Survival After Trauma: Metabolic Changes and Response of the Immune System

Figure 18.1 A summary of the metabolic response to trauma. A major fuel in trauma is glutamine: it is synthesised, stored and released by muscle and taken up particularly by tissues in which cell proliferation is occurring. These are cells in the wound, which include lymphocytes, macrophages and fibroblasts. Glutamine is also used by proliferating immune cells in the lymph nodes and the cells in the bone marrow. These cells also use glucose. They produce aspartate from glutamine and lactate from glucose. The muscle releases amino acids, all of which (except for lysine and leucine) are precursors for glucose in the liver (via gluconeogenesis) and the branched-chain amino acids are precursors for glutamine in muscle (Chapter 8). Fatty acids are mobilised from adipose tissues, to be oxidised by muscle. Glucose, glutamine and fatty acid metabolism generates ATP for these cells (Chapter 9). Almost all of the immune cells are present in the lymph nodes.

Figure 18.2 Source of glutamine for use by immune cells and cells in the bone and fate of its metabolic products. Glutamine, which is synthesised and stored in muscle, is released and used by the immune cells in lymph nodes and in the wound, and by the cells in the bone marrow. For other tissues that provide glutamine and those that use it, see chapter 8 and see Figure 17.40.

Figure 18.3 Competition for iron between proliferating bacteria, erythropoiesis in the bone marrow and proliferating lymphocytes in the lymph nodes. The iron ion is required for synthesis of haemoglobin, cytochromes and iron-sulphur proteins, and for maintenance of the structure of DNA.

Figure 18.4 Effects of cytokines on fate of iron during an infection. Transferrin is the form in which iron is transported in the blood (Chapter 15). Cytokines increase the number of ferritin receptors in proliferating lymphocytes, to facilitate the uptake of iron by lymphocytes. They also stimulate synthesis of apoferritin in the liver, which removes iron from the blood to reduce that available for bacteria. (See Chapter 15 for discussion of iron metabolism)

Figure 18.5 A summary of the biochemical, physiological and immunological changes brought about by cytokines in response to trauma. Cytokines can be produced in trauma from macrophages, lymphocytes, endothelial cells in the tissue that is damaged, and also by Kupffer cells if the liver is damaged. IL-1, IL-6 – interleukins 1 and 6; TNF – tumour necrosis factor, IFN – interferon.

Figure 18.6 Damage to the colon caused by excessive levels of proinflammatory cytokines and its consequences. The excessive levels of proinflammatory cytokines that result from severe trauma can damage the physical barrier of the colon, so that bacteria and toxins in the colon leak into the peritoneal cavity, which can cause sepsis and/or endotoxaemia.