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Performing a Digital Rectal Examination on Trauma Patients Does Not Increase the Likelihood of Detecting a Spinal Cord Injury

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Performing a Digital Rectal Examination on Trauma Patients Does Not Increase the Likelihood of Detecting a Spinal Cord Injury

Abstract

Background: Current Advanced Trauma Life Support (ATLS) guidelines recommend a digital rectal examination (DRE) as part of the initial evaluation of all trauma patients. The finding of decreased or absent anal sphincter tone during the DRE is suggestive of spinal cord injury.

Hypothesis: The primary goal of this paper was to evaluate whether or not performing a digital rectal exam on trauma patients increases the likelihood of detecting a spinal cord injury, in the hopes that, when appropriate, the digital rectal examination may be deferred during the initial trauma evaluation.

Study Design: An exhaustive search of the available medical literature was performed, and relevant articles were analyzed to determine their validity and usefulness in answering the clinical question.

Methods: Ovid MEDLINE, CINAHL (EBSCOhost) and PubMed were searched using the keywords “digital rectal examination AND trauma OR wounds and injuries.” Bibliographic references found in the most relevant articles were also reviewed to identify additional applicable literature.

Results: Five articles were found that met all selection criteria, four of which were retrospective chart reviews, and one of which was a prospective trial.

Conclusion: In trauma patients, digital rectal examination does not increase the likelihood of detecting spinal cord injury. Advanced Trauma Life Support guidelines should be reviewed in consideration of this evidence.

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Performing a Digital Rectal Examination on Trauma Patients Does Not Increase the Likelihood of Detecting a Spinal Cord Injury

Jennifer Byrne



A Clinical Graduate Project Submitted to the Faculty of the

School of Physician Assistant Studies

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Faculty Advisor: Dr. Rob Rosenow

Clinical Graduate Project Coordinators: Rob Rosenow PharmD, OD & Annjanette Sommers MS,
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BIOGRAPHY

Jennifer Byrne is a native of Dublin, Ireland, who immigrated to Toronto, Canada in 1988, before settling with her family in Seattle, Washington in 1993. She received a Bachelor of Science in Exercise Science with a Minor in Biology from Western Washington University in 2006, and worked as a home health aide for persons with AIDS before being accepted into Pacific University of Oregon's physician assistant program in 2007. Jennifer will graduate as a PA in August of 2009, after which she and her fiancé will be moving to Bend, Oregon. Jennifer hopes to work as a primary care physician assistant, and looks forward to learning a variety of outdoor sports while living in Bend.

ABSTRACT

Background: Current Advanced Trauma Life Support (ATLS) guidelines recommend a digital rectal examination (DRE) as part of the initial evaluation of all trauma patients. The finding of decreased or absent anal sphincter tone during the DRE is suggestive of spinal cord injury.

Hypothesis: The primary goal of this paper was to evaluate whether or not performing a digital rectal exam on trauma patients increases the likelihood of detecting a spinal cord injury, in the hopes that, when appropriate, the digital rectal examination may be deferred during the initial trauma evaluation.

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Results: Five articles were found that met all selection criteria, four of which were retrospective chart reviews, and one of which was a prospective trial.

Conclusion: In trauma patients, digital rectal examination does not increase the likelihood of detecting spinal cord injury. Advanced Trauma Life Support guidelines should be reviewed in consideration of this evidence.

Keywords: Digital rectal examination, trauma, spinal cord injury.

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LIST OF ABBREVIATIONS

ATLS.....Advanced Trauma Life Support

DRE.....Digital Rectal Examination

GCS.....Glasgow Coma Scale

SCI.....Spinal Cord Injury

Performing a Digital Rectal Examination on Trauma Patients Does Not Increase the Likelihood of Detecting a Spinal Cord Injury

INTRODUCTION AND BACKGROUND

Approximately 10,000 new spinal cord injuries, resulting in paralysis occur each year, with a societal cost of ten billion dollars.¹ Motor vehicle collisions are responsible for most spinal cord injuries. The next most common cause is sports injuries, followed by violence and falls (Figure 2).^{1,2} In 1978, the American College of Surgeons developed a systematic approach to care for individuals with major, life-threatening injuries, the Advanced Trauma Life Support (ATLS) program. Per current ATLS guidelines, every trauma patient should receive a digital rectal examination as part of the initial physical exam.³ The underlying principle for this test is to discover pertinent positive or negative findings that may confirm or dismiss the possibility of injuries to the spinal cord, urethra, bowel and pelvis (Table 2).⁴ Current logic dictates that the finding of decreased or absent anal sphincter tone in a patient with traumatic injuries may alert the trauma team to the presence of a spinal cord injury before radiographic confirmation can be made.³ While the digital rectal exam is an inexpensive, time-efficient test that conforms to the adage, “a finger or tube in every orifice,” it is generally considered a very uncomfortable exam, both physically and emotionally, for the patient.⁵ Considering that a patient who requires the activation of a trauma team is likely already under duress, the deferral of the digital rectal exam, when appropriate, may lead to greater patient satisfaction without compromising medical care. This systematic review of the literature aims to determine whether performing a digital rectal examination on trauma patients, increases the likelihood of detecting a spinal cord injury.

METHODS

An exhaustive literature search was performed using Ovid MEDLINE (1950 to present), CINAHL (EBSCOhost) and PubMed searches using the keywords, “digital rectal examination AND trauma OR wounds and injuries.” Limiting the results to human studies and English language yielded ten articles. Bibliographic references found in the most relevant articles were also reviewed to identify additional, applicable literature. Articles with a study population of less than 100 persons, as well as those articles where patients had been pharmacologically paralyzed prior to digital rectal examination, were not included. Articles addressing both pediatric and adult trauma patients were included. Those articles specifically related to the use of digital rectal examination in trauma patients, were included in this systematic review.

RESULTS

Five original, published research articles were identified that addressed the use of the digital rectal examination in trauma patients to detect spinal cord injury. Four of the studies were retrospective chart reviews, and one was a prospective study. No randomized controlled trials addressing this topic have been published. Table 1 outlines each study, and the corresponding outcomes.

Guldner and Brzenski

This retrospective, consecutive case series studied patients aged 15 and over with blunt trauma, for a period between January 1st 2000 to December 31st 2001. The results of the digital rectal examination as recorded by the trauma team, were compared with discharge diagnoses on those patients, looking for International Classification of Diseases, Ninth Revision (ICD-9) codes, consistent with spinal cord injuries. Data abstractors were blinded to the study objective and discharge diagnoses of the patients. Patients with penetrating traumas, prior spinal cord injuries, paraplegia, quadriplegia and chemical paralysis prior to the DRE were excluded, as were those patients who refused the DRE, those who expired before the DRE was performed and patients in whom there was no documented digital rectal exam. 1,168 blunt trauma patients were identified, and after all exclusions, a total of 1,032 patients remained who met the study criteria. 933 patients had normal rectal tone on DRE and 99 had decreased tone. Of the patients with normal rectal tone on DRE, 27 (2.89%) had a discharge diagnosis consistent with a spinal cord injury, and the remaining 906 did not. Of the 99 patients with documented decreased rectal tone, 27 (27.27%) had a discharge diagnosis indicative of spinal cord injury, and the remaining 72 patients did not have any such diagnosis. The sensitivity and specificity of rectal tone in the detection of spinal cord injury was 50% and 93% respectively. The positive predictive value was

27%, negative predictive value was 97%, positive likelihood ratio was 6.8 and the negative likelihood ratio was 0.5. The authors concluded that any abnormal tone detected during the digital rectal examination should be interpreted using the pretest likelihood of spinal cord injury. They recommend that the trauma physicians determine whether or not further evaluation is required in a blunt trauma patient with decreased rectal tone, without any additional signs or symptoms of spinal cord injury. The authors did write, however, that in the patients with abnormal rectal tone, “the DRE would likely have meaningfully changed post-test probability in only a small number of patients.”⁶

Guldner et al.

This retrospective, consecutive case series sought to develop a clinical decision rule that would allow for the safe deferral of the digital rectal examination in blunt trauma patients. The evaluation forms of blunt trauma patients, older than 15 years of age, who presented to a level 1 trauma center over a 14-month period, ending in March of 2001, were reviewed by trained data abstractors who were not blinded to the study objectives. Patients with penetrating trauma, direct anal trauma, documented complaint of anal pain, paraplegia, quadriplegia, prior spinal cord injury and chemical paralysis before the DRE was performed were excluded, as well as those patients without a documented DRE, those who refused a DRE and patients who expired prior to the digital rectal exam being performed. Potential predictor variables were defined and included an abnormal neurological examination, abdominal tenderness, pelvic instability, blood at the urethral meatus and a systolic blood pressure less than 90 mm Hg on admission, altered mental status and advanced age (greater than 65). The outcome measure was the presence or absence of a true-positive abnormal DRE, which was defined as decreased or absent rectal tone, a high riding prostate, gross rectal blood, a palpable rectal mucosal defect or a palpable pelvic fracture,

in addition to the presence of at least one of the following diagnoses: vertebral fracture, spinal cord injury without fracture, Glasgow Coma Scale score (GCS) less than 8 (Table 3), urethral injury, bowel injury requiring operative repair or pelvic fracture on radiography. There were a total of 862 adult trauma activations, and after exclusion criteria were applied, 579 patients met the study criteria. 526 patients had a normal digital rectal exam, and 53 had an abnormal DRE, with 51 of those indicating decreased rectal tone, one showing gross blood and one abnormal prostate exam. 19 of these abnormal digital rectal exams were shown to be false positives, leaving 34 true positive abnormal DREs. The diagnostic results associated with false digital rectal exams were not provided, so likelihood ratios are not calculable. When looking specifically at neurological injuries, 91% of patients with a true positive digital rectal examination also had an abnormal neurological examination. The authors state that, “the likelihood of detecting significant spinal injury by DRE alone, in the absence of any other neurological deficit, seems remote.”⁷ The authors suggest that in a patient with a normal neurological examination, no blood at the urethral meatus and who is under 65 years of age, the digital rectal examination can be safely deferred, as the probability of a true-positive abnormal DRE in these patients during this study was below 0.8%.⁷

Shlamovitz et al. (July 2007)

This study is a retrospective, consecutive case series review that sought to estimate the test characteristics of the digital rectal exam in trauma patients for the detection of spinal cord injury, bowel injury, pelvic fracture and urethral disruption. All trauma patients who presented to the emergency department of an academic, university-based Level 1 (adult and pediatric) medical center over a 14-month period were reviewed. Patients who were transferred to the medical center for “higher level of care” from other hospitals were excluded, as were patients

who did not meet trauma team activation criteria, but were examined by the trauma team after initial evaluation. Additionally, patients who refused the DRE, had no documented DRE or in whom the digital rectal exam was deferred were also excluded. Finally, patients who had direct anal trauma, were pharmacologically paralyzed prior to DRE, had previous spinal cord injury or who expired in the emergency department before undergoing confirmatory studies were excluded. Trained data abstractors reviewed the medical records of these patients to correlate the DRE findings with the documented disease processes diagnosed. Spinal cord injury was defined as documentation of spinal canal disruption in spinal imaging reports, documentation of spinal cord injury in operation reports, or a discharge diagnosis of spinal cord injury, paraplegia or quadriplegia in the absence of prior spinal cord injury. 1,401 patients met the selection criteria and were included in the analysis. 47 of these patients (3%), had documented spinal cord injuries and the digital rectal examination failed to identify (false-negative), 63% of these spinal cord injuries. Additionally, 77% of those patients with decreased anal sphincter tone did not have a documented spinal cord injury. The finding of decreased anal sphincter tone as a predictor of spinal cord injury was found to have a sensitivity of 37%, a specificity of 95.7%, a positive likelihood ratio of 8.5 and a negative likelihood ratio of 0.6. The authors concluded that, “such poor sensitivity precludes the use of the digital rectal examination to rule out spinal cord injuries, because approximately two-thirds of those injuries are missed.”⁸

Shlamovitz et al. (August 2007)

This noncurrent, retrospective, chart review study focused on estimating the test characteristics of the digital rectal exam in pediatric patients for spinal cord injuries, bowel injuries, rectal injuries, pelvic fractures and urethral disruptions. The study appears to run concurrently with the aforementioned Shlamovitz et al. study, except this particular article

includes only those patients under age 18. The authors excluded patients without a documented digital rectal exam, patients who were transferred to the studying medical center for a “higher level of care” from other hospitals, patients seen as consultations by the trauma team, those who refused a digital rectal exam or in whom the exam was deferred, patients with direct anal trauma or who expired before undergoing any further confirmatory studies. Patients who were pharmacologically paralyzed prior to having a digital rectal exam, or who had prior spinal cord injury, were excluded from the test characteristics calculation for DRE in spinal cord injuries. Decreased anal sphincter tone was defined as documentation of decreased or absent anal sphincter tone in any of the clinical documents, and spinal cord injury was defined as documentation of spinal canal disruption in spinal imaging reports, documentation of spinal cord injury in operation reports, or a discharge diagnosis of spinal cord injury, paraplegia or quadriplegia in the absence of prior spinal cord injury. A total of 213 patients met the study criteria, three of whom received a diagnosis of spinal cord injury. The digital rectal exam missed (false-negative) 66% of these spinal cord injuries. Two patients with a documented positive DRE did not have any spinal cord injury (false-positive). The finding of decreased anal sphincter tone on digital rectal exam used for the detection of spinal cord injury had a sensitivity of 33%, a specificity of 99%, a positive likelihood ratio of 34 and a negative likelihood ratio of 0.67. Based on these findings, a low pretest probability of 1% (as determined by the treating physician) would increase only to 25% in the presence of decreased anal sphincter tone, whereas a high pretest probability of 99% would drop a half of a percentage point to 98.5% in the presence of normal anal sphincter tone. Furthermore, the authors concluded that the poor sensitivity of the digital rectal examination precluded its use to rule out spinal cord injuries in pediatric trauma patients.³

Esposito et al.

This was a prospective study of patients treated at a level one trauma center that aimed to determine the value of mandating a digital rectal exam for all trauma patients, and to discern whether it can be routinely omitted. The study compared DRE findings with, “other clinical indicators” denoting gastrointestinal bleeding, urethral disruption or spinal cord injury. The authors hypothesized that “other clinical indicators” would be equivalent to the digital rectal exam for confirming or excluding the presence of injuries.⁴ The study excluded patients with a Glasgow Coma Scale score of 3, as well as those who had been pharmacologically paralyzed, from the spinal cord injury analysis. Over a one year period, 512 patients, ages ranging from two months to 102 years, met the study criteria and were included in the analysis. Digital rectal exam findings were compared with the definitive diagnosis of injuries found on radiographic studies. “A diagnosis of spinal cord injury was only assigned if cord injury was documented by a definitive test. Vertebral bony injury, without associated cord injury, was not categorized as a spinal cord injury.”⁴ The study found that, for spinal cord injuries, the digital rectal exam had a negative predictive value of 98% and a positive predictive value of 47%. Other clinical indicators had a negative predictive value of 99% and a positive predictive value of 44%. Digital rectal exam findings agreed with one or more other clinical indicators in 92% of cases evaluated for spinal cord injury. For confirmed spinal cord injuries, digital rectal exam findings were positive 36% of the time, whereas other clinical indicators were positive in 79% of cases. Clinical findings missed three spinal cord injuries, while the digital rectal exam missed nine such injuries. Due to the fact that the authors did not specifically disclose the results of the DREs that did not agree with the final diagnoses, it is impossible to calculate likelihood ratios for this study. Worth noting is that this study includes patients with relatively minor spinal cord injuries, which

would not be disruptive enough to cause significant neurological signs and symptoms, such as a loss of rectal tone.⁴ In these cases, a negative DRE would not correlate with SCI findings, but not because of a lack of effectiveness of the test. The study authors concluded that the digital rectal exam rarely provided additional, accurate information that affected patient management, and that other clinical indicators were just as useful as the DRE for confirming or excluding the presence of the studied injuries in a trauma patient. “Clinical acumen...short of DRE results, appears to be a safe and accurate method of ruling in, or ruling out any index injury...”⁴

Discussion and Recommendations

In this review of the literature, five studies were found to help answer the question, does performing a digital rectal exam in trauma patients increase the likelihood of detecting spinal cord injuries? Of these, four were retrospective case studies, and one was prospective, using data collected by members of the trauma team. Limitations present in all studies are the lack of randomization, double-blinding and placebo-control. Retrospective studies are susceptible to missing data, poor interrater reliability of data abstractors and subjectivity in coding.⁶ There is also a potential for lack of interrater reliability when determining normal and abnormal rectal examinations, which has been demonstrated in at least one study where digital rectal examination correlated poorly with manometric sphincter tone investigations, even when performed by experienced proctologists.⁹ Moreover, on most trauma teams, the digital rectal exam is performed by a resident physician or medical student, who has no specialized training in performing the exam, other than the basic training provided in medical school.⁴ In none of the studies did a second physician verify the results of the DRE, which would have given more validity to the sphincter tone findings. Finally, because the digital rectal exam was performed by a physician on the trauma team who was aware of the patient's other clinical signs and symptoms, the provider's interpretation of the sphincter tone may have been biased by their understanding of the patient's mechanism of injury, or by other neurological findings on initial exam.

Each study included in this systematic analysis also had specific limitations. Guldner and Brzenski was the only article in which the data abstractors were blinded to the study objectives. A second data abstractor was used to randomly review a sample of the study records to assess interrater reliability for coding of the DRE result, which was found to have a κ value of 0.88,

“suggesting substantial abstractor agreement.”⁶ In this study, the authors admitted that some patients may have had some radiographic testing prior to the DRE, which could have biased the provider performing the test. Additionally, their use of discharge diagnoses in charts as a method of identifying spinal cord injuries leaves open the possibility that the patient had a SCI that was not identified prior to discharge.⁶ It is also worth mentioning that due to timing and population similarities, it is likely that the Guldner and Brzenksi study was performed concurrently with the Guldner et al. study, in which data abstractors were not blinded. Were the same data abstractors used to perform chart reviews in both studies, blinding in the Guldner and Brzenksi article would have less validity because the two study’s objectives were so similar.

In Guldner et al, data abstractors performing the chart reviews were not blinded to the study objective of creating a decision rule to allow for the safe deferral of digital rectal examinations in trauma patients. An independent data abstractor was used to estimate measure of interrater reliability, with a resulting κ of 0.88. The authors of this study did not review the charts of patients with normal digital rectal examinations to look for the presence of spinal cord injury, which could have provided extra information about the DRE’s sensitivity and specificity for SCI.⁷

Shlamovitz et al. (July 2007) also did not blind their data abstractors to the study’s goal, but did provide another abstractor to review a random sample to assess interrater reliability, which was calculated as a κ of 0.8, “suggesting excellent abstractor agreement.”⁸ In this study, the DRE was deferred or not recorded in 371 patients, six of whom were later diagnosed with spinal cord injury, however the authors believed that, given the total population sample size, this missing data would not have affected the test characteristics calculated.⁸

Finally, in Shlamovitz et al. (August 2007), a study looking just at pediatric trauma patients, data abstractors were not blinded to the study's objectives, though again, interrater reliability was given a κ value of 0.8. The author did admit that the high specificity of the DRE calculated in the study was likely an overestimate of the true value as a result of the study's design. "The high specificity should be balanced against the very high false-negative rates that were calculated," including the 66% false-negative rate for the finding of decreased anal sphincter tone.³

Esposito et al. is a prospective study with a relatively large population size of 512. The first serious flaw with this article is the lack of definition of "other clinical indicators," (OCI) which is a term used repeatedly throughout the study. In the discussion, the authors state, "the OCI used in this study may be considered as somewhat broad and nonspecific,"⁴ which may have had some influence on the positive predictive value. Secondly, in order to obtain data regarding the digital rectal examination results in trauma patients, "a resident or attending staff was responsible for completing a study data collection sheet."⁴ The article itself notes that the actual DRE may or may not have been performed by the provider completing the form, which creates room for transcriber error. Furthermore, the data collection sheet prompts the provider to search for related clinical findings, including "neurologic deficit above waist,"⁴ which could lead to bias in that provider's interpretation of the patient's rectal tone. Finally, the data collection sheet asks for a "final diagnosis,"⁴ which, if filled in prior to the recording of the DRE findings, could again bias the provider's findings on the DRE.

CONCLUSIONS AND RECOMMENDATIONS

The five studies appearing in this systematic review are all peer-reviewed, published articles, each with its own strengths and weaknesses. Guldner and Brzenski is a large (N=1,032) study with blinded data abstractors, however, the question of whether or not the same data abstractors were used to concurrently conduct the Guldner et al. study makes it difficult to evaluate any bias that might have been introduced. This article's objective was the most applicable to this systematic review, and it was the most competent of the five studies appraised.

With so few published studies on this topic, and no randomized-controlled trials, it is hard to make a strong case against the use of digital rectal examinations in trauma patients as a method of detecting spinal cord injuries. With the current Advanced Trauma Life Support guidelines recommending a DRE for every trauma patient, it would be difficult to perform a randomized controlled trial where some trauma patients did not receive a digital rectal exam. Were a spinal cord injury to be detected at a later juncture in a trauma patient who had not been given a DRE, the legal ramifications could be significant. Perhaps the best way to go about this type of study would be for the ATLS itself to either perform or endorse the trial, citing current mounting evidence that the DRE does not provide useful information in the detection of spinal cord injuries in trauma patients. In such a trial, it would be ideal for a trained physician who is not part of the trauma team, and blinded to the mechanism of injury or neurologic findings on initial exam, to be called in for the sole purpose of performing the digital rectal exam. A second physician to confirm sphincter tone findings for the duration of the study would be optimum, but unlikely to be feasible, unless significant funding was available. An additional method of preventing errors in a future trial would be to mandate that all patients, regardless of digital rectal

examination findings, undergo definitive testing for the diagnosis of spinal cord injury with an MRI of the cervical, thoracic and lumbar spines.³

TABLES

Table 1: Summary Matrix of Articles Appraised

Author/ Title	Yr. published	Patients/ Population	Intervention	Comparison	Outcome(s)	Study type
Guldner & Brzenski/ “The sensitivity and specificity of the digital rectal examination for detecting spinal cord injury in adult populations with blunt trauma.”	2006	Adult patients with blunt trauma over a 2-year period (N=1032)	Digital rectal exam	None	Detection of spinal cord injury	Retrospective chart review (case series)
Guldner et al. “Deferral of the rectal examination in blunt trauma patients: A clinical decision rule.”	2004	Adult blunt trauma patients meeting trauma team activation criteria over a 14-month period (N=579)	Digital rectal exam	Deferral of digital rectal exam	Presence or absence of a true-positive abnormal digital rectal exam	Retrospective case series

Shlamovitz et al. “Lack of evidence to support routine digital rectal examination in pediatric trauma patients.”	2007	All patients younger than 18 years seen in UCLA’s ED from Jan 2003 to Feb 2005 (N=213)	Digital rectal exam	None	Identification of specific injuries and the associated DRE findings	Noncurrent observational chart review study (case series)
Shlamovitz et al. “Poor test characteristics for the digital rectal examination in trauma patients.”	2007	Consecutive trauma patients treated in the UCLA ED from Jan 2003 to Feb 2005 for whom the trauma team was activated (N=1401)	Digital rectal exam	None	Identification of specific injuries and the associated DRE findings	Retrospective medical record review study (case series)

Esposito et al. “Reasons to omit digital rectal exam in trauma patients: No fingers, no rectum, no useful additional information.”	2005	Patients treated at a level I trauma center over a 1 year period beginning May 2003 (N=512)	Digital rectal exam	“Other clinical indicators”	Confirming or excluding the presence of index injuries	Prospective study
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Table 2: Potential Findings on Digital Rectal Examinations in Trauma Patients⁸

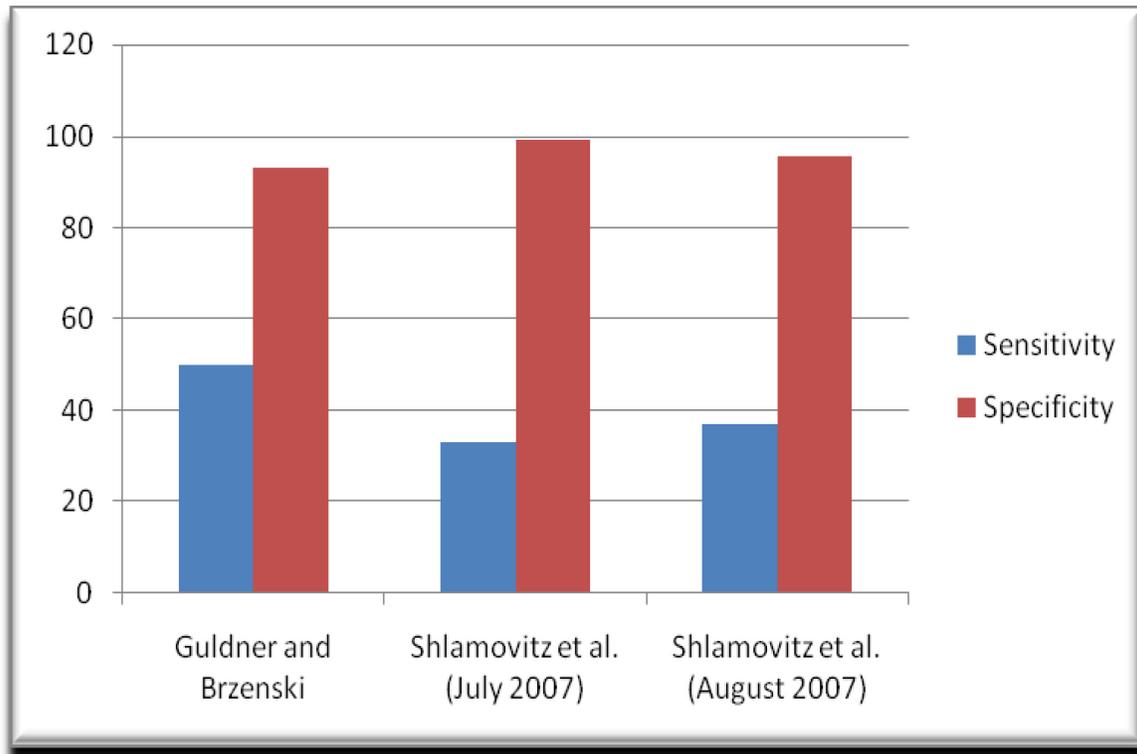
<i>Finding on DRE</i>	<i>Suggested Diagnosis</i>	<i>Recommended Testing to Confirm Diagnosis</i>
Decreased anal sphincter tone	Spinal cord injury	CT/MRI of spine
High riding prostate	Urethral injury	Urethrogram
Disruption of Rectal Wall Integrity	Rectal injury	Proctoscopy or CT of pelvis
Gross blood	Bowel injury	Abdominal CT
Bony fragments and/or extreme pain	Pelvic fracture	Plain film or CT of pelvis

Table 3: Glasgow Coma Scale Scoring¹

EYE OPENING	4 = Spontaneous 3 = To voice 2 = To pain 1 = None
VERBAL RESPONSE	5 = Oriented 4 = Confused 3 = Inappropriate 2 = Incomprehensible 1 = None
MOTOR RESPONSE	6 = Obeys command 5 = Localizes to pain 4 = Withdraws to pain 3 = Flexion 2 = Extension 1 = None
TOTAL SCORE	3 – 15 - A GCS < 8 is generally defines a coma.

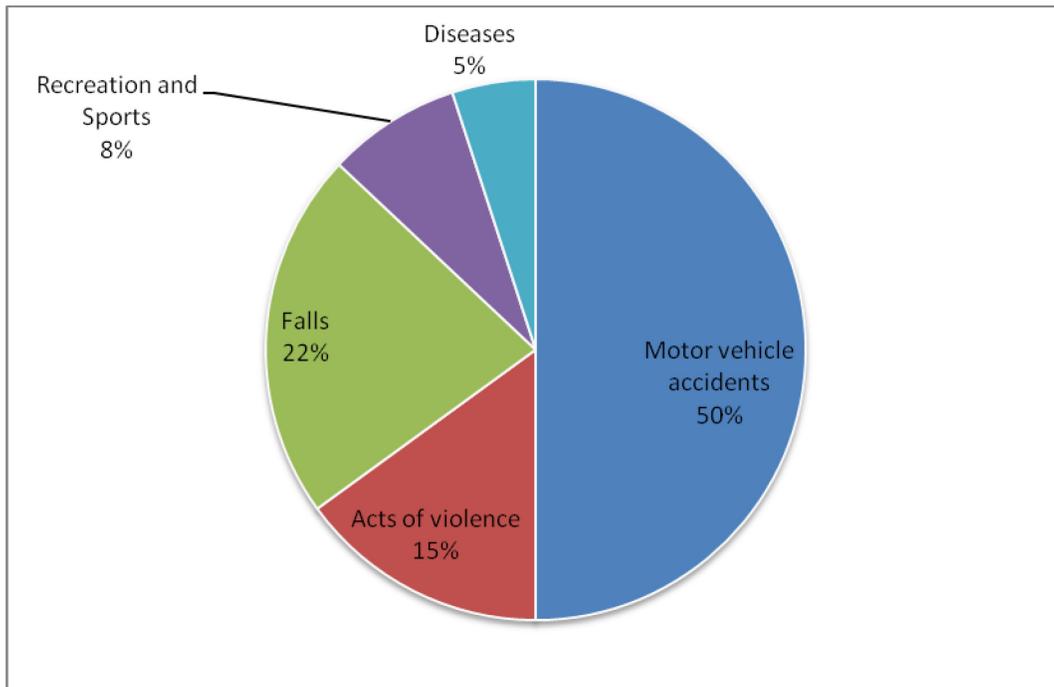
FIGURES

Figure 1:



Sensitivity and Specificity of DRE in detecting SCI in Trauma Patients^{3,6,8}

Figure 2:



Common Causes of Spinal Cord Injury in the United States¹⁰

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