Post-Trauma Immunological Disruptions: A Review

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Abstract

Accidents and trauma are one of the world’s most serious but neglected health problems. The fast moving transportation systems, unprecedented and unplanned urbanization and changing social patterns have contributed to the global increase in the incidence of trauma. Traffic accidents are an endemic disease which affects mainly the young adults in the economically productive age groups and are the leading cause of death in persons under 44 years of age. Globally, 26% of all deaths in the age group of 15-44 years are due to injuries. The national vital registration system registers around 18 million deaths annually due to injuries worldwide. In Developing countries, trauma is a major problem, due to a very high incidence of vehicular accidents, other accidental injuries, crime and violence. Rising population, urbanization, industrialization and a drastic rise in vehicular transport has contributed to an annual increase in road traffic accidents by 3% in India alone. An accident death is reported every 1.9 minutes in India; in 1997, 10.1% of all deaths in India were due to accidents and injuries. Despite of this, trauma care is still at a developmental stage in our country. Thus, there is a growing population of traumatized patients requiring highly sophisticated and specialized care. Because most of these patients are young adults, with no underlying illness, there is a great concern to save these patients.

Keywords: Multidisciplinary trauma centers; Post-trauma complications; Immunological disturbances

Introduction

Accidents and trauma are one of the world’s most serious but neglected health problems. The fast moving transportation systems, unprecedented and unplanned urbanization and changing social patterns have contributed to the global increase in the incidence of trauma. Traffic accidents are an endemic disease which affects mainly the young adults in the economically productive age groups and are the leading cause of death in persons under 44 years of age. Globally, 26% of all deaths in the age group of 15-44 years are due to injuries. The national vital registration system registers around 18 million deaths annually due to injuries worldwide.

In Developing countries, trauma is a major problem, due to a very high incidence of vehicular accidents, other accidental injuries, crime and violence. Rising population, urbanization, industrialization and a drastic rise in vehicular transport has contributed to an annual increase in road traffic accidents by 3% in India alone. An accident death is reported every 1.9 minutes in India; in 1997, 10.1% of all deaths in India were due to accidents and injuries. Despite of this, trauma care is still at a developmental stage in our country [1-6].

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Post-Trauma Complications and Mortality

With the establishment of multidisciplinary Trauma Centers, the initiation of Advanced Trauma Life Support (ATLS) programs and advancements in intensive care, the management of major contributors of trauma associated mortality like hemorrhage, circulatory collapse and respiratory failure has greatly improved. However, patients admitted with trauma and injuries are highly prone to develop complications like sepsis, systemic inflammatory response syndrome (SIRS) and multiple organ dysfunction syndrome (MODS), which contributes to almost 80% of late deaths in them [7,8].

Thus, mortality in trauma patients who survive the initial resuscitation is usually due to MODS or sepsis. Recent studies support that these complications are the result of activation or suppression of innate and adaptive immune responses. Although developments of modern trauma systems have significantly reduced early deaths, late organ complications in the surviving patients still present therapeutic challenges to surgeons and critical care physicians [7,8].

Post-Trauma Immunological Disturbances

Immunological disturbances are the main drivers for post-trauma complications, morbidity and mortality. It is generally agreed that the disruptions of natural and adaptive immunity after traumatic and burn injuries are related to the increased susceptibility to SIRS, sepsis, and multiple organ failure (MOF) exhibited by those patients who survive beyond the initial resuscitation period. Furthermore, evidence suggests that trauma produces a bias towards a TH2 response and an exaggerated TH1 suppression, the degree of which may further predispose patients to sepsis, SIRS, and MOF. The body’s immunologic response to trauma and burn injuries has been a subject of interest in recent years [8-29].

The post-trauma acute -phase immune response is mainly characterized by production and release of various pro-inflammatory cytokines like TNF-α and IL-1β. Excessive production of these cytokines may predispose to SIRS. In order to balance the excessive cytokines, the body produces a compensatory response by releasing...
anti-inflammatory cytokines (IL-10 and TGF-β), which is called compensatory anti-inflammatory response syndrome (CARS). Overproduction of either pro- or anti-inflammatory cytokines may result in organ dysfunction. These balances are depicted in figure 1. The inflammatory mediator increase could be used as early prognostic or diagnostic markers for complications. Serious injury also results in progressive suppression of adaptive immune response during the first week after trauma, which may contribute to the development of sepsis and MODS. When SIRS leads to MODS, mortality can increase up to 50-80%. The overall mortality associated with sepsis ranges from 30-50% [8-29].

Studies to identify markers which could identify patients at risk for complications have identified decreased production of IL-12, IL-2 and IFN-γ, increased production of IL-10, IL-4 and IL-18, elevated sIL-2RA and the IL-6:IL-10 ratio as the most promising prognostic markers. Currently, IL-6 is regarded as being the most accurate marker for prognosis of SIRS, sepsis or MODS in trauma patients. However, different studies have observed markedly different levels of IL-6 post-trauma, depending on the time frames of sampling. The half-life of TNF-α is 20 minutes and that of IL-1 is 6 minutes, which may be a reason for the variable post-trauma levels found in different studies [8-29].

A drawback of most of the studies on post-trauma immunological disturbances has been that they have been done using serum/plasma cytokine estimation, which may not depict the actual role of lymphocytic or monocytic dysfunction (Figure 1).

To achieve further knowledge about the role of TH1/TH2-type cytokines in the immune response after trauma, a recent study questioned the hypothesis that a shift toward TH2-type cytokine response occurs in the plasma of patients after major trauma that correlates with adverse outcome 29. The authors investigated in a retrospective study 195 severely injured patients, both males and females during their ICU stay, post-trauma. TH1-type cytokines- IL-2, interferon γ, IL-12 and IL-18 and TH2-type cytokines IL-4, IL-10, and IL-11 were determined using ELISA in patients and in healthy controls. However, in their study, no TH1/TH2 shift was observed after major trauma. A drawback of this study was again that the authors used plasma levels of cytokines to monitor TH1/TH2 response [10,12,29].

Spolarics et al. [12] studied the TH1/TH2 status in severely injured male patients by assessing the number of IL-4, IFN-γ and TNF-α producing CD4+ and CD8+ T cells. They tested the hypothesis that major trauma results in coordinated alterations in the cytokine producing activity of both monocytes and T cells and that initial monocyte and lymphocyte responses correlated with the severity of the inflammatory response as well as adverse clinical outcome. They observed that major trauma results in an early and marked decrease in monocyte cytokine producing activity, which may promote T-cell commitment towards a TH-2 pattern early after trauma. Further, in their study, they found that the degree of alterations in monocytes and T cell responses on day 2 post injury correlates with the development of adverse clinical outcome and the duration of the inflammatory response. However, this study included only 12 patients [10,12,29].

Role of Monocytes in Post-Trauma Immunological Response

In order to salvage the trauma victims, attention has now shifted to the studying of functional aspects of monocytes during post-trauma phase. Monocyte activity may be the major driving force for post-trauma immunological disturbance. Cytokines are produced by macrophages and monocytes at the local site of injury and in the end organs [11,12,15].

Spolarics et al. [12] showed that after LPS stimulation, the number of IL-12, TNF α, IL-6, and IL-1α-producing monocytes were 40-70% lower in trauma patients. The number of IL-12-producing monocytes was markedly decreased in trauma patients who developed sepsis, and infections.

A recent study has shown that an immediate hyper activation of circulating monocytes is rapidly followed by a substantial paralysis of cell function, which correlated with the development of MODS [15].

Investigators have assayed monocyte activity in biological fluids from mixed or purified monocyte cultures or in whole blood challenged with LPS. Post-traumatic serum cytokine levels may represent only the peak of the cytokine release that takes place locally from diverse cell sources. Thus, the examination of monocytes function using LPS-stimulated whole blood via flowcytometric
analysis may represent a more accurate assessment of changes in acute cellular function after severe trauma.

Role of Monocoyte Human Leucocyte Antigen-DR

Since specific clinical signs of immune dysfunction are often absent in intensive care patients, studies have moved towards evaluation of biomarkers of immune suppression [30,31]. Diminished expression of Human Leucocyte Antigen DR on circulation monocytes (mHLA-DR) is widely accepted as a reliable indicator of immunosupression in ICU patients. Very few studies have been done to assess the role of mHLA-DR in trauma patients. A literature review shows that except two studies, all the remaining preliminary studies were performed more than 10 years ago (i.e before the advent of advanced trauma life support [ATLS] protocols for the management of multiple-injured patients). These preliminary findings on mHLA-DR were based on limited numbers of patients and used non-standardized flowcometry protocols [30,31].

The first study on trauma patients based on standardized protocols was published by Cheront et al in 2010 [31]. In this prospective, observational, 23-month study, the authors demonstrated that a persistently decreased expression of mHLA-DR post-trauma was associated with development of sepsis. Multivariate logistic regression analysis revealed that a slope of mHLA-DR expression between days 1-2 and days 3-4 below 1.2 was associated with the development of sepsis [30,31].

In a very recent study (published in 2012), conducted over a period of 24 months in a trauma ICU, 100 consecutive severely injured patients were followed up to determine whether early measurement of IL-6 and IL-10 plasma concentrations (as markers of initial severity) along with mHL-DR recovery could improve the prediction of sepsis. In this study, IL-6 and IL-10 were measured by ELISA. Of the 100 patients, 37 developed sepsis. The IL-6 concentrations and slope of mHLA-DR expression between days 1-2 and 3-4 were significantly different between septic and non-septic patients [31].

It was concluded that a high IL-6 concentration and a persistent mHLA-DR decreased expression were found to be the best predictive marker for development of sepsis.

A limitation of this study was that only two cytokines were assessed and they were assessed only till day 4 post-trauma, with no attempt to analyze the intracellular cytokine productions.

Role of Programmed Death -1 (PD-1) Related Molecules

Programmed death -1 (PD-1) related molecules constitute a complex system of negative regulators involved in controlling T-cell response. This system is composed of PD-1 (CD-279) and its two ligands, PD-L1 (B7-H1, CD-274) and PD-L2 (B7-DC, CD-273). These molecules belong to the B7: CD-28 family. They are best understood relative to their role in viral infections and oncology32.

It has been proposed that pathogens and tumor cells may take advantage of this pathway to escape the host’s immune defenses considering their immune regulatory properties. It is postulated that the PD-1 system could participate in sepsis-induced immune dysfunctions. It was recently shown that PD-1 knockout mice exhibited not only a greater capacity to clear bacteria, but more importantly, a lower mortality in response to experimental sepsis [32].

No study has been done on PD-1 related molecules in trauma patients.

Role of IL-18

IL-18, originally termed IFN-γ inducing factor (IGIF), is a relatively new cytokine which shares structured homology with IL-1 family and some functional properties with IL-12 [33,34].

A few recent studies have found that IL-18 levels in plasma represent early and reliable markers for post-traumatic complications such as MODS and sepsis. However, these studies have also been done to assess extracellular cytokines in plasma [33,34].

To conclude, it is now established that the immediate post-trauma mortality is due to hemorrhage, circulatory and respiratory collapse or severe brain injury. However, for those patients who survive the initial 4-5 days, immunological disruptions play a significant role in their progression to MODS, SIRS and Sepsis.

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