THE LYMPHATIC SYSTEM

PART 2 – THE LYMPHATIC ORGANS

The first article in this four-part series gave an overview of the lymphatic system. This second article looks at the two major lymphatic organs – the thymus and the spleen.

THE THYMUS

The thymus gland is a bi-lobed, pinkish-grey organ located in the mediastinum on the superior portion of the heart (Fig 1). In addition to being a major lymphoid organ, it is part of the endocrine system and secretes a family of hormones collectively referred to as thymosin.

Structurally, it resembles a small bow tie (Fig 2) that gradually atrophies (shrinks) with age. In pre-pubescents, it is relatively large, weighing around 40g but, by middle age, it may have shrunk sufficiently to be difficult to locate (Marieb, 2006). Each lobe is surrounded by a capsule containing numerous micro-lobules, typically 2–3mm in width, held together by loose connective tissue (Fig 2). Each lobule contains thymosin-secreting epithelial cells and T-lymphocytes (commonly referred to as T-cells), and has two distinct areas – a dense outer cortex rich in actively dividing T-cells and an inner medulla that functions as an area of T-cell maturation.

The role of the thymus in T-cell maturation

T-lymphocytes originate as immature stem cells (haemocytoblasts) from the red bone marrow of most flat bones. Some of these infiltrate the thymus where they mature into active T-lymphocytes (Doan et al, 2007). A proportion of these mature T-cells continually emigrate from the thymus into the blood and other lymphoid organs (spleen and lymph nodes) and play a major role in specific immune responses (to be discussed in part 3 next week). Their importance is apparent in people with depleted T-cell populations, such as those with HIV infection.

The process of T-cell maturation is controlled by thymosin, the group of hormones secreted by the thymic epithelial cells. These hormones are essential for normal immune function, although the exact mechanism of their action is not fully understood.

One of the most important functions of the thymus is programming T-cells to recognise ‘self’ antigens, allowing them to distinguish foreign (potentially pathogenic) material from antigens that belong to the body. Removal of the thymus leads to an increase in autoimmune diseases as this ability to recognise self is diminished (Bonomo et al, 1995).

THE SPLEEN

The spleen is the largest lymph organ. Situated in the left hypochondriac region of the abdominal cavity, between the diaphragm and the stomach (Fig 1). It primarily functions as a filter for the blood, bringing it into close contact with scavenging phagocytes and lymphocytes (Watson, 2005).

The dark-purplish spleen is approximately 12cm long, oval in shape, highly vascular and enclosed in a dense, fibro-elastic capsule that protrudes as trabeculae into the organ (Fig 3). The trabeculae constitute the framework of the spleen.

Blood enters the spleen from the splenic artery at the hilum and leaves via the splenic vein, which also exits at the hilum (Fig 3) and eventually becomes a tributary of the hepatic portal vein.
The spleen is made up of two regions – the stroma and the parenchyma. The stroma consists of the outer capsule with its trabeculae, fibres and fibroblasts (cells that secrete collagen). The parenchyma is composed of two types of intermingling tissue called white pulp and red pulp. White pulp consists mainly of lymphocytes and macrophages arranged as lymphatic nodules around branches of the splenic artery. Blood flows into the spleen via this artery, entering smaller, central arteries of the white pulp and eventually reaching the red pulp (Marieb, 2006). The red pulp consists of blood-filled venous sinuses and splenic cords. Splenic cords are areas of perivascular tissue containing red and white blood cells and plasma cells (antibody-secreting cells). The walls of the meshwork of sinuses in the red pulp contain phagocytes that engulf foreign particles and cell debris, filtering and removing them from the circulation (Lichtman and Abbas, 2004).

**Destruction of red blood cells (haemolysis)**

Old and senescent red blood cells are digested by phagocytic macrophages within the red pulp (Marieb, 2006). The haem and globin portions of haemoglobin are split apart:

- The globin is broken down into its constituent amino acids, which can be utilised in the synthesis of new protein;
- The haem ring is opened, resulting in free iron and four non-iron (pyrrole) rings. The iron is removed and transported (by transferrin) for storage as ferritin, and reused to make new haemoglobin in the red bone marrow;
- The non-iron part of haem is converted by macrophages to the green pigment biliverdin, and then into a yellow pigment, bilirubin. Both are transported to the liver bound to plasma albumin. Bilirubin, the more toxic pigment, is conjugated in the liver to form a less toxic compound, which is excreted in the bile.

**Storage of platelets**

The red pulp partly serves to store a large, reserve portion of platelets (up to one-third of the total supply). Following haemorrhage, the capsule of the spleen may contract, releasing these reserves into the circulation. The spleen also plays a minor role in haematopoiesis (formation of blood cells). This is usually early in foetal life (up to five months’ gestation), where, along with the bone marrow, erythrocytes are produced by the spleen.

**Splenomegaly (enlargement of the spleen)**

The spleen is the body’s largest collection of lymphoid tissue, so infections, which give rise to white blood cell proliferation and antigenic stimulation, may cause germinal centres in the spleen to expand, enlarging the spleen. Enlargement may also be caused by any obstruction in blood flow.

**Splenectomy (removal of the spleen)**

The spleen is a fragile organ and, due to its highly vascularised nature, can be easily damaged or ruptured by a severe crushing injury or blow, rapidly leading to severe intraperitoneal haemorrhage. Death may result due to massive blood loss and shock. A ruptured spleen is best treated by complete and prompt removal (splenectomy), without which the mortality rate is approximately 90%. Following a splenectomy, patients may be at increased risk of infection but other structures such as the bone marrow and the liver can take over some of the functions normally carried out by the spleen.

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**REFERENCES**