Point-of-Care Ultrasonography (POCUS) in a Community Emergency Department

An Analysis of Decision Making and Cost Savings Associated With POCUS

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Objectives—Point-of-care ultrasonography (POCUS) is an increasingly integral part of emergency medicine. This study investigated community emergency department physicians' choices regarding ultrasonography as a branch point in clinical decision making.

Methods—During shifts covering all days of the week and all time-spans over a 3-month period, emergency department physicians were interviewed whenever POCUS was used. Questions focused on the role of POCUS in clinical management and on tests avoided because of ultrasonography use. Cost savings attributable to POCUS were calculated using Center for Medicare and Medicaid Services and FairHealth data. Anonymization of data precluded follow-up testing to account for misdiagnosis.

Results—On average, POCUS use eliminated $1134.31 of additional testing for privately insured patients, $2826.31 for out-of-network or uninsured patients, and $181.63 for Center for Medicare and Medicaid Services patients. Differences were significant when the total cost of eliminated additional testing was compared to a baseline of no savings ($p < .001$). Aggregate cost savings remained significant when analyses were broadened to include POCUS encounters that did not yield changes in management ($p < .001$).

Conclusions—When physicians' clinical expertise suggests that POCUS may be indicated, its use results in significant cost savings, even in encounters in which management is not directly impacted. POCUS, when incorporated earlier and more frequently into community hospital emergency medicine diagnostic protocols, can lower direct and indirect costs associated with diagnostic workups. Community emergency departments, in particular, would benefit from additional investigation informing specific guidelines for the integration of POCUS into clinical management and the role that this has in cost savings.

Key Words—point-of-care ultrasonography; cost efficacy; medical decision making; community emergency medicine

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Abbreviations

CMS, Center for Medicare and Medicaid Services; EDs, emergency departments; IV, intravenous; POCUS, point-of-care ultrasonography; CPT, current procedural terminology

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Point-of-care ultrasonography (POCUS) is an increasingly integral part of diagnostic guidelines and algorithms in emergency medicine.[1–3] Studies have demonstrated its utility in the emergent diagnosis and management of acute appendicitis,[4,5] airway compromise,[6,7] pneumonia,[8] abdominal aortic aneurysm,[9] nephrolithiasis,[10] pulseless electrical activity,[11] and urolithiasis.[12] It

also aids in the characterization of traumatic injury,[13] and it reduces diagnostic uncertainty in the setting of undifferentiated hypotension[14] and in hemodynamically unstable patients.[13] As of 2015, despite the critical role that ultrasonography has been shown to play in clinical decision making in emergency departments (EDs), it is not used uniformly or regularly in emergency settings.[15] Lack of training in the use and interpretation of ultrasonography, concerns about credentialing, and inconsistent reimbursement have been cited as some of the reasons for variability in ultrasonography use across different types of ED settings.[15,16] A further, and less well characterized aspect of ultrasonography use in emergency clinical decision making, involves features particular to academic or community EDs.[15–17] Studies of ultrasonography use in community settings in the United States underscore the utility of ultrasonography but caution that community providers, in contrast to their counterparts in larger centers, frequently have fewer opportunities to develop and to maintain skills in ultrasonography use and interpretation.[15–17]

Providers' use of and competency with ultrasonography can yield benefits not only for patient care but also for direct and indirect cost savings at the institutional and national levels.[18] Many of these studies rely on Medicare claims data, insurance claims data, or general surveys asking providers about their habits of ultrasonography use.[19–22] This strategy, while yielding useful insights, does not necessarily provide information about providers' decisions regarding POCUS use at the moment of clinical contact. In light of the established evidence about the clinical importance of ultrasonography use and its potential for cost saving, we sought to investigate emergency department physicians' perceptions regarding the role of ultrasonography as a branch point in clinical decision making. Since studies of emergency ultrasonography use tend to emerge from academic environments, we focused on community emergency providers in an effort to identify more ways to bridge the gap between ultrasonography use in large, academic hospital settings and its use in community settings. Specifically, we sought to examine community emergency practitioners' decisions regarding the use of ultrasonography. We focused on whether such use changed practitioners' clinical management, and how such changes might be quantified for basic cost savings analysis. Because many studies rely on data about ultrasonography use obtained after the fact (ie, Medicare claims data or surveys) and are not asking providers about their use of ultrasonography in the context of clinical decision making, we sought to redress this gap in the literature by surveying practitioners in the ED, shortly after they elected to employ ultrasonography in diagnostic or therapeutic management. This enabled the study to add to the existing literature and also facilitated estimation of cost avoidance through the use of POCUS.

Methods

Study Design, Setting, and Population

We examined POCUS use within the ED of a 213-bed community hospital. No information about age, sex, name, or other identifying characteristics was recorded about patients or about the physicians participating in the study, and the investigators were not able to see any of the ultrasound images obtained. Prior to its commencement, this study was reviewed and assigned exempt status by the Mt. Auburn Hospital Institutional Review Board (45 CFR 46.101[b] [2]).

Study Protocol

Data for the study were obtained during 15 nonconsecutive 8-hour shifts, occurring at all hours of the day and night, and over every day of the week, in a 3-month time frame in the spring of 2018. Such distribution of evaluations sought to minimize provider-use bias and diurnal trends in the ED census. At the start of each shift, the investigator explained the goal and protocol of the study to the attending physician(s) on the shift and sought verbal consent for their participation.

To identify when ultrasonography was used in clinical evaluations, the investigators observed the cart-based ultrasound machine, without entering any patient rooms or accessing protected health information. When ultrasonography was incorporated into clinical care, the investigator, at a nonacute time shortly after the ultrasound examination had been completed, approached the attending physician outside of the examination room and asked the following

3 questions about the examination that had just occurred:

1. What did you expect to see on the sonogram (in terms of likely diagnosis)?
2. What would have been your next diagnostic or therapeutic step if there were no ultrasonography immediately available?
3. Did the outcome of the ultrasound examination change the management of this particular patient's problem?

These POCUS examinations were completed by ED physicians competent in the use of bedside ultrasonography. Examinations were of varying length, depending on the clinical questions being answered, but no examination lasted more than 10 minutes. Images were not saved, but data obtained during the ultrasound examination was used in further clinical decision making, as described below.

Data Collection

The answers to the above questions were recorded in a password-protected, offline, encrypted data-collection tool and further parsed into 5 groupings for analysis: (1) observation number (cumulative number of encounters for which ultrasonography was used over the observation periods, e.g., 1, 2, 3 …); (2) likely diagnosis prior to POCUS use; (3) next steps after POCUS incorporation; (4) management change (yes/no); and (5) workup avoided from change in management. The category "work-up avoided" considered specific management steps rendered unnecessary from the involvement of POCUS in clinical decision making. These management changes were limited to those specified in the initial tests and treatment steps as outlined using UpToDate: for example, for an encounter in which POCUS use resulted in a diagnosis of decompensated congestive heart failure rather than pericardial effusion, workup steps avoided, as enumerated in UpToDate, include a referred echocardiogram.[23,24] An additional example of how potentially avoided charges were calculated can be seen in Table 1.

Once the components in the "workup avoided" grouping had been enumerated and aggregated for each encounter, Current Procedural Terminology (CPT) codes were designated for each component. From these Current Procedural Terminology codes, the direct costs of care avoided were determined using 3 sources to take into account various payers: the Center for Medicare and Medicaid Services (CMS) Physician Fee Scheduler (amount reimbursable to the hospital from CMS),[25] Fair Health Consumer database (cost to the patient or private insurer with or without insurance),[26] and CMS's Clinical Laboratory Fee Scheduler (amount reimbursable by CMS for laboratory tests).[25] In the case of the CMS Physician Fee Scheduler and Fair Health Consumer database, cost estimates were based on those assessed within the geographic area of the community hospital where the study was conducted. For the purposes of this research, CMS reimbursements were taken to be those that would have been accrued in an academic facility. This was done because the community hospital where our observations took place, although a community site, was still affiliated with an academic medical center. The Fair Health consumer data used were the average charges assessed to a private third-party payer in a specific area, an out-of-network individual, or someone without insurance coverage. Fair Health cost estimates "are based on claims … paid for by private insurance plans … [their] database includes more than 26 billion private health care

Table 1. Example Cost Matrix of Expenses Potentially Eliminated for All 3 Payer Types by Ruling Out a CHF Exacerbation Using POCUS

Test	CPT	CMS Total	FH Out of Network/ Uninsured	FH Insured
ECG	93000	$19	$351	$157
CBC w/o differential	85027	$8	$113	$43
CMP	80053	$13	$227	$80
BNP	83880	$42	$599	$250
Glucose	82962	$3	$29	$10
CXR	71020	$32	$539	$211
Troponins	84484	$12	$270	$98
Total		**$130**[a]	**$2,128**	**$849**

[a]CMS expenses are composed of those billed according to the CMS Fee Scheduler, as well as the CLS. For the sake of this table, both charges from the Fee Scheduler and CLS are aggregated under the title "CMS." Numbers may not add up precisely due to rounding of cent values.

BNP indicates brain natriuretic peptide; CBC, complete blood count; CHF, congestive heart failure; CLS, Clinical Laboratory Schedule; CMS, Center for Medicare and Medicaid Services; CMP, comprehensive metabolic profile; CPT, current procedural terminology; CXR, chest X-ray; ECG, electrocardiogram; FH, FairHealth; and POCUS, point-of-care ultrasonography.

claims and 20 billion Medicare claims for 10,000 services in all areas of the United States, dating back to 2002. [They] receive about 1.7 billion new records each year."[26] The size and comprehensiveness of this database made it an appropriate choice for the estimates described above.

Data Analysis

Once the relevant information for each encounter had been listed, aggregated, and quantified with respect to direct costs, as exemplified for a congestive heart failure exacerbation in Table 1, descriptive statistics and 2-sample *t*-tests were performed (Microsoft Excel for Mac, Version 14.0.0) across each of the 3 payer groups listed above, to ascertain the significance of cost savings after POCUS. Since patients were not followed for their whole hospital stay, cost savings for each encounter are representative of savings accrued by eliminating the initial workup and treatment steps that would be completed in an emergent setting.

Key Outcome Measures

Key outcomes were the direct cost savings associated with POCUS use, from the perspective of the patient and of the hospital. Secondary outcome measures were based on empirical observation of the indirect cost savings associated with POCUS, including potential time savings accrued by physicians and patients, and the elimination of unnecessary discomfort for patients (i.e., multiple needle sticks to start an intravenous line).

Results

Forty-nine observations were made over 15 shifts, 16 of which (33%) resulted in a change in management, as determined by the attending physician on shift. Of the 33 observations noted not to have changed management, 18 occurred when ultrasonography was used for a procedure within the ED (55%); no additional information was gathered regarding these encounters.

In each of the 16 encounters deemed to have changed clinical management, POCUS use resulted in the elimination of additional diagnostic tests and in potential charge avoidance, although in none of these 16 cases did POCUS generate a completely new or unexpected diagnosis. Of all 49 uses of ultrasonography, 14 were for cardiac indications (29%). Thirteen of the 16 encounters (81%) resulting in clinical management changes were for cardiac indications, most commonly for the assessment of congestive heart failure exacerbation versus another disease process (56%).

On average, POCUS use eliminated $1134.31 of additional testing for privately insured patients, $2826.31 for out-of-network or uninsured patients, and $181.63 of potentially negative-margin additional CMS-reimbursable procedures or tests to the hospital. Table 2 highlights the mean cost avoidance accrued according to each payment schema, as well as the maximums and minimums in the study. These data, which were calculated based on management steps avoided due to POCUS, take into account the cost of the aforementioned avoided management, as well as the cost to perform POCUS. Further explanation of how these data were derived can be found in the Data Collection section above. As no additional patient health information was collected for individual encounters, each patient's insurance status was unknown. Therefore, profitability at the patient and hospital level was not calculated as part of this study.

Two-sample, 1-sided *t*-tests indicated a significant elimination of additional costs in cases in which POCUS changed the course of clinical management, particularly for patients without insurance or for those seeking out-of-network care. Costs were calculated for each of the 3 payer groups previously identified: privately insured patients, out-of-network/uninsured patients (both groups are considered equivalent with respect to cost according to Fair Health's cost calculation guidelines), and CMS fees. Differences were found to be significant when the total cost of eliminated additional testing, less the cost of POCUS, was compared to a baseline of no savings (Table 3). For

Table 2. Descriptive Statistics of the Cost Savings Achieved for Each Payer Group When POCUS Changed Patient Management

	CMS	Out of Network/ Uninsured	In Network
Mean	$181.63	$2,826.31	$1,134.31
Minimum	$40.21	$823.00	$322.00
Maximum	$501.38	$7,393.00	$3,090.00

CMS indicates Center for Medicare and Medicaid Services; and POCUS, point-of-care ultrasonography.

all 3 cost-calculation schemata, *p*-values were less than .001 at the 99% confidence interval (n = 16, $t_{critical}$ = 2.60, $t_{private}$ = 5.69, t_{out} = 5.10, t_{CMS} = 6.75).

Aggregate cost savings remained statistically significant at the 99% confidence level for each payer type when analyses were broadened to include observed POCUS encounters that did not yield any changes in the course of clinical management (n = 49, $p < .01$, $t_{critical}$ = 2.41, $t_{private}$ = 3.13, t_{out} = 3.07, t_{CMS} = 3.11).

While this study did not seek to quantify the indirect cost savings from POCUS, empirical evidence from this work suggests that POCUS use did result in a quicker diagnosis and subsequently increased patient throughput, thereby minimizing discomfort and stress for patients (eg, as inferred from use of the machine for procedures).

Overall, protocol implementation was largely successful. All uses of the ultrasound machine were accounted for, and no attending physician refused to participate in the study. Although this protocol did foster context-focused observation of POCUS use in a community hospital setting, the number of samples it yielded (n = 49) was limited.

Discussion

In this observational study, the average savings associated with the use of POCUS (Table 2) supports the claim that increasing the use of POCUS in community EDs can reduce direct costs, boost hospital profitability, and improve patient care.

Direct Costs and Profitability

Our results are consistent with those of other studies demonstrating the cost savings associated with POCUS, including a study from 2014 indicating that handheld ultrasound examination of patients referred for transthoracic echocardiography saved an average of $63.01 per patient, in comparison with a physical examination.[27] In this study, of the 250 patients referred for transthoracic echocardiography, 142 were diagnosed with an abnormal finding via gold-standard echocardiogram. Among these 142 patients, handheld ultrasonography correctly identified pathology in 117 patients (82%), compared to 67 (47%) with physical examination alone.[27] These savings, while less in magnitude than the direct cost savings observed in our study, were assessed for a single diagnostic test (referred transthoracic echocardiography), rather than an initial workup and treatment (as would be seen in the ED). These savings also occur later in a patient's hospital course. Despite these differences, the research described above provides further support for the present investigation's claim that an increase in the use of POCUS can significantly lower the direct cost of patient care by the elimination of unnecessary diagnostic procedures.

Furthermore, lowering the cost of direct care in the ED can increase hospital profitability. One study found that, of the 11 million patients in their data set, only privately insured patients had a positive profit margin (39.6%).[28] However, privately insured patients accounted for 35% of the average patient mix. The remaining 65%, composed of Medicare (26%), Medicaid (21%), and uninsured individuals (18%), had negative profit margins that ranged between –15.6% and –54.4%. This data set, while much larger than that used for the present work, supports the assertion that lowering direct patient costs, particularly for CMS and uninsured patients, can improve hospital profit margins and long-term viability.[28] That is, in a hospital serving CMS and uninsured patients, the avoidance of unnecessary patient charges for this group will save the hospital lost profits on what otherwise would be

Table 3. Paired 2-Sample *T* Tests at the 99% Confidence Interval for Charge Avoidance Due to POCUS

	CMS With Management Change	CMS All Encounters	Out of Network/ Uninsured Management Change	Out of Network/ Uninsured All Encounters	Private Pay	Private Pay All Encounters
T critical	2.60	2.41	2.60	2.41	2.60	2.41
T statistic	6.75	3.11	5.10	3.07	5.69	3.13
p-value	<.001	.002	<.001	.002	<.001	.002

Each cost-calculation type takes into account charges avoided, less POCUS.
CMS, Center for Medicare and Medicaid Services; and POCUS, point-of-care ultrasonography.

net-negative management steps. For example, using the previously cited negative profit margins as a benchmark, a hospital may bill $100 for a given procedure and be reimbursed $70 by CMS, resulting in a loss of $30. Had this charge been avoided, these kinds of losses would be minimized or eliminated.

Indirect Cost and Patient Care

Of the 49 POCUS encounters observed in this study, 18 occurred when the device was used for a procedure rather than for clinical decision making. This, in turn, suggests that POCUS promotes indirect cost savings (eg, reducing patient discomfort, saving time for patients and providers), especially in the context of procedures. At least 1 study from 2016 has drawn a parallel conclusion about indirect savings: ultrasound-trained ED technicians were able to place intravenous (IV) lines with ultrasound guidance in fewer attempts (1.15 attempts, on average), in patients classified as difficult by access criteria, than published studies indicated to be the case for non-trained technicians (1.27–1.70 attempts).[29] Furthermore, this 2016 study showed that ultrasound-trained technicians placing IV lines with ultrasound guidance reached first-attempt success rates of 97%, nearly equivalent to published success rates for nurses and physicians.[29] Although the present work does not specifically assess the indirect cost savings associated with ED physicians using POCUS for IV access, it does suggest that POCUS can allow technicians to reach physician-level proficiency at IV placements, sparing patients discomfort and hastening their time in the ED, and facilitating providers' treatment and throughput of patients.

Clinical Decision Making and Guidelines

Our results indicated the importance of ultrasonography use for clinical decision making in emergent settings, suggesting the possibility for direct and indirect cost savings if ultrasonography is more regularly incorporated, and at earlier stages, in the clinical decision-making process. One of the challenges of this recommendation, however, is that it fails to address the well-documented issue of variable provider familiarity with the use and interpretation of ultrasound data. Some attempts have been made to define competencies for ultrasound-guided bedside procedures,[30,31] and medical schools are increasingly incorporating instruction in ultrasound examinations into teaching modules.[32,33] However, providers' relative willingness to employ ultrasonography and variable comfort levels and abilities in appropriately interpreting the results remain a barrier to the regular use of this method of examination in emergency settings. This study provides further evidence, especially in the context of a community hospital, that ultrasonography use in the ED can facilitate clinical decision making in a way that leads to direct and indirect cost savings.

Limitations

Our study was limited for several reasons, including its generalizability. Although the study design provided for observation of shifts distributed over all times of day and days of the week, this did not fully mitigate the biases inherent in observing a single hospital's patient population, thereby leading to omission as well as inclusion biases. It is possible that working in a community hospital associated with a large academic medical center yielded a patient population more amenable to ultrasonography and more willing to undergo such testing at the bedside. These patients' characteristics may have also predisposed them to pathologies that are more easily characterized via imaging (e.g., pleural effusions). This, in turn, could mean that physicians may have been biased toward the use of POCUS in situations in which clinical judgment could have yielded similar results, thereby inflating the cost savings attributable to POCUS. Additionally, because this investigation was limited to 1 community hospital, with a limited sample size (n = 49, with 16 POCUS encounters that prompted clinical management changes), it is more challenging to draw conclusions broadly applicable to community EDs nationwide.

Another potential source of bias stems from the study's design, which involved consenting attending physicians for study participation prior to the start of their shift. This procedure could have rendered them more likely to use POCUS than they otherwise would have, thereby introducing response bias. Furthermore, because no specific patient identification information was recorded, no data regarding the patient mix are available, and anonymization of data recording precluded follow-up testing to assess for the possibility of misdiagnosis. This lack of follow-up testing may

have minimized accounting for downstream costs associated with misdiagnosis.

Finally, this research was conducted in a state that historically has had some of the highest health care costs in the country, across all procedures. Because our method looked at the cost avoided based on avoided diagnostics, it is likely that our direct savings were increased compared to other national payers, because of the location in which the research was conducted. Cost data vary widely across different patient populations and locations and are often difficult to parse out because of the diverse cost structures employed (fee-for-service, value-based pricing, time-driven activity-based costing, etc). Although the methodology used in this study does not account for each cost structure, it can nevertheless serve as a starting point for further analyses regarding the clinically appropriate and financially sustainable use of POCUS in the ED.

Conclusions

In light of the increasing direct costs of care experienced by patients and hospitals alike, our research suggests that POCUS, when incorporated earlier and more frequently into community hospital emergency medicine diagnostic protocols, can lower these costs across payer classes. These statistically significant savings brought about by bedside ultrasonography, inclusive of cases when management is not directly changed by POCUS, provide evidence that emergency physicians should maintain a lower threshold to use bedside ultrasonography. Finally, this work suggests that additional indirect costs (such as patient time in the ED, discomfort, etc.) can be lessened through increased ultrasonography use in the ED, and it provides a foundation for additional research to more narrowly define best-case POCUS use.

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