The main results are summarized in Table 3. In the context of our small sample at North Shore University Hospital, an opportunity cost of $6885.34 was incurred over the 6 month period studied. This makes a bold cost-saving statement. It also suggests that there are significant cost savings across many measures of cost not quantified here such as physician time, patient time and indirect economic opportunity cost which should serve to indicate the possible generality of our results.

Once the individual ‘North Shore’ opportunity cost had been generated, the next step was to generalize the payments to the entire nation. The nation is helpfully subdivided into 91 socio-economic regions, such as ‘NYC/Long island,’ ‘Rest of Florida’ and ‘Fort Lauderdale’ rather than conventional political or geographical delimiters. Obviously the estimates are comparable with any hospital in the GPCI region because of Medicare’s universality. We then computed the actual costs for our sample by simple addition of tests performed. The opportunity costs, here defined as the number of extra tests over and above the emergency department ultrasound, were subtracted from this amount for each case. The cost ratio of actual cost to opportunity cost was about 65% for the entire group and the variance between the samples was statistically significant at the 1% level using the standard student t-test ratio.

Now comes the extrapolation step. As mentioned above, we ask ‘what if the relationship between actual and opportunity costs existed for the entire region covered by North Shore University Hospitals’ GPCI code? We found the population of Nassau
Adding to this the fact that there are approximately 20 cholecystomies performed annually per 10,000 people in the United States, this gives us a potential 1,802 cases in Nassau County per year. This provides a measure of cost for the entire county by simple multiplication. Now, there is no way to tell at this level of resolution of the data what percentage of these cases come through the ED of a typical ‘Nassau County’ hospital, so we calculate our extrapolation assuming, respectively, 1%, 10%, 25%, 50%, 75% and 100% of the cholecystectomies seen in Nassau County are seen in Emergency Departments (See Figure 2).

**Extrapolation Results**

The extrapolation of this data to Nassau County has the merit of producing a positive, comparable cost calculation for a small region of the country. One weakness, of course, is that the extrapolation is taken from a small sample size. It is also true that all Emergency physicians are not performing focused emergency departments ultrasounds. The aim of this analysis is not to be 100% accurate with our estimates of actual and opportunity cost losses. Our point is to demonstrate that there is a loss occurring, and to hint at its potential magnitude with a simple ‘back of the envelope’ calculation. For this we ask the reader’s forbearance. Hopefully the reader can see that if they follow our assumptions and if our calculations are correct, then we have simply scraped the surface of an important opportunity for health care savings and an economic argument for the acceptance and utilization of ultrasounds performed by Emergency Physicians with a high level of ultrasound training.

Figure Two shows a black bar above a grey bar. The black bar measures the component of the grey bar that could be saved if the ED ultrasound was taken as the only test. There is no double-counting here, and the graph is not constructed to confuse the issue, but rather to highlight our most salient point: there is clearly rather significant wastage in the system if, for one procedure and one test for one county, under realistic assumptions, one can save at least $500,000 per county. Another way of looking at the X axis is if one assumes that 1%, 5%, 10%, 25%, 50% or 100% of the patients getting a cholecystectomy each year present to an emergency department and have a similar experience, ie., the emergency physician has a similar level of ultrasound ability and the number of additional tests they receive is also equivalent, the cost is equivalent to the corresponding Y axis value.

Next it was natural, once we had this basic calculation completed, to extrapolate further and ask our question of the nation based on the 591,468 cholecystectomies performed in the United States annually as determined at the outset of this paper (See Figure 3). Typing RVUs by GPCls for the nation, and assuming a uniform population density throughout, we can make this extrapolation. Our findings are summarized in Figure 3 Assuming that 50% of patients undergoing cholecystectomy each year have a similar emergency department and radiology evaluation, the extrapolation to national data yielded an opportunity cost of $83 million. If only 1% of patients have a similar experience to those at North Shore the opportunity cost is potentially $1.66 million per year.

Given that there is debated evidence regarding the performance of HIDA scans in this patient population we repeated our analysis excluding the additional cost incurred by
HIDA scans. Figure 4 represents the opportunity cost of the additional ultrasounds alone, again extrapolated to the national level with the same assumptions outlined above.

In conclusion, the ultrasounds performed by RDMS certified/eligible Emergency physicians in this setting have a high positive predictive value consistent with current radiology data. The potential cost of additional or redundant radiology tests, when extrapolated to national levels, is more than considerable. These findings should prompt the examination of our individual practice and the consideration that potentially redundant testing greatly taxes the health care system. As a community of physicians, we must endeavor to work, practice, and spend health care dollars efficiently and effectively. Further studies, both prospective and retrospective, into the economy of this and other diagnostic algorithms, such as in the evaluation of deep venous thrombosis, are warranted. Ultimately this may enable us to save significant quantities of health care dollars without sacrificing the quality of care provided.

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TODO “In the Acknowledgment section of the manuscript, include the names, academic degrees, affiliations, and specific contributions of all persons who have contributed to the work reported in the manuscript (eg, data collection, analysis, writing or editing assistance, review of manuscript) but who do not fulfill authorship criteria, and also indicate whether any compensation was received for such contributions. Written permission must be obtained from all persons named in the Acknowledgment (see also the Acknowledgment statement in the Authorship Form that must be signed by the corresponding author).”
Tables

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§Source: US Department of Health and Human Services, Centers for Medicare and Medicaid Studies, available at [http://www.cms.hhs.gov/apps/pfslookup/](http://www.cms.hhs.gov/apps/pfslookup/). This table shows the technical (TC) and professional (26) components of limited right upper quadrant ultrasound in both relative value units and Medicare reimbursement values. Each component is further subdivided into work, facility and malpractice portions which are added to give the total RVU’s.
Figures:

Figure 1: Clinical Outcome of Patients with Positive ED Ultrasounds

Positive ED US (32 patients)

- DISIDA Scan
  - 5 patients (16.5%)
  - All Positive Pathology

- Radiology Ultrasound
  - 4 patients (12.5%)

- Radiology, Ultrasound and DISIDA
  - 15 patients (47%)

- No Additional Study
  - 8 patients (25%)
  - All positive pathology

- Positive Radiology US
  - All Positive Pathology

- Negative Radiology US
  - Patient with CHF, see text

- Negative DISIDA/US
  - 1 patient (3%)
  - Positive Pathology

- Positive DISIDA/US
  - 12 patients (37.5%)
  - All Positive Pathology

- Indeterminate DISIDA/US
  - 2 patients (6%)
  - One observed w/ a negative repeat US
  - One with positive pathology
Figure 2: The extrapolated relationship between actual and opportunity costs of scans for upper abdominal pain leading to the positive diagnosis of cholecystitis for Nassau County. On this graph the whole column represents the cost of all studies performed, including the emergency physician performed ultrasound. The black portion of the column represents the opportunity cost.
This graph represents the nationally extrapolated data. On the X axis the .5 represents the theoretical assumption that 50% of all patients who undergo cholecystectomy each year have an equivalent experience in their initial evaluation. On the graph this corresponds to a 109 million dollar total cost and an opportunity cost of 83 million dollars.
This graph represents the nationally extrapolated data without including assumption that the cost of the extra HIDA scans is medically useless information given the positive ED ultrasound findings. On the X axis the .5 represents the theoretical assumption that 50% of all patients who undergo cholecystectomy each year have an equivalent experience in their initial evaluation. On the graph this corresponds to a 24.96 million dollar total cost and an opportunity cost of 8.37 million dollars.
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2) Trowbridge RL, Rutkowski NK, Shojania KG. Does this patient have acute cholecystitis? *JAMA*. 2003;289:80-86.
12) Townsend Sabistom Textbook of Surgery, 17th ed. 2004: 1609-10 (this needs more info for the JAMA format, sp. Editors names, publication site, publisher)
