Amount of Usage and Involvement in Explosions Not Associated with Increased Contamination of Prehospital Vehicles with Multi-drug-resistant Organisms

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Abbreviations:
HRO: high-risk organism
MDRO: multidrug-resistant organism
MRSA: methicillin-resistant *Staphlococcus aureus*

Abstract

Introduction: The role of explosions and patient transport vehicles as sources and vectors of Gram-negative, multidrug-resistant organisms (MDROs) that predominate infections following lengthy evacuations after disasters due to natural hazards and in current war-trauma patients is unknown.

Hypothesis/Problem: Damaged or heavily-used vehicles could be sources of the MDROs subsequently linked to nosocomial infections.

Methods: From January through May 2008 in Iraq, inside surfaces of heavily-used, tactical vehicles (Experimental Group) were sampled with sterile, pre-moistened swabs. Swabs, along with positive and negative controls, were shipped to the reference laboratory in Washington, DC, where they underwent culture, identification and susceptibility testing, and pulsed-field gel electrophoresis. Multidrug-resistant organisms were defined according to the standard Centers for Disease Control and Prevention definitions. High risk organisms (HROs) were defined as susceptible *E. coli*, *A. baumannii*, *P. aeruginosa*, *Enterobacter spp*, or *Klebsiella spp*. Concurrently, new counterparts (Control Group) were similarly surveyed in a storage lot in Georgia, USA. Groups were compared using the Chi-squared test.

Results: One hundred thirty-nine consecutive vehicles including all available ambulances were sampled, yielding 153 swabs. Nineteen were lost or damaged during shipping. Seventy-nine swabs yielded growth of one or more Gram-negative bacteria. The amount and genotype of MDROs in heavily-used vehicles, including those involved in roadside bombings, were compared to control vehicles and to strains isolated from wounds and environmental surfaces at the base hospital. Predominant organisms included *P. agglomerans* (34%), *S. flexneri* (8%), *E. vulneris* (6%), *Pseudomonas sp.* (6%), and *K. pneumonia* (6%). No MDROs were isolated. Thirteen vehicles (eight of 94 experimental and five of 45 control) yielded HRO. There was no difference in contamination rates ($P = .63$). No HROs were isolated from ambulances. No clonal association existed between vehicle and hospital strains.

Conclusion: Given the implications that this knowledge gap has on military and civilian prehospital reservoirs of infection, further study is warranted to confirm these findings and identify targets for preventive intervention throughout civilian disaster and military casualty evacuation chains.

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Introduction

Gram-negative, multidrug-resistant organisms (MDROs) predominate wound and nosocomial infections in current war trauma and earthquake victims.[1,2] Despite the

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application of molecular fingerprinting, source attribution of MDRO outbreaks and epidemics in these settings remains challenging.[3,4] Recent evidence suggests that host nation patients with little or no previous health care contact were the origins of MDROs in a new, uncontaminated health care facility at the beginning of an evacuation and referral chain.[5]

Casualties from the current wars and disasters due to natural hazards are akin because both involve heavy environmental contamination of wounds and health care equipment, similar wound flora, and requirement for transfer to distant referral centers,[1,2] with considerable time in improvised evacuation vehicles and ground and air ambulances. Additionally, roadside bombs commonly wound service members who are inside their patrol vehicles. Therefore, it was hypothesized that these damaged or heavily-used vehicles could be sources of the MDROs subsequently linked to nosocomial infections.

No studies were found addressing this possibility in MEDLINE. Contamination with MDROs of a heavily-used (including bombed) group of these vehicles were compared with an unused control group of vehicles, and then it was determined whether any of the recovered strains were genetically related to strains subsequently isolated from nosocomial infections or environmental surfaces at the hospital served by these vehicles.

Methods

Monthly, from January through May 2008, two groups of vehicles were surveyed, one extensively utilized throughout Iraq (Experimental Group) and the other consisting of new or unused counterparts in a storage lot in Savannah, Georgia USA (Control Group), for the presence of MDRO using methods described previously, including the use of positive and negative control swabs.[4,5] Inside surfaces, including door handles, panels, steering wheels, electronic equipment, stretchers, and floors, were sampled. Multidrug-resistant organisms were defined as methicillin-resistant *Staphlococcus aureus* (MRSA), *E. coli, K. pneumoniae, A. baumannii, E. cloacae,* or *P. aeruginosa* resistant to three or more classes of antibiotics or producing an extended spectrum beta-lactamase. High-risk organisms (HROs) were defined as susceptible isolates of the same species. All MDROs and HROs underwent pulsed-field gel electrophoreses using methods previously described.[4,5] Results were compared to those from patients, staff, and surfaces at the base hospital. Isolates with ≥90% similarity on Dice coefficients were considered related. The chi-squared test was used for statistical processing.

Results

A total of 139 consecutive designated and improvised ground and air ambulances were sampled. Predominant organisms included *P. agglomerans* (34%), *S. flexneri* (8%), *E. vulneris* (6%), *Pseudomonas sp.* (6%), and *K. pneumoniae* (6%). No Gram-negative MDROs or MRSA were isolated. Of the total number of vehicles sampled, 13 (9.3%) vehicles (eight of 94 deployed (8.5%) and five of 45 non-deployed (11.1%)) yielded HROs. There was no statistically significant difference in the amount of HROs between deployed and non-deployed vehicles ($P = .63$). High-risk organisms were isolated from 20% (two of 10) of the deployed vehicles involved in explosions, 7% (six of 84) of the deployed vehicles not involved in explosions ($P = .63$), and 11% (five of 45) of non-deployed vehicles (Table 1). The HROs recovered from these vehicles were not related to the strains of HRO or MDRO recovered from patients, staff, or trauma equipment at the base hospital.[5]

	Control Group	Experimental Group
Total number of vehicles	45	94
Average number of months in use (range)	0	22 (10-60)
Average number of patient transports (range)	0	50 (25-1000)
Number of explosions (number of vehicles)	0 (0)	13 (10)
Number of vehicles with MDRO	0	0
Number of vehicles with high risk organisms (HRO) (%) $P = .63$ [expected value]	5 (11) [4.202]	8 (9) [8.791] 2 [0.932] with explosion 6 [7.856] with no explosion
Number of vehicles with no HRO [expected value]	40 [40.791]	86 [85.209] 8 [9.065] with explosion 78 [76.144] with no explosion

Table 1. Vehicle Characteristics and Statistical Analysis

Discussion

The used (experimental) vehicles did not harbor more MDROs or HROs than did the Control Group maintained in a similar hot, dusty climate, which was surprising for several reasons. First, they were continuously contaminated by soil, a known reservoir of MDROs and resistance mechanisms.[6-8] Second, the pathogens sought are environmentally hardy and persistent.[9] Third, other than periodic removal of visible blood and sweeping of dirt, there was no ability to thoroughly disinfect or clean these vehicles between usages, nor during the course of this entire observation period. Finally, others have linked environmental contamination at a remote hospital to a cluster of serious *Acinetobacter* infections.[10] Although the sample size is small, immediate access to such vehicles during actual use or in explosions is rare and restricted.

Conclusion

The lack of clonal association between vehicle and treatment facility HRO strains isolated from patients does not support a link between vehicle contamination and clinical infection at this facility. Given the relevance to the evacuation of both civilian casualties from disasters due to natural hazards and military medicine, it is hoped that these observations lead to further confirmatory studies.

Disclaimer

The views expressed in the paper are solely those of the authors and are not to be considered official or representing those of the US Department of Defense or the US Army.

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