CLINICAL RESEARCH STUDY

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Health Risks Associated with Crude Oil Spill Exposure

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ABSTRACT

BACKGROUND: Human exposure to crude oil spills is associated with multiple adverse health effects including hematopoietic, hepatic, renal, and pulmonary abnormalities. The purpose of this study was to assess the hematological and liver function indices among the subjects participating in the Gulf oil spill cleanup operations in comparison with the standardized normal range reference values.

METHODS: Using medical charts, clinical data (including white blood cell [WBC] count, platelet count, hemoglobin, hematocrit, blood urea nitrogen [BUN] creatinine, alkaline phosphatase [ALP], aspartate amino transferase [AST], alanine amino transferase [ALT], and urinary phenol) were gathered for the subjects who were exposed to the Gulf oil spill and analyzed.

RESULTS: A total of 117 subjects exposed to the oil spill were included. Over 77% of subjects had WBC counts in the mid range (6-10 $\times$ 10^3 per μL), while none of the subjects had the upper limit of the normal range (11 $\times$ 10^3 per μL). A similar pattern was seen in the platelet counts and BUN levels among the oil spill-exposed subjects. Conversely, over 70% of the subjects had creatinine levels toward the upper limit of the normal range and 23% of subjects had creatinine levels above the upper limit of the normal range (>1.3 mg per dL). Similarly, hemoglobin and hematocrit levels were toward the upper limit of normal in more than two thirds of the subjects. AST and ALT levels above the upper limit of normal range (>40 IU per L) were seen in 15% and 31% of subjects, respectively. Over 80% of subjects had urinary phenol levels higher than detectable levels (2 mg per L).

CONCLUSION: The results of this study support our earlier study findings in which we found that people who participated in oil spill cleanup activities are at risk of developing alterations in hematological profile and liver function.

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KEYWORDS: Chemical exposure; Health impact; Hematological toxicity; Hepatotoxicity; Urinary phenol

Crude oil spills are tragic environmental disasters that can affect human health through exposure to inherent toxic chemicals including para-phenols and volatile benzene.[1,2] Human exposure to crude oil spills can lead to deleterious effects on many biological systems, including changes in the hematologic, hepatic, respiratory, renal, and neurological functions.[3,4] Recently, we investigated the adverse health effects of the Deepwater Horizon oil spill exposure in subjects participating in oil spill cleanup activities along the coast of Louisiana.[5] Specifically, we assessed the hematologic and hepatic markers in a cohort of oil spill cleanup workers and the clinical findings were compared with a group of unexposed (control) subjects. The findings of the study revealed significant differences in blood profiles and liver enzymes between the oil spill exposed and unexposed cohorts, indicating health risks among subjects who participated in the oil spill cleanup operation.[5]

Because the most reported clinical biomarker findings for both hematological and liver function indices fell within the normal range values for exposed and unexposed groups, concerns were raised about the study design and interpretation of the study findings.[6,7] This prompted us to carry out an additional analysis of clinical data that has been recently reported.[5] In the analysis, we assessed the blood profile and liver function data in comparison with the standard normal range values among the subjects who participated in the

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Gulf oil spill cleanup operation. The resultant outcomes are summarized to further facilitate the understanding of the health impact of oil spill exposure among subjects observed previously.

MATERIALS AND METHODS

Subjects

The details of identification of the subjects exposed to the oil spill were described in our previous manuscript.[5] Briefly, the subjects exposed to the oil spill were identified as participants in the oil spill cleanup activities along the coast of Louisiana. Medical charts were reviewed by an experienced physician. Clinical data such as white blood cell (WBC) counts, platelet counts, hemoglobin, hematocrit, blood urea nitrogen (BUN), creatinine, alkaline phosphatase (ALP), aspartate aminotransferase (AST), and alanine aminotransferase (ALT) levels were collected and evaluated. In addition, data on urinary phenol was also assessed as a benzene metabolite in the oil spill-exposed subjects.

Analysis

As shown in Table 1, the average reference values were derived from the normal range values for various indices of hematological and liver functions and the clinical data were processed. In addition, the normal range values were divided into various categories and the clinical data were analyzed. The variables included WBC and platelet counts, as well as the levels of hemoglobin, hematocrit, creatinine, BUN, ALP, AST, ALT, and urinary phenol.

Table 1 Normal Range Values for Various Indices

Parameter	Normal Range Value	Optimal (Average) Normal Value
WBC ($\times 10^3$ per μ L)	4.0-10.5	7.25
Platelets ($\times 10^3$ per μL)	140-415	276
Hemoglobin (g per dL)	12.6-17.7	15
Hematocrit (%)	37.5-51.0	44
BUN (mg per dL)	6-24	15
Creatinine (mg per dL)	0.76-1.27	1.0
ALP (IU per L)	25-150	88
AST (IU per L)	0-40	20
ALT (IU per L)	0-40	20
Beta-2 macroglobulin (mg per L)	0.6-2.4	1.5
Urinary phenol (mg per L)	0-trace	2

ALP = alkaline phosphatase; ALT = alanine aminotransferase; AST = aspartate aminotransferase; BUN = blood urea nitrogen; IU per L = International Units per liter; WBC = White blood cells.

CLINICAL SIGNIFICANCE

- Crude oil spills are tragic environmental disasters that have high potential to affect human health.
- The results of this study indicate that humans exposed to crude oil spill have a risk of developing hepatic or blood-related disorders.
- The hematological and hepatic alterations include altered platelet counts, serum creatinine, urinary phenol, and liver function enzymes.

RESULTS

This study included a total of 117 subjects who were involved in the cleanup operations of the oil spill. Of the 117 subjects, 104 (89%) were male and 13 (11%) were female. The median age of the subjects was 34.0 (18-63) years.

The findings presented in the Figure (panel A) indicate the outcomes of WBC, platelet counts, and BUN levels assessment in the oil spill-exposed subjects. Based on the normal range values, WBC count was averaged at 7.2 ($\times 10^3$ per μL) and the total number of subjects who had WBC counts below and above the average value of normal range was determined. Of the 117 subjects, 71 (61%) had WBC counts below the average value of normal range. Similarly, 79 (68%) of the subjects had platelet counts below the average value of normal range when 276 ($\times 10^3$ per μL) was considered as the average value of normal range. Assessment of BUN levels also indicated that 68% of the subjects had below the average value of normal range when the average value of normal range of BUN levels was considered to be at 15 mg per dL.

The results shown in the Figure (panel B) depict the outcomes of serum creatinine, hemoglobin, hematocrit, and urinary phenol levels assessment in the oil spill-exposed subjects. Based on the normal range values, serum creatinine levels averaged 1.0 mg per dL and the total number of subjects who had creatinine levels above and below the average value of normal range was determined. Of the 117 subjects, 57 (49%) had serum creatinine levels above the average. Similarly, 76 (65%) of the subjects had hemoglobin levels above the average when 15 mg per dL was considered as the average value of normal range. Assessment of hematocrit levels indicated that 65% of the subjects had levels above the average value of normal range when the average value of normal range of hematocrit levels was considered to be at 44 mg per dL. Similarly, 93 (79%) of the subjects had urinary phenol levels above the average value of the normal range when 2.0 mg per L was considered as the average value of the normal range.

The findings presented in the Figure (panel C) reveal the outcomes of liver function enzymes such as AST, ALT, and ALP levels assessment in the serum of oil spill-exposed subjects. Based on the normal range values, AST and ALT levels in the serum were averaged at 20 IU per L, and the total number of subjects who had AST or ALT levels above and below the average was determined. Of the 117 subjects, 84 (72%) had serum AST levels above the average of the normal range. Similarly, 89 (76%) subjects had serum