Genitourinary Trauma at a Combat Support Hospital During Operation Iraqi Freedom: The Impact of Body Armor

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Purpose: This report details the occurrences of genitourinary trauma experienced during Operation Iraqi Freedom at a United States Army Combat Support Hospital, and determines if wearing body armor decreases the frequency of genitourinary and specifically kidney trauma.

Materials and Methods: The Joint Theater Trauma Registry was used to conduct a retrospective study of 2,712 trauma admissions to a United States Army Combat Support Hospital in Baghdad, Iraq from April 1, 2005 to February 28, 2006. There were 1,216 casualties who were wearing body armor and 1,496 casualties not wearing body armor.

Results: Of the 2,712 trauma admissions 76 (2.8%) had 1 or more genitourinary injuries for a total of 98 genitourinary injuries. Of the 29 kidney injuries 2 (6.9%) were explored without any treatment, 7 (24.1%) were observed, 1 (3.4%) was repaired and 19 (65.5%) casualties required nephrectomy. Casualties wearing body armor had a 2.1% rate of genitourinary injury versus 3.4% not wearing body armor ($p = 0.037$). Casualties wearing body armor had a 0.5% rate of kidney injury compared to 1.4% not wearing body armor ($p = 0.017$).

Conclusions: The percentage of casualties with genitourinary injuries and the distribution of these injuries appear similar to previous conflicts. The percentage of casualties undergoing nephrectomy appears to be greater than that observed in other recent conflicts. There was a significant reduction in overall genitourinary injuries and specifically kidney injuries in those casualties wearing body armor.

Key Words: wounds and injuries, urogenital system, protective devices, war, nephrectomy

Injury to GU organs occurs in 0.5% to 4.2% of all war injuries.[1–7] The pattern of GU injury in OIF, the most recent conflict the United States Military has been engaged in, is described. The standard in civilian renal trauma series is for nonoperative management for most nonpenetrating trauma. If a surgery is performed (more likely for penetrating injury) débridement and repair are the norm.[8,9] Unique characteristics of this conflict and our evacuation procedures resulted in a lower rate of renal salvage than expected and this topic is discussed in detail.

Of particular interest is the role of modern body armor in reducing GU injuries. A recent article has shown a decreased rate of intra-abdominal and thoracic injuries in Israeli soldiers wearing body armor.[10] To my knowledge this current series is the first to demonstrate a statistically significant reduction in overall GU and specifically renal injury in casualties wearing body armor.

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MATERIALS AND METHODS

Study Subjects

The Joint Theater Trauma Registry is a United States Military trauma registry that follows the American College of Surgeons Committee on Trauma inclusion and exclusion criteria. The registry prospectively collects data on trauma patients in Operation Iraqi Freedom and Operation Enduring Freedom (Afghanistan). Data in the JTTR are obtained from a systematic review of available inpatient medical records from levels III through IV (a CSH is a level III facility) of the United States Army Health Services Support System. Casualty medical records are reviewed by JTTR nursing personnel and information is abstracted to a standardized data collection form. There are 48 data elements that are extracted from each medical record ranging from type of injury to time of tourniquet to method of evacuation. The complete JTTR is located at Fort Sam Houston, Texas. The raw data elements from the CSH were searched for groin or abdominal injuries (the JTTR does not specifically record data on each GU organ). The medical records were then reviewed by the author to determine if the abdominal wounds included any upper tract GU injury and if the groin wounds included any lower tract GU injuries.

The population observed is casualties admitted to the 10th and 86th CSH in Baghdad, Iraq from April 1, 2005 to February 28, 2006, excluding detainees or prisoners of war. There were 2,794 trauma admissions during this 11-month period. Of these admissions 82 charts were unavailable or incomplete resulting in a total of 2,712 charts that were

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available for review. From this population 76 patients were identified as having a GU injury.

Of particular interest is the use of body armor in this population. Modern body armor is a KEVLAR® vest with anterior and posterior ceramic plates that primarily cover the thorax and upper abdomen. A KEVLAR helmet is also part of the personal protective equipment of a coalition soldier. A detachable, lightweight groin protector made of KEVLAR hangs down from the anterior vest and gives some protection to the penis and scrotum, but would be of no benefit for high velocity missiles. It was not documented in our database if this groin protector piece was worn at the time of injury. Of the 76 patients treated for a GU injury 26 were coalition forces, and 50 were Foreign National civilians, police or military. All but 1 of the coalition forces was wearing protective body armor at the time of injury. None of the civilians were wearing body armor and our experience demonstrated that body armor was rarely worn by Foreign National police or military admissions to the CSH. A total of 1,216 casualties were wearing body armor and 1,496 were not wearing body armor at the time of their injury. In terms of statistical analysis Fisher's exact test (1 tail) was used to determine the significance of GU and kidney injuries between casualties wearing and not wearing body armor.

Facility

The CHS was located in a former Iraqi hospital which is similar in capabilities to an American community hospital. Electricity and running water were available. Computerized tomography, plain films and basic laboratory studies were available. Blood bank activity was reflective of the high volume and severity of injury of our casualties, transfusing more than 50 units of packed red blood cells per day. Interventional radiology was not available. Four operating rooms could be used. United States casualties were evacuated out of theater as soon as they were clinically stable. Nearly all casualties were flown to Germany, which is a more than 8-hour flight from Baghdad. On this flight there was critical care nursing but no operative treatment available. Foreign National casualties were transferred to Iraqi medical facilities after they were treated and stabilized. These Iraqi facilities had limited resources. These evacuation and transfer policies coupled with limited followup for casualties precluded any analysis of mortality, and contributed to the decision to perform nephrectomy vs a renal sparing procedure on some casualties.

Computerized tomography or on table excretory urography was usually done before nephrectomy. If no radiological imaging was done the contralateral kidney was palpated before nephrectomy. Limited retrospective access to radiographs and complete operation reports made accurate staging of renal injuries difficult. The majority of the GU injuries were treated by 1 of the 3 urologists who were sequentially stationed at the CSH. However, there were several GU injuries treated by general surgeons because a urologist was not available.

RESULTS

There were 76 (2.8%) patients from the population of 2,712 trauma admissions that were treated for 1 or more GU injuries in OIF. The mechanism of these GU injuries can be accounted for as 10 (13.2%) blunt trauma, 28 (36.8%) bullet and 38 (50%) explosive ordinance. A total of 98 GU injuries were recorded. The breakdown of the injuries incurred in OIF is summarized in the table, which also includes the rates of GU injuries in prior conflicts.

Of the 29 kidney injuries in this study shown in the table, 2 were explored without any treatment (6.9%), 7 (24.1%) were observed, 1 (3.4%) was repaired and 19 (65.5%) were removed. Of the 29 kidney injuries 7 occurred in patients wearing modern body armor. Of these 7 patients 5 had nephrectomy, 1 was repaired and 1 was explored without treatment. The mechanism of injury of these 7 casualties was 1 blunt motor vehicle accident (nephrectomy was done), 4 by IEDs and 2 by bullets. Of these 7 patients wearing modern body armor with renal trauma all had significant associated injuries, including 1 with a diaphragm injury and the other with a chest injury.

There were 1,216 casualties wearing body armor and 1,496 casualties not wearing body armor at the time of injury. Casualties wearing body armor had a 2.1% (25 of 1,216) rate of GU injury versus 3.4% (51 of 1,496) for those not wearing body armor ($p = 0.037$). Casualties wearing body armor had a 0.5% (7 of 1,216) rate of kidney injury compared to 1.4% (22 of 1,496) not wearing body armor ($p = 0.017$).

DISCUSSION

This study demonstrates that 2.8% of all trauma admissions sustained a GU injury. The number of casualties having GU trauma during war has varied during the last 70 years. During the Iran-Iraq conflict it was the lowest at 0.51%.[1] In the wars of Bosnia and Croatia it varied from 2.4% to 3.6%.[5,7] During Vietnam is was 3% to 4.2%[3,4] and studies from World War II demonstrated a rate ranging from 0.7% to 2.6%.[6,11]

OIF is a conflict involving high velocity weapons, primarily M16 and AK-47 automatic rifles and IEDs. IEDs cause injury from a combination of the blast effect of the explosion as well as airborne debris that can cause penetrating as well as blunt trauma.[12] In this study explosive devices (mostly IEDs) were responsible for 50% of the injuries, individual firearms caused 37%, and the remaining 13% was due to blunt injury, primarily motor vehicle accidents. Wettlaufer and Weigel's extensive experience during Vietnam revealed that 80% of GU injuries were due to penetrating missiles (combined explosive ordinances and bullets) and 20% were due to blunt trauma.[2] Hudolin and Hudolin from Bosnia-Herzegovina described 53% of casualties being injured by explosive ordinances and 47% had bullet wounds (no GU injuries were due to blunt trauma).[7] Vuckovic et al from

GU injuries in OIF and comparison to previous conflicts

	No. OIF-Current Study (%)	% Bosnia-Croatia[5]	% Vietnam[2]	% WWII[6]
Kidney	29 (29.6)	39.6	19.1	40
Ureter	2 (2.0)	7.8	5.2	3.3
Bladder	13 (13.3)	17.2	10.4	11.6
Urethra	17 (17.3)	4.6	12.0	15
Scrotum	19 (19.4)	22.7	32.8	30
Testicle	12 (12.2)	*	*	†
Penis	6 (6.1)	8.1	18.5	†
Total	98			

* Testicular trauma categorized as scrotal trauma in these studies.
† Testicular and penis trauma categorized as scrotal trauma in this study.

Croatia demonstrated that 66% of the injuries were from explosive ordinances, 26% from bullets and 8% were blunt.[5]

The distribution of GU injuries is also similar over several conflicts as shown in the table. This is striking considering the evolution of weaponry and the different types of warfare; from the battlefields of World War II to the jungles of Vietnam, to the urban-type warfare of OIF. During the first Gulf War the most comprehensive review of GU injuries was from Thompson et al.[13] They described 30 GU injuries with a distribution of 17% (5) involving the kidney, none involving the ureter, 17% (5) bladder, 30% (9) penis/urethra, 10% (3) testis and 17% (8) involving the scrotum. Their data were obtained via surveys of urologists who were deployed rather than queries of a database as in the current study and are, therefore, severely limited.

The effect of modern body armor on renal trauma was also examined. The data demonstrated a statistically significant reduction in overall GU trauma and specifically renal trauma in those patients wearing body armor compared with those casualties not wearing body armor. Three recent wartime trauma experiences suggest that modern body armor may be protective of GU or abdominal trauma but limited data precluded them from making any conclusions.[13–15] A recent review from the Israeli military demonstrated that soldiers wearing body armor had a significantly lower rate of chest and abdominal injuries than civilians, however they did not specifically examine any GU injuries.[10] This current study demonstrates that significant renal trauma necessitating nephrectomy can still occur even if protective body armor is worn. There was no mention if the body armor was penetrated in the JTTR database for these 7 patients. I suspect the trajectory of the missiles were under the protective plates. All 7 of these casualties had extensive nonGU injuries including 2 casualties with significant associated thoracic injuries. In summary, those patients who were wearing body armor did have a lower rate of overall GU trauma (2.1% vs 3.4%, $p = 0.037$) and specifically renal trauma (0.5% vs 1.4%, $p = 0.017$) compared with those casualties that were not wearing body armor.

The data concerning renal trauma and its treatment in this deployed environment deserve some explanation. Of the casualties with renal trauma 65.5% underwent nephrectomy in this study, more than in the conflicts in the former Yugoslavia. Vuckovic et al had a nephrectomy rate of 42.5% and Tucak et al 25%.[5,16] However, it is similar to the data from Vietnam. In 3 of the largest series of GU trauma from Vietnam, nephrectomy rates were 42%, 51% and 84%.[2–4] Interestingly the group with the lowest nephrectomy rate also had the highest rate of postoperative major complications from renal salvage procedures at 29.4%. This figure included 10 of 106 patients undergoing delayed nephrectomy, 5 for bleeding and 5 for sepsis.[2]

The relatively high rate of nephrectomy in this study is multifactorial. The patients treated were most often coagulopathic, cold and with extensive other nonGU injuries, and 100% had at least 1 other organ system significantly injured. The blast effect of the explosive weaponry also cannot be underestimated. Upon exploration many kidneys were found to be completely destroyed. Many of these patients who sustained significant renal trauma as well as other nonGU injuries would have died during the evacuation route or on the battlefield in previous conflicts and would not have reached a medical facility to even attempt to have their kidney salvaged. Of the 29 patients who underwent nephrectomy 26 had penetrating trauma, many with high velocity missiles. Patients with penetrating trauma have much higher rates of nephrectomy in civilian trauma series.[8,9] Of the 3 patients with blunt renal trauma 2 were treated with close observation. The lack of full facilities and the long evacuation route also contributed to our high nephrectomy rate. The rate of rebleeding is upwards of 23.5% as demonstrated in a civilian series of patients with penetrating renal trauma treated nonoperatively, most of whom were able to be treated angiographically.[17] However, this option was not available in United States military hospitals in Iraq or in civilian facilities. Rebleeding for a United States casualty on a medical evacuation flight to Germany could be a fatal event. Similarly, rebleeding for a Foreign National as well as the risk of urinoma, fistula formation, sepsis or other complications from a renal salvage procedure in a limited health care system could be fatal.

Again, in this series, renal salvage was performed whenever possible and safe. However, conditions encountered in an underdeveloped country at war often relegated the operative team to performing the quickest immediately lifesaving procedure. Narkun-Burgess et al retrospectively studied 62 servicemen who lost a kidney in a combat situation with followup to 45 years. No patient had any mortality or adverse consequences due to the nephrectomy.[18] Renal preservation is always ideal but battlefield conditions and hemodynamic status must always dictate care.

CONCLUSIONS

This study used a trauma registry to document the occurrence of genitourinary trauma during OIF. The percentage of casualties with a GU injury in this conflict was similar to that of previous conflicts. The renal salvage rate was lower than in previous conflicts due to multiple factors unique to OIF. A significantly lower rate of overall GU injury and specifically kidney injury was demonstrated in those casualties who were wearing body armor. To our knowledge this is the first study in the literature to demonstrate the effectiveness of body armor in protecting against GU injury. A larger theater-wide study of GU trauma in OIF using the JTTR database is warranted.

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Abbreviations and Acronyms

CSH	=	Combat Support Hospital
GU	=	genitourinary
IED	=	improvised explosive devices
JTTR	=	Joint Theater Trauma Registry
OIF	=	Operation Iraqi Freedom

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EDITORIAL COMMENT

This study of GU injuries and prevention in wartime is a significant contribution to the trauma literature despite the small number of genitourinary injuries identified in the database. Rapid analysis of data during an ongoing military conflict is innovative and points toward a future when we use injury analysis to modify risks in real time. The rate of renal injury in this military conflict (29 of 2,712 or 1.1%) is similar to population based rates in the United States. The finding that body armor did not prevent severe kidney injury was notable. As in civilian practice nephrectomy is the most commonly performed operative intervention for renal trauma.[1] The most important finding of the study is the reduced rate of GU injuries in soldiers equipped with body armor. However, several important limitations require further analysis before we can attribute a protective effect to body armor.

The author needs to adjust for important confounders that could affect the rate of GU trauma overall and renal injury in particular. Without adjustment for age, mechanism of injury, injury severity score, associated injuries, diagnostic studies and accuracy of staging the conclusions are subject to significant bias. For example, it is possible that those with body armor had more blunt injuries and, thus, a lower rate of renal trauma. It is also possible that those without armor had more severe associated injuries resulting in more diagnostic testing and/or operative interventions that led to a higher discovery rate for GU injuries. Furthermore, it was not documented in the database whether the groin protector piece was worn at the time of injury. If the men without such protection were not at lower risk for injury, the biological plausibility of the association would be further weakened. If the finding of a reduced rate of genitourinary injury in soldiers wearing body armor can be validated in a larger, better characterized cohort, further research and expenditures to protect our military personnel will be indicated.

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REPLY BY AUTHOR

Unfortunately the relatively small cohort prevented us from doing multiple subset analysis, which might have teased out some of the effects of confounders. The majority of casualties were of adult age and so adjustment for age would be of no benefit. Injury severity score was not included because it was not available for everyone in the JTTR. As discussed, the lack of renal injury staging was due to inadequate access to radiological studies and complete operation reports in this austere environment. I agree that an analysis of renal salvage based on injury stage would be useful.

We were actually surprised that overall GU injuries were significantly less in casualties wearing body armor compared to those not wearing body armor. The original intention was to examine the effect of body armor on renal injuries only. The ceramic plates are specifically designed to protect against thoracic and upper abdominal trauma. The lack of documentation of the groin protector is a clear weakness of the database, especially when dealing with GU trauma. Continued analysis of the trauma database and the protective armor worn by our soldiers in ongoing and necessary.