The Liver Response to Hemorrhagic Shock and Subsequent Resuscitation – MRI Analysis

[1]Abramovitch .R ,[2]Idit .M ,[1]Hila .B

Anesthesiology and [2]Goldyne Savad Institute for Gene Therapy, Hadassah Hebrew University Medical Center, Jerusalem, Israel, [1] Critical Care Medicine, Hadassah Hebrew University Medical Center, Jerusalem, Israel

Background/ Aims:

The liver is a target for injury in low flow states associated with trauma and hemorrhage. Even after homeostasis and initial successful resuscitation, liver damage may persist for prolonged period of time. Currently, there is an ongoing discussion about resuscitation strategies. Markers of liver injury are either invasive or not rapidly responding. MRI may offer an innovative, noninvasive and clinically relevant alternative to evaluate liver injury. To date, the MRI characteristics of the immediate liver response to hemorrhagic shock and subsequent resuscitation have not been fully investigated. We recently developed a new MRI method that enables us to follow liver perfusion and hemodynamics by changing the enrichment of gas. This method allows us to monitor flow rate and distribution of arterial vs. portal blood[1]. Using this method, we defined the characteristics of the normal liver and the changes in vascular reactivity in response to changes in the fractional inspired O_2 and CO_2[1]. In the present study we aimed to characterize the liver response to hemorrhagic shock and subsequent fluid resuscitation as assessed by fMRI.

Methods:

MRI: Experiments were preformed on a 4.7T Bruker Biospec spectrometer using a bird cage coil. Changes in hepatic hemodynamics were evaluated from GE images acquired during breathing of air, air-CO_2 (5% CO_2), and carbogen as described previously[1]. Four images were acquired at each gas mixture (slice thickness = 1.5 mm; TR/TE= 147/10 ms; FOV = 5.8 cm; 256 × 128; 4 averages). VF- the change induced by carbogen; VD- the change generated by CO_2, as described previously[2]. Results are expressed as mean ± SEM. Groups were compared using paired t test.

Animal: Sabra rats (250-400g) were used (NIH approval OPRR-A01-5011). Catheters were inserted into both femoral veins and arteries for measurements of blood pressure, administration of fluid and for bleeding (controlled hemorrhage). Liver MRI, as described above, was acquired: at baseline, after controlled hemorrhage and in selected animals, after resuscitation. Animals were sacrificed and livers were taken for histology.

Results and Discussion:

Following MRI baseline acquisition we withdrew 15% (3±1 ml) (n=3) or 35-40% (10 ±1.5 ml) (n=7) of the total blood volume from anesthetized rats (~0.5 ml/min). Mean VF values following hemorrhage was significantly reduced compared to normovolemia (-0.0002±0.007; Figure 1a, $p<0.01$), suggesting that the decrease in red blood cell diminished the change brought by gas saturation. Mean VD values were significantly higher than in normovolemia (-0.004±0.006; Figure 1b $p<0.01$) suggesting a decrease in red blood cell volume and vascular reactivity as a result of physiological response of the body to hypovolemia (e.g., redistribution of blood to vital organs and reduced responsiveness of blood vessels, which are already dilated or vasoconstricted to their maximum level). The change induced on VF and VD values after hemorrhage correlated with the percentage of blood loss (figure 1a,b). Five hrs post shock there was no significant change in VF and VD compared to post hemorrhage. Pathological changes appeared in histological sections only 6 hrs after hemorrhage. Ten minutes after completion of hemorrhagic shock, three additional animals underwent resuscitation with continuous Ringer Lactate solution administered iv at a rate of 1 ml/min till MAP of 50 mmHg (12±2 ml). Immediately after resuscitation, mean VD values were significantly more negative than values obtained after bleeding and during normovolemia (-0.05) and returned to baseline values 5 hrs after shock. Mean VF values gradually returned to normovolemia values (0.008, 0.016; post resuscitation and 5 hrs later respectively).

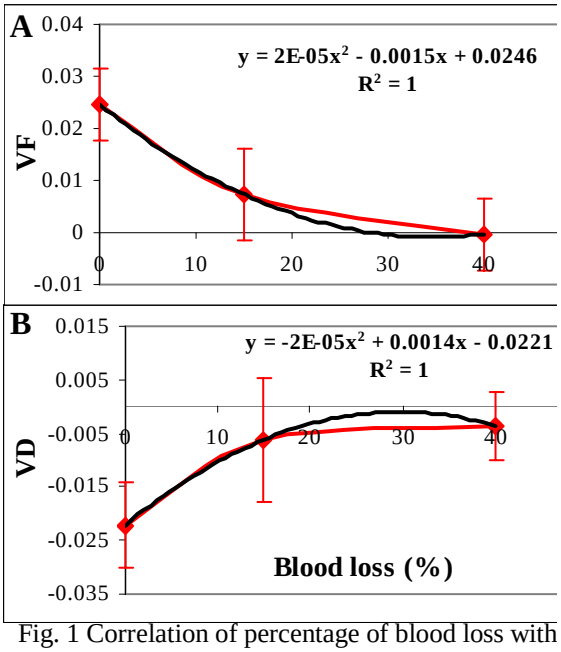

Fig. 1 Correlation of percentage of blood loss with mean VF (a) and VD (b) values

In summary, results from this study provide the basis for the development of the MRI as a noninvasive, rapidly-responding monitoring method of liver injury caused by hemorrhagic shock and subsequent resuscitation. Future studies will focus on fMRI evaluation of other treatment strategies aimed at improving liver perfusion during hemorrhagic shock.

References:

1. Harel H, Gross E, Spira G, Matot I, Galun E, Vlodavsky I, Abramovitch R; [2004] abstract no. 357, ISMRM.
2. Abramovitch R [1999] Canc. Res. 59:5012-5016.