

Lack of justification for routine abdominal ultrasonography in patients with chronic spinal cord injury

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Abstract—Little evidence-based research is available to indicate which procedures should routinely be performed for screening exams in patients with spinal cord injuries (SCIs). It had been the procedure to routinely perform abdominal ultrasonography on a yearly basis at our medical center. Therefore, we conducted a retrospective study to determine whether the repetition of these procedures resulted in detection of any pathology warranting treatment that otherwise would have gone undetected. The electronic records of 174 individuals were reviewed, along with a total of 359 abdominal ultrasounds and exams. High incidences of abnormal findings were found in the liver, pancreas, spleen, gallbladder, and kidney; however, no specific interventions were noted solely on the basis of the ultrasound findings. Moreover, no added benefits could be documented through the performance of repetitive exams. We recommend that further evidence-based studies be performed to ascertain the benefits of performance of routine procedures in patients with SCIs.

Key words: ultrasound, SCI.

INTRODUCTION

Spinal cord injury (SCI) results in lifelong changes to the nervous system and other organ systems. Depending on their level and degree of injury, persons with SCI suffer from varying degrees of sensory loss that may affect the abdominal area [1]. Depending on their level and

degree of neurologic dysfunction, persons with SCI may also suffer from neurogenic bladder, bowel, and sexual dysfunctions. Well-known abdominal complications of SCI include urinary-tract infections and stones, fecal impaction [2], and peptic ulcers [3]. Other pathologic conditions known to occur more frequently in individuals with SCI include gallstones [4], abdominal aortic aneurysms [5], and bladder carcinoma [6].

In light of the numerous intra-abdominal conditions that can occur in persons with SCI, the Miami Veterans Affairs (VA) SCI unit developed a policy of performing routine abdominal ultrasounds as part of the SCI patient's annual examinations. The goal of our retrospective study

Abbreviations: ASIA = American Spinal Cord Injury Association, CBD = common bile duct, GB = gallbladder, HCC = hepatocellular carcinoma, SCD = spinal cord disorder, SCI = spinal cord injury, VA = Department of Veterans Affairs.

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was to assess whether this clinical practice resulted in the finding of any treatable pathology that otherwise would not have been found. We also sought to determine the usefulness of performing a single baseline abdominal ultrasound in persons with SCI and/or whether longitudinal studies were justified.

SUBJECTS

We reviewed the charts of 174 individuals with SCI or spinal cord disorder (SCD), followed for their routine annual evaluations and who underwent abdominal ultrasound testing between 1997 and 2000. Mean age was 58 years old with a range of 23 to 85 years. Subjects were a mean of 22.49 years post-injury, with a range of 1 to 56 years. Ninety percent of subjects (156) had sustained traumatic injuries, and 10 percent (18) had nontraumatic etiologies for their SCD. Of the subjects, 56.9 percent (99) had complete injuries and 43.1 percent (75) had incomplete injuries. Levels of injury ranged from C2 to L5, with a mean level at T3. Their American Spinal Injury Association (ASIA) injury classifications were 56.32 percent (98) ASIA A, 13.22 percent (23) ASIA B, 10.34 percent (18) ASIA C, 18.97 percent (33) ASIA D, and 1.15 percent (2) ASIA E. All but three subjects were males.

METHODOLOGY

A retrospective review was conducted of the electronic charts of all individuals with SCIs. Results of their abdominal ultrasound studies performed between 1997 and 2000 were recorded. In general, six outcome measurements were collected from the ultrasound exam: liver, kidney, pancreas, spleen, common bile duct (CBD), and gallbladder (GB). Results were then entered into a Version 10 SPSS database. The percentage of abnormal findings in each organ system was noted and described. Since most abnormal categories had low incidences, and as any of these isolated findings would not result in an alteration of care, we also combined abnormal categories for purposes of further chronological analysis. In order to get an overall picture of the percentage of abnormal findings for each organ system, data were organized into three study periods. Study period 1 refers to all abdomi-

nal ultrasounds done in 1997, period 2 refers to those done in 1998, and period 3 to those done in 1999.

STATISTICAL ANALYSES

Statistical analysis was performed using SAS software, Version 8e. To determine whether the proportion of abnormal ultrasound findings increased or decreased as more exams were performed, we conducted a between-subject analysis. For purposes of this analysis, the subjects were divided into three groups: Group 1 ($n = 48$) had one ultrasound exam, Group 2 ($n = 67$) had two exams, and Group 3 ($n = 59$) had three exams.

We used a contingency table with chi-square test to compare data from Group 1's single exam, Group 2's second exam, and Group 3's third exam. We also used multiple logistic regression analysis to adjust for the potentially confounding effects of patient characteristics (i.e., age, ASIA level and classification of injury, and years post-injury).

RESULTS

A surprisingly high incidence of abnormalities was noted throughout the study. **Table 1** shows the percentages of abnormalities per organ system. Abnormal liver findings were in the form of fatty infiltration, parenchymal changes, and enlargement. Kidney abnormalities were in the form of solitary cysts, lithiasis, abnormal size, and a report of a Hampton's hump. No hydronephrosis was reported. Interestingly, no comment was made on the kidney in a large percentage of the abdominal ultrasound reports (30%). We believe that comments pertinent to normal renal systems were often omitted by the ultrasonography reader, as patients were also undergoing a renal imaging as part of the renal ultrasound, also a component of the annual examination. Gallstones were the only reported abnormality for the GB, with only one patient having a CBD abnormality. Chronic pancreatitis and splenomegaly were the reported abnormalities for these organs.

Table 2 presents the incidence of abnormal findings during each of the periods of ultrasound studies. Of note, 66 percent of subjects had abnormal findings on their liver during the first exam, 75 percent of subjects had abnormal findings during the second exam, and 90 percent had abnormal findings during the third study. Four

Table 1.
Abnormalities detected by abdominal ultrasound by organ system.

| Organ System | Percentage with Abnormal Findings |
|---|-----------------------------------|
| Liver | |
| Parenchymal Disease | 45.6 |
| Fatty Infiltration | 19.7 |
| Combined Pathology (Parenchymal Disease + Fatty Infiltration) | 11.5 |
| Spleen | |
| Splénomegaly | 18.1 |
| Pancreas | |
| Pancreatitis | 20.6 |
| Kidney | |
| Cyst | 5.6 |
| Hampton's Hump | 0.3 |
| Abnormal Size | 0.6 |
| Combined Pathology (Cyst + Abnormal Size) | 0.6 |
| Gallbladder | |
| Stones | 16.9 |
| Common Bile Duct | |
| Abnormal Diameter | 0.8 |

Table 2.
Percentage of abnormal findings for each study period.

| Abnormal System | Study Period 1 (n = 174) | Study Period 2 (n = 126) | Study Period 3 (n = 59) |
|------------------|--------------------------|--------------------------|-------------------------|
| Liver | 114 (66%) | 94 (75%) | 53 (90%) |
| Kidney | 7 (4%) | 6 (5%) | 10 (17%) |
| Common Bile Duct | 1 (1%) | 2 (2%) | 0 (0%) |
| Gallbladder | 29 (17%) | 23 (18%) | 9 (15%) |
| Pancreas | 26 (15%) | 24 (19%) | 24 (41%) |
| Spleen | 37 (21%) | 24 (19%) | 3 (5%) |

percent of subjects had evidence of abnormal kidney during the first study, 5 percent during the second study, and 17 percent during the third study. Only 1 percent of subjects had evidence of abnormal CBD on the first study, 2 percent on the second study, and none on the third study. Seventeen percent of subject had gallstones during the first study, eighteen percent during the second study, and fifteen percent on the third study. Fifteen percent of subjects had ultrasound evidence of pancreatitis on the first study, nineteen percent on the second study, and forty-one percent on the third study. Twenty-one percent of subjects had evidence of splénomegaly during the first study, nineteen percent during the second study, and five percent during the third study.

One-way analysis of variance found that the three groups were not significantly different in their years post-injury ($F_{(2,169)} = 1.10, p = 0.3363$) but were different in their age ($F_{(2,170)} = 3.59, p = 0.0298$). The mean ages of the three groups (Group 1 = 59.47 years, Group 2 = 54.25 years, and Group 3 = 60.25 years) were not significantly different from each other in post hoc comparisons (Tukey's HSD [honestly significant difference] = 0.05).

Across the three groups, there was no significant difference in the percentage of subjects with complete injuries ($\chi^2_2 = 0.34, p = 0.8431$), etiology ($\chi^2_2 = 1.56, p = 0.4587$), or level of injury ($\chi^2_{46} = 48.16, p = 0.3855$). However, the number of exams was significantly associated with the subject's ASIA classification ($\chi^2_8 = 18.01$,

$p = 0.0212$). Combining A and B ASIA classifications (where A = complete, no motor or sensory function preserved in sacral segments S4–S5; and B = incomplete sensory but not motor function preserved below neurological level and includes sacral segments S4–S5), Group 3 had a higher rate (A = 55.93%; B = 16.95%) than Group 1 (A = 60.42%; B = 8.33%) or Group 2 (A = 53.73%; B = 13.43%). Thus, subjects who had three studies performed were more likely to be motor-complete subjects than subjects with only one or two studies. However, further analysis using a Mantel-Haenszel trend analysis ($\chi^2_1 = 0.5522$, $p = 0.4574$) did not reveal any significant directional change in terms of subjects' ASIA classifications through Group 1 to Group 3.

Table 3 presents the occurrence of abnormalities in Group 1's first exam, Group 2's second exam, and Group 3's third exam. For each of the six measurements, data points were excluded if there were any missing values (no documentation of organ in ultrasound report). The number of exams bore no relationship with findings for the following five measurements using a row by column contingency test: liver ($\chi^2_2 = 3.38$, $p = 0.1844$), kidney ($\chi^2_2 = 0.95$, $p = 0.6233$), CBD ($\chi^2_2 = 3.62$, $p = 0.1638$), GB ($\chi^2_2 = 0.19$, $p = 0.9073$), and pancreas ($\chi^2_2 = 2.85$, $p = 0.2410$). We also found no significant differences across groups in any of the above five measurements in logistic regression analysis when specific patient characteristics were controlled as in the previous analyses.

There was a significant relationship between the number of exams and classification in spleen measurement using a row by column contingency test ($\chi^2_2 = 11.87$, $p = 0.0026$). However, further trend analysis showed that the incidence of reports of abnormal spleen findings did not change significantly from Group 1 to 3 (Mantel-Haenszel $\chi^2_2 = 1.92$, $p = 0.1660$). Specifically,

the incidence of abnormal spleen findings was 12.5 percent for those who had been examined once ($n = 5$), 27.42 percent for those examined twice ($n = 17$), and 5.08 percent for those examined three times ($n = 3$). After adjustment for patient characteristics using logistic regression analysis, the relationship between the number of exams and spleen findings remained significant ($\chi^2_2 = 11.40$, $p = 0.0033$). An abnormal spleen was reported much more frequently among those who had been examined once than among those who had been examined three times (odds ratio of Group 1 vs. Group 3 = 2.778), whereas the odds of having abnormal spleen was almost seven times as high among those examined twice as among those examined three times (odds ratio of Group 2 vs. Group 3 = 6.926).

A within-subject analysis (McNemar's test) was also performed to compare the first and second exam findings of subjects in Groups 2 and 3. The same analysis was performed to compare the second and third exam findings for subjects in Group 3. This was done to determine if the sequence of the exam affects the distribution of abnormal findings. The results were similar to those obtained using between-subject analysis.

No specific interventions were performed on any of the subjects (i.e., cholecystectomy, lithotripsy, liver biopsy, new medications) following detection of abnormal ultrasound findings.

DISCUSSION

Ultrasound Surveillance for Detection of Clinical Pathology

Our results come from a retrospective study of ultrasound films done in a male veteran population with chronic SCI. Results reveal that patients with complete

Table 3.

Abnormal findings in Group 1's first exam, Group 2's second exam, and Group 3's third exam.

| Abnormal System | Group 1 First Exam | Group 2 Second Exam | Group 3 Third Exam | Significance (<i>p</i>) |
|--------------------------------|-----------------------|------------------------|-----------------------|------------------------------|
| Liver ($n = 167$) | 37 (78.72%) | 53 (85.48%) | 53 (91.38%) | 0.1844 |
| Kidney ($n = 69$) | 3 (18.75%) | 5 (23.81%) | 10 (31.25%) | 0.6233 |
| Common Bile Duct ($n = 156$) | 0 | 2 (3.57%) | 0 | 0.1638 |
| Gallbladder ($n = 133$) | 7 (17.95%) | 11 (21.57%) | 9 (20.93%) | 0.9073 |
| Pancreas ($n = 110$) | 12 (38.71%) | 18 (47.37%) | 24 (58.54%) | 0.2410 |
| Spleen ($n = 161$) | 5 (12.5%) | 17 (27.42%) | 3 (5.08%) | 0.0026 |

Note: Missing values were excluded for each measurement.

injuries underwent more studies. This is expected, as these patients would be more likely to come in for annual follow-up exams and thereby undergo more procedures. In this population we found a very high incidence of abnormal ultrasound findings in multiple organ systems. In the liver, parenchymal disease was present in 48 percent of studies. Chronic pancreatitis was noted at a high frequency of 20 percent, splenomegaly was noted in 10 percent of the cases, and gallstones in 17 percent. However, no aortic aneurysms, hydronephrosis, or renal masses were detected. Surprisingly, renal abnormalities were infrequent, and the most common renal abnormality reported was that of a cyst. There was only one report of an abnormal CBD diameter.

Although we found a high incidence of abnormal findings, there were generally no significant differences in the incidence of abnormal findings noted between the first, second, and third ultrasound examinations. The exception was the spleen, which showed a higher incidence of reported abnormality early on and lower incidence with repeated studies. We hypothesize that this occurred (1) because active infection decreased with time post-injury, (2) for neurogenic reasons, or (3) because the radiologists failed to repeatedly record the findings. We will review the findings pertinent to each separate organ system. In general, however, we believe our database indicates that repeated abdominal ultrasound studies are not useful in detecting disease that warrants clinical intervention.

Ultrasound Surveillance for Liver Disease in SCI

The liver can be in a denervated state for several years, a state that has been noted in transplanted livers [7]. This denervated state does not affect liver function, nor should it affect liver appearance on ultrasound. Review of the SCI literature also does not reveal any other reports of liver abnormalities on ultrasound as a direct consequence of the SCI. Therefore, it is likely that this abnormal finding is due to a high rate of co-morbid conditions, namely, hepatitis and alcohol use, which are well known to exist in the veteran population. Even more germane, the liver abnormalities reported are nonspecific and do not require any intervention in the absence of symptoms. Ultrasound surveillance for the detection of liver abnormalities reported in this study seems unfounded, since a clinical history and laboratory testing can obtain information regarding these co-morbid conditions. In fact, more useful clinical information can be

obtained from a hepatitis profile and liver function enzyme to detect specific disease.

Serial ultrasound measurements of the liver are not even generally recommended for use in persons with established cirrhosis [8]. Abdominal ultrasound surveillance as a screening tool for hepatocellular carcinoma in the setting of chronic hepatitis also presents with problems related to the occurrence of false positive results. In a three-year prospective study of 447 patients with compensated cirrhosis, 59 developed hepatocellular carcinoma (HCC) and 46 developed non-HCC nodules. Therefore, the sensitivity of the ultrasound was 91 percent, its specificity was 95 percent, and its positive predictive value was 54 percent [9]. The low positive predictive value of serial testing in established cirrhosis, therefore, does not support the use of serial abdominal ultrasounds as a screening tool for HCC in the SCI patient with cirrhosis.

Ultrasound Surveillance for Pancreatic Disease in SCI

Evidence of pancreatitis was also noted by ultrasonography in approximately one-fifth of our patients. Chronic pancreatitis is also a condition that is related to alcohol use. Although the pathogenesis is unclear, pancreatitis can also be gallstone-induced. Several theories regarding the pathogenesis exist, but the theory of obstruction of the pancreatic duct has the most support. While pancreatitis is not uncommon during the acute stage as a direct consequence of SCI, this higher incidence of pancreatitis in chronic injury has not been reported. Given the patient population in this study, alcohol use and presence of gallstones are the most likely etiologies for the observed chronic pancreatitis.

Epidemiologic studies conducted in the 1990s have shown an association between chronic pancreatitis and pancreatic cancer. The cumulative risk of pancreatic cancer in patients with chronic pancreatitis for 10 and 20 years was 1.8 and 4.0 percent, respectively. This finding, however, does not mandate the use of serial abdominal ultrasound for cancer surveillance. The pancreas is difficult to evaluate by current imaging modalities and routine ultrasonography of the pancreas for cancer screening is currently not a recommendation. The 2001 consensus conference sponsored by the International Association of Pancreatologists recommended that screening be offered to patients with hereditary pancreatitis 40 years of age and older. Optimally, this should be done at medical

centers expert in the care of hereditary pancreatitis with state-of-the-art imaging technology [10].

Ultrasound Surveillance of the GB in SCI

Our findings are consistent with the previous literature showing that gallstone formation has to be more common after SCI. A prevalence study indicated a 31-percent rate of biliary calculus disease in SCI patients [11]. This is a significantly higher rate compared to noninjured males, as demonstrated in several prevalence studies [12–14]. The pathogenic mechanism underlying this association is unclear, although it may be related to denervation from SCI and resultant biliary stasis. GB emptying, which is mediated by the vagus nerve and the action of cholecystokinin, remains intact after SCI [15]. GB relaxation, however, which is mediated by efferent sympathetic nerve fibers originating at or above the T10 level, is impaired in patients with injuries at the cord levels T10 and higher.

Given this information, the important question that needs to be addressed is whether this increased risk of gallstone formation should dictate a change in medical or surgical management in this population of patients, and whether there is any value in routinely monitoring patients for gallstones. To date, however, justification for this procedure has not surfaced. Moonka and associates, in their study on the prevalence and natural history of gallstones in SCI patients, specifically looked into “prophylactic cholecystectomy” and whether this practice would reduce the morbidity and mortality related to this disease [11]. Their study did not find evidence to support this recommendation.

Ultrasound Surveillance for Abdominal Aneurysms in SCI

No aortic aneurysms were detected in this study, which is also an unexpected finding considering previously cited reports in the literature of the high incidence of this abnormality in SCI. This previous study by Gordon et al. noted that that this increased risk in the SCI group was a direct effect of the injury itself, rather than an association with risk factors that contribute to arteriosclerosis [5]. They theorize that this increased risk is due to autonomic nervous system dysfunction, chronic sepsis, and decreased intraabdominal pressures. However, the study authors recommended no screening guidelines in SCI patients. A similar study using ultrasound as a screening test to detect abdominal aortic aneurysms was done in a high-risk population of patients with hyperten-

sion and coronary artery disease. The screening recommendation based on their results is a one-time screening with abdominal ultrasound in obese older men (>60 yr) at high risk for the disease, regardless of findings on physical examination [16]. Although we did not detect any aneurysms in our patient population, it may be prudent to apply this one-time screening recommendation to SCI patients because of another high-risk factor present in this population: dyslipidemia.

Ultrasound Surveillance of the Kidney in SCI

Ultrasound surveillance of the kidney has been previously recommended to monitor for the development of hydronephrosis and for early detection of renal cell carcinoma. Neither condition was reported in the sonograms reviewed for this study.

In a retrospective review of SCI patients in a VA system, the diagnosis of renal carcinoma was seen as an incidental finding in 81 percent of subjects on surveillance imaging [17]. This is consistent with the 68 to 81 percent of cases of renal cell carcinoma diagnosed by ultrasound in the neurally intact population. It is difficult to make a clinical diagnosis of renal cell carcinoma in this patient group because the diagnostic triad of hematuria, flank pain, and a palpable abdominal mass is difficult to interpret in a person with SCI. Thus, early detection of this disease is critical, since it impacts on the amount of kidney tissue spared post-surgery. This need is amplified in persons with SCI who have a lifelong risk of loss of renal function from infection and/or hydronephrosis. Annual renal sonography for this purpose would impact therapeutic outcomes, morbidity, and mortality.

A directed renal ultrasound remains useful for upper-tract surveillance in SCI. However, the cost-effectiveness of performing annual renal sonography to detect treatable pathology in SCI is another consideration. A prospective study and cost-benefit analysis performed to determine the cost-effectiveness of renal sonography in SCI showed this practice is cost-effective only if used selectively in patients with genito-urinary symptoms [18]. The use of a renal ultrasound as a tool for monitoring renal function has been investigated and Gousse et al. recently advocated the use of renal ultrasound in lieu of renal scans [19].

Ultrasound Surveillance of the Spleen in SCI

Our results show a high incidence of splenomegaly. We believe the most likely explanation represents an increase in the phagocytic function of the spleen as seen

in other conditions characterized by chronic systemic infection. It is well established that persons with SCI have higher rates of urinary tract infection and invariably have asymptomatic bacteruria. Increased splenic size is also seen in circumstances in which the immune function is hyperactive, and in hepatitis A, B, and C, even in the absence of portal hypertension [20]. The decrease in size with time may be due to a decrease in infections with time. Another less possible explanation may be related to changes in neural innervation affecting splenic size and the radiologist failing to comment on it in serial studies.

We were unable to find other reports of an increased incidence of splenomegaly in the SCI patient population. The clinical relevance of this observation is not clear to us at this point and therefore recommendations for surveillance cannot be made. However, this is an area that warrants further research.

Primary and Preventive Care for Persons with SCI

The approach to the care of patients with SCI requires a continuum of services that starts from acute medical and surgical care, acute rehabilitation, and then subsequent reintegration into the community with episodic medical and preventive care. This is the concept underlying the model system of regional SCI centers. Preventive care emphasizes risk modification through lifestyle and behavior changes, prescription of activities that promote wellness, and use of surveillance programs for early detection of malignancies and specific disorders for which people with SCIs are at risk. Information regarding relevant assessments and their recommended frequencies are available as general guidelines for the lifetime care of persons with SCI [21]. The VA has also prepared similar guidelines [22]. However, most of these recommendations are a result of clinical experience and opinions, rather than evidence-based research. Cost-effectiveness analysis of these assessments as screening tools, particularly the abdominal and GB ultrasound, has not been conducted. Our data suggest that the routine performance of these studies may not be warranted.

Limitations of the Study

The retrospective design of this study resulted in a loss of multiple data points. Additionally, it does not allow us to make age-matched comparisons with non-SCI males patients in the VA. The applicability of our conclusions to the general population with SCI is limited by the retrospective design of this study, involving a

highly select group of older males with chronic SCI. This population also has a higher incidence of alcohol and tobacco use and higher exposure to blood-borne pathogens and therefore presents with more co-morbidities to the patients' injuries. However, our finding that the use of routine abdominal ultrasound in this group did not result in detection of treatable pathology speaks of even less clinical utility in a younger, healthier group.

CONCLUSION

Our study does not indicate that serial abdominal ultrasonographic studies increased the detection of treatable pathology. Although many findings were noted, no specific interventions were performed based on abnormal findings in the absence of clinical symptomatology. Its usefulness as a tool for surveillance for hepatic or pancreatic cancer is not supported by large epidemiologic studies in non-SCI patients. All of these indicate a lack of usefulness or justification for repeated abdominal ultrasound studies.

However, our study emphasizes the need for further research, particularly with regard to the high percentage of splenic, pancreatic, and liver abnormalities. We recommend that prospective studies be conducted, comparing VA and non-VA SCI populations to determine the effectiveness of abdominal ultrasonography in the identification of diseases that warrant intervention. Decision matrices and cost-effectiveness analysis should also be applied to these investigations.

Implementing a lifetime care plan for persons with SCI requires development of a system of care that is beneficial to the patient and cost-effective to society. In addition to performing more research into the cost-effectiveness of our assessments and interventions, it is also prudent to be more flexible with our follow-up strategies. Frequencies of follow-up, assessments, and surveillance tests should be driven by evidence. Treatment plans should be modified by factors related to clinical needs—the patient's motivation and ability to self-monitor their general health—and not through routine policy. This strategy will promote increased responsibility and control for both the patient and the clinician.

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