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Ultrasound Based Key Clinical Pathway Reduces the use of Hospital Resources for the Evaluation of Blunt Abdominal Trauma

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Abstract

Background: Evaluating blunt abdominal trauma remains a resource intensive aspect of trauma care. Recently, emergency department ultrasound has been promulgated as a noninvasive diagnostic alternative. Consequently, we hypothesized that an ultrasound based key clinical pathway (KCP) would reduce the number of diagnostic peritoneal lavage (DPL) and computed tomographic (CT) scans required to evaluate blunt abdominal trauma without increased risk to the patient.

Methods: This study was a prospective analysis of patients evaluated for blunt abdominal trauma during a 3-month period using this KCP compared with a 3-month historical cohort.

Results: Data were collected for 486 KCP patients and were compared with 516 patients in the study cohort. No differences were noted regarding demographics, number of laparotomies, or type of injuries. Using the KCP, DPL was reduced from 17 to 4%, and computed tomography from 56 to 26%. Furthermore, the injury severity score increased from 11.6 to 21.5 for DPL patients and from 4.6 to 8.3 for computed tomography patients. Ultrasound exams were used exclusively in 65% of patients.

Conclusions: An ultrasound based KCP resulted in significant reductions in the use of invasive DPL and costly CT scanning in the evaluation of blunt abdominal trauma without risk to the patient.

Key Words: Ultrasound, Blunt abdominal trauma, Key clinical pathway, Diagnostic peritoneal lavage, Computed tomography.

Evaluating patients who sustained blunt abdominal trauma remains one of the most resource intensive aspects of acute trauma management. Physical examination is notoriously unreliable in patients with multisystem injuries due to intoxication, concomitant head injuries, and other distracting injuries. Historically, patients often underwent diagnostic peritoneal lavage (DPL) followed by hospitalization for serial physical examinations and laboratory testing. In the past decade, computed tomography has been shown to be a sensitive means of detecting intraperitoneal injury, but it is expensive and requires significant time to prepare and execute a study. More recently, ultrasound has emerged as an alternative means of evaluating patients who have sustained blunt abdominal trauma. Ultrasound can be performed rapidly, is readily repeatable, and has been shown to be a sensitive means of detecting abdominal injury. Despite its intuitive appeal, as well as demonstrated efficacy in Japan [1] and Germany, [2] the acceptance and implementation of ultrasound in the United States has been cautious.

At Denver Health Medical Center, we developed a key clinical pathway (KCP) for the evaluation of blunt abdominal trauma patients to test the hypothesis that emergency department (ED) ultrasound, performed by emergency physicians and surgeons, would reduce the need for invasive diagnostic peritoneal lavage as well as costly computed tomographic (CT) scans for the evaluation of blunt abdominal trauma. Indeed, we propose that using ultrasound as our primary diagnostic modality will result in significantly lower charges for the evaluation of patients sustaining blunt abdominal trauma. To evaluate this question, we prospectively compared the results of an ultrasound based KCP with a historical cohort before the institution of the KCP.

MATERIALS AND METHODS

A multidisciplinary panel developed a KCP in which ED ultrasound was the primary diagnostic tool for the evaluation of blunt abdominal trauma in those patients whose initial presentation did not mandate immediate laparotomy (Figure 1). In brief, the initial ultrasound examination served as the first level of triage to laparotomy or additional diagnostic testing. The other diagnostic modalities included DPL, CT scanning, and serial ultrasound examinations; we have not found laparoscopy useful for the evaluation of acute blunt abdominal trauma.

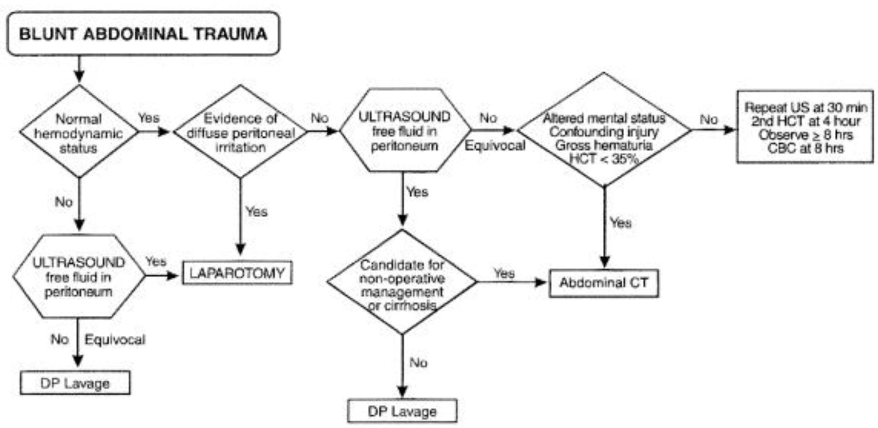

Figure 1. KCP for the evaluation of blunt abdominal trauma.

After a 2-month introductory period, data were gathered from August 1, 1995, until October 31, 1995, and compared with a historical cohort from the interval August 1, 1994, to October 31, 1994, before instituting the KCP. Data were collected prospectively during the KCP period, whereas trauma registry data were used for the historical cohort. Hospital admission records, CT scanner log books, and observation unit records were used to identify any additional patients not identified with the above mechanisms.

The medical records of all KCP patients were reviewed 6 months after the conclusion of the study period (up to April 30, 1996) for any potential injuries missed at their initial presentation. Estimates of the reduction in hospital costs were made using the hospital's cost for DPL, whereas the cost for abdominal/pelvic CT scanning was taken directly from the literature. [3,4] Estimates of potential revenue increases from charges for sonographic procedures were calculated as a percentage (0.25) of the cost of a formal abdominal ultrasound performed in the radiology department of our hospital. This amount is almost identical to that being charged for abdominal ultrasound examinations at another hospital in Denver with long-standing experience with ED ultrasound. Continuous variables were compared using Student's t test, and categorical variables were compared using chi^2 analysis using SAS statistical software (SAS, Cary, NC).

RESULTS

During the prospective data collection period, 486 consecutive patients were enrolled in the KCP. These patients were compared with 516 patients from the historical cohort. Comparison of the two groups is shown in Table 1. There was no significant difference in the age, men:women ratio, or average Injury Severity Score (ISS) between the two groups. The number of patients with alcohol levels greater than 100 mg/dL was 40% for the KCP group and 38% for the cohort. The means by which the abdomen was evaluated is summarized in Figure 2. Reliance on DPL decreased from 17 to 4% of cases (74% reduction), and CT scans were reduced from 56 to 26% of cases (58% reduction). These data as well as the ISS of patients are shown in Table 2. In sum, the absolute number of DPL and CT scans declined, and these tests were performed on individuals with greater ISS than the cohort. Ultrasound examinations were exclusively used to evaluate the abdomen in nearly two thirds of the KCP patients.

Group	Average Age ± (SEM)	Male:Female (Ratio)	Percent Intoxicated	Average ISS ± (SEM)
KCP	32.2 ± (0.85)[a]	324:162 (2:1)	40[a]	6.2 ± (0.44)[a]
Cohort	33.6 ± (0.79)[a]	346:166 (2.1:1)	38[a]	5.6 ± (0.34)[a]

SEM, standard error of the mean.
[a] No significant differences.

Table 1. Study group characteristics.

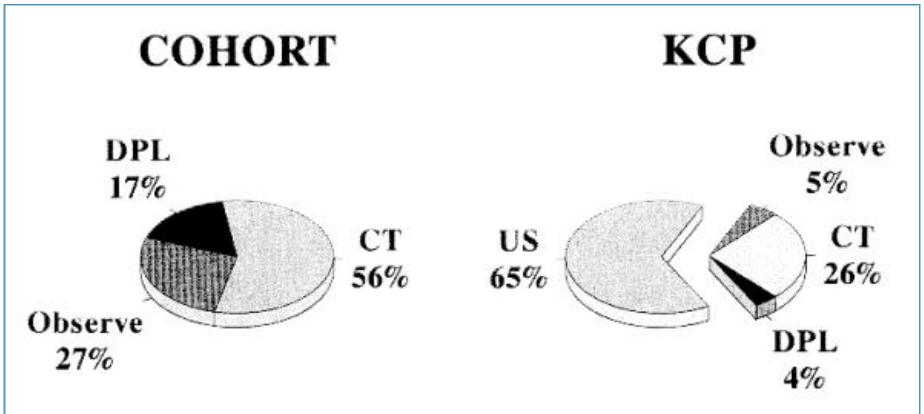

Figure 2. Comparison of methods of abdominal evaluation: KCP vs. Cohort.

	Cohort	KCP	$p < 0.01$	Cohort ISS	KCP ISS	$p < 0.01$
DPL	17%	4%	−74%	11.6 ± 12.1	21.5 ± 17.8	+190%
CT	56%	26%	−58%	4.6 ± 5.0	8.3 ± 9.0	+180%
US	—	65%	—	—	5.5 ± 6.4	

Table 2. Abdominal evaluation vis-a-vis ISS scores.

(Table 3) compares the distribution of injuries between the KCP and the cohort. There were no significant differences in number or type of injuries between the two groups. This is also demonstrated in Table 4, which compares the findings at laparotomy for the KCP and the cohort. Overall, 3.6% of patients in the KCP group and 4.1% in the cohort underwent laparotomy (p = 0.74). As well as having comparable operative rates, there were no significant differences in the findings at laparotomy between the cohort and the KCP group. Only one individual in the KCP group having serial sonographic examinations ultimately underwent laparotomy. In retrospect, the laparotomy was probably not necessary because the patient had a nonbleeding grade II splenic injury. No patient in the KCP group returned with a missed injury in the 6 months after the study period. Three deaths occurred; one in the cohort group, and two in the KCP group. After instituting the KCP, 196 patients who formerly would have been admitted to the hospital for greater than 24 hours were, instead, observed for less than 12 hours using serial ultrasound examinations to rule out blunt abdominal trauma, resulting in a 38% decrease in hospital admissions. Had these 196 patients been admitted to the hospital for 24 hours, the total charges would have been $130,536. Hospital charges for observing these patients for 8 to 12 hours in the emergency department were $90,944. This resulted in a reduction of hospital charges for evaluating these patients of $39,592.

Injury	Cohort[a]	KCP[a]
Liver	28	28
Spleen	32	27
Hollow viscus	5	2
Spinal injury	14	19

Head injury	84	60
Long bone fracture	43	37
Pelvis fracture	15	12
Soft tissue	257	238
Musculoskeletal	30	19
Chest	14	10
Multiple Injuries[b]	50	43

[a] No significant differences.

[b] Multiple injuries defined as involvement of three or more of the above injury categories.

Table 3. Comparison of injury types: KCP vs. cohort.

Injury	Cohort[a]	KCP[a]
Spleen		
Grade 4	2	1
Grade 3	6	4
Grade 1–2	8	6
Liver		
Grade 4	1	0
Grade 3	0	2
Grade 1–2	4	4
Hollow viscus	3	2
Pancreas	1	0

[a] No significant differences.

Table 4. Comparison of laparotomy findings: KCP vs. cohort.

The calculations for the reductions in hospital costs attributable to diagnostic testing are illustrated in Table 5. Had the KCP group been evaluated using DPL and CT scanning in the same proportions as had occurred in the cohort, an additional 146 CT scans and 64 DPL would have been performed. The total cost would have amounted to: 146 CT scans @ $600/study + 64 DPL @ $350/study = $110,000; i.e., the reductions in costs that occurred by not performing these procedures during the 3-month KCP period were $110,000. Moreover, additional savings accrued from the 38% reduction in hospitalizations greater than 24 hours. We have not yet begun billing for ED ultrasound procedures at our institution. Calculations of the potential revenue generated with ultrasound were based on a hypothetical charge for the procedure of 25% of the charge for an abdominal ultrasound performed by our radiology department ($300). Had we been billing at this rate, the total charges for this group would have been: 516 Traumatic Abdominal Ultrasound studies @ $75/study = $38,700. This should allow for the recovery of the initial investment in a fully capable ultrasound device within 6 months.

Cost Reductions due to Changes in Resource Allocation

Procedure	Cohort	KCP	Δ Procedures
CT scan	56%	26%	+146
DPL	17%	4%	+64
146 CT scans @ $600/study			
64 DPL @ $350/study			
Reduction in charges	$110,000 (over 3 months)		

Potential Revenue from Diagnostic Ultrasound Studies

516 Limited trauma ultrasound studies @ $75/study

Potential revenue $38,700 (over 3 months)

Potential revenue	[illegible]

Table 5. Cost analysis: KCP vs. cohort.

DISCUSSION

The evaluation of patients sustaining blunt trauma to the abdomen has been one of the more controversial aspects of trauma care. Physical examination has been shown to have a sensitivity for the detection of significant intraperitoneal injury of 50 to 60%. [5,6] The sensitivity of physical examination is further hampered by the presence of intoxicants or coexisting head injuries, both of which are common in this patient population. Consequently, the evaluation for intraperitoneal injuries after blunt trauma has been highly dependent upon other diagnostic modalities. Shortly after its introduction by Root et al. in 1965, [7] DPL became the primary means of evaluating the abdomen after blunt trauma. DPL is a very sensitive means of detecting intraperitoneal hemorrhage, but in fact is overly sensitive for the detection of intraperitoneal blood as well as having poor specificity for the severity of organ injury. [8] Furthermore, DPL is an invasive procedure with reported complication rates ranging from 0.5 to 5%. [3-9] More recently computed tomography has been established as a sensitive means of detecting intraperitoneal hemorrhage, as well as demonstrating the magnitude of solid organ injury. [10-12] However, the sensitivity of computed tomography for the detection of hollow viscus injuries ranges from 50 to 88%, [13] and the need for oral radiographic contrast material requires time for its administration and places the patient at risk for aspiration. Moreover, patients must be sufficiently stable to be transported to the radiology department to undergo CT scanning.

Ultrasound is among the newest technologies for the evaluation of abdominal trauma. It may be performed rapidly at the patient's bedside, and is readily repeatable. Prospective trials have shown ultrasound to have a sensitivity for the detection of intraperitoneal fluid of 86 to 98%. [1,2,14-16] The most common sonographic finding is the demonstration of free intraperitoneal fluid, and although ultrasound may demonstrate specific organ injury, its sensitivity for this purpose has ranged from 40 to 87%. [10,12,17]

Each of these technologies has its own advantages and disadvantage for evaluating abdominal trauma. Whereas computed tomography has been shown to have excellent organ specificity as well as superb sensitivity for the detection of intraperitoneal injury, it also requires the most time to perform and is less sensitive for the detection of hollow viscus injuries. DPL is very sensitive for the presence of hemoperitoneum and is moderately effective at diagnosing hollow viscus injury, but lacks organ specificity and is invasive. Ultrasound is sensitive, easily repeatable, and noninvasive, but also does not do well detecting hollow viscus injury and does not demonstrate specific organ injuries well. Thus, an optimal schema for the evaluation of abdominal trauma should capitalize on the relative advantages of each of these diagnostic modalities.

KCPs are structured algorithms designed to improve patient care and decrease resource utilization. They are based on consensus derived assumptions organized into a standardized framework by which patients can be evaluated. Commonly, KCPs are expressed in an annotated algorithm format, that provides literature based reasoning for each of the major decision points. [18] Rather than rigid protocols, these algorithms are recommended guidelines for evaluating specific clinical problems, allowing the clinician to deviate from the suggested work-up if they feel it is clinically warranted. Such KCPs have been applied to a wide variety of clinical scenarios in different medical disciplines, including surgery. [19,20]

There are several compelling reasons to use a KCP for evaluating blunt abdominal trauma. KCPs are believed to be most effective for common clinical scenarios that are expensive to diagnose. This is certainly the case for the evaluation of blunt abdominal trauma at our institution, a regional Level I trauma center with 56,000 ED patients per year (46% of them trauma related). Second, KCPs are useful for structuring the evaluation of complex clinical issues to ensure that appropriate interventions are undertaken in a timely fashion with a minimum of duplicity. This is particularly advantageous for a teaching hospital, in which the KCP provides a succinct overview that ensures appropriate patient evaluation by residents at differing levels of skill and experience.

Our KCP was derived by a consensus panel of surgeons, emergency physicians, and radiologists; the goal was to develop an algorithm that would allow for a rapid, safe, and cost-conscious evaluation of blunt abdominal trauma. The relative strengths of each of the diagnostic modalities is used within the KCP. The initial screening examination is accomplished rapidly with bedside ultrasonography. This screening allows patients with hemodynamic instability with free intraperitoneal fluid to be identified immediately. If the patient has evidence of acute blood loss or has signs of peritoneal irritation with an equivocal ultrasound, the sensitivity of DPL for the detection of hemoperitoneum is exploited. For those patients who are nonoperative candidates, for whom accurate demonstration of the extent of parenchymal injury is of greater importance, CT scanning is used. Finally for those patients who are stable with negative examinations, serial ultrasonography and observation replaces DPL or CT studies.

This ultrasound based KCP has resulted in significant changes in the means by which we evaluate blunt abdominal trauma. There were marked differences in the use of both DPL and CT scanning between the KCP and the cohort. DPL was reduced to only 4% of cases, but these patients had significantly greater ISS than any other subgroup in the study. CT scanning was also used less frequently, and reserved for patients with greater ISS than in the cohort. Most importantly, 65% of patients now have ultrasonography as their only imaging modality. Ultrasound is used to identify those most in need of operative intervention, but also serves to evaluate those with less severe injuries without the invasiveness of DPL or the cost of CT scanning.

Quantifying the value of these changes in resource utilization is difficult. On a qualitative level, there are often times when the availability of CT scanning can become the rate limiting step in the evaluation of trauma patients at a busy center such as our own. The need to evaluate multiple trauma patients can result in unacceptably long delays to obtain abdominal/pelvic CT scans, and can result in the use of otherwise unwarranted DPL to evaluate the abdomen. Reliance on computed tomography to evaluate abdominal trauma also results in reduced availability of CT scan for other purposes without effective alternatives, such as the detection of intracranial hemorrhage or intraperitoneal infection. Expediting the flow of trauma patients through the ED by reducing the number of patients undergoing CT studies and freeing CT resources for other patients is one of the strongest points of the KCP.

On a quantitative level, cost savings cannot be generated unless fixed costs currently dedicated to either DPL or CT scanning can be reduced. Whereas hospital charges are a poor surrogate for actual costs, the reductions in costs for CT scans and reduced charges for 24-hour admissions in even this short 3-month study suggests a potential financial benefit may be derived by changing the diagnostic modalities currently used to evaluate blunt abdominal trauma. Ultrasound represents a less costly technology than CT scanning both in terms of the initial capital outlay and the cost per subsequent study. In addition, whereas the number of CT scans are reduced, the sonographic studies of the traumatic abdomen are obtained and interpreted by personnel (surgeon or emergency physician) outside of the radiology department. This shift could permit a reduction in the number of radiology personnel full time equivalents required for the evaluation of trauma patients.

The potential for ultrasound to rapidly recoup the capital outlay is demonstrated by the data from this KCP. Billing for patients receiving ultrasound studies, we could have recovered our investment in ultrasound equipment within 6 months. This almost certainly overstates the time to recoup costs as it addresses only blunt abdominal trauma, and does not consider the evaluation of pericardial tamponade, vascular injury, cardiac function, hydronephrosis, aortic aneurysm, and intrauterine pregnancy that occurs on a daily basis using the same ultrasound device. These cost considerations are especially poignant in capitated medical systems in which the outlay for more expensive CT scanning would be much less favorable than ultrasound examinations which entail little additional cost per study excepting operator time and equipment depreciation. Additional research is needed to better define the cost reductions and improved efficiency that may be achieved using ultrasound based evaluation of trauma.

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IMAGE GALLERY

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Figure 1

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Cohort	[illegible]	[illegible]	[illegible]	[illegible]

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Table 1

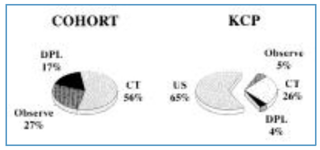

Figure 2

	Cohort	KCP	$p < 0.01$	Cohort ISS	KCP ISS	$p < 0.01$
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US	—	65%	—	—	5.5 ± 6.4	

Table 2

Injury	Cohort*	KCP*
Liver	28	28
Spleen	32	27
Hollow viscus	5	2
Spinal injury	14	19
Head injury	84	60
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Pelvis fracture	15	12
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Musculoskeletal	30	19
Chest	14	10
Multiple injuries[b]	50	43

* No significant differences.
[b] Multiple injuries defined as involvement of three or more of the above injury categories.

Table 3

Injury	Cohort*	KCP*
Spleen		
Grade 4	2	1
Grade 3	6	4
Grade 1–2	8	6
Liver		
Grade 4	1	0
Grade 3	0	2
Grade 1–2	4	4
Hollow viscus	3	2
Pancreas	1	0

* No significant differences.

Table 4

Cost Reductions due to Changes in Resource Allocation

Procedure	Cohort	KCP	Δ Procedures
CT scan	56%	26%	+146
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146 CT scans @ $800/study
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Reduction in charges $110,000 (over 3 months)

Potential Revenue from Diagnostic Ultrasound Studies
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Table 5

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