SPLEEN
STRUCTURE AND FUNCTIONS

Khodabakhshi B.
Belarusian State Medical University
Department of Human Morphology

The spleen is the largest organ in the lymphatic system. It has been considered a neglected organ so far. In medieval times, people believed that spleen was the source of "morose feelings and bad temper." The connotation entered into common speech (via Latin, *splen*)—no one would want to be around you if you were spleenful, though spleenless was a prized way to be. Today, the word spleen is still in Webster's Dictionary meaning "feelings of ill-will or anger, often suppressed". Spleen plays an important role in the clearance of circulating apoptotic cells, the differentiation and activation of T and B cells and production of antibodies in the white pulp. Furthermore, splenic macrophages are able to remove bacteria from the blood and protect from sepsis during systemic infections.

Aim

The aim of this study was to represent the function and structure of spleen in humans.

Material and Methods

PubMed search was carried out in English language literature for spleen structure and functions. Twenty two articles for the 2003-2018 years were included in this study.

Results

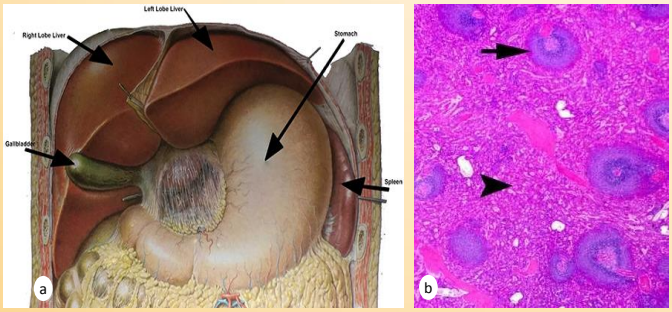

Figure 1. The spleen is an organ shaped like a shoe that lies relative to the 9th and 11th ribs and is located in the left hypochondrium and partly in the epigastrium. Thus, the spleen is situated between the fundus of the stomach and the diaphragm (a). The spleen is comprised of 2 functionally and morphologically distinct compartments, the red pulp (arrowhead) and the white pulp (arrow) (b).

The Red Pulp is composed of a three dimensional meshwork of splenic cords and venous sinuses. The splenic cords are composed of reticular fibers, reticular cells, and associated macrophages. The reticular cells are considered to be myofibroblasts and may play a role in splenic contraction. Within the spaces between the cords are blood cells, including erythrocytes, granulocytes, and circulating mononuclear cells. Also associated with the splenic cords, are lymphocytes and hematopoietic cells as well as plasma cells and plasma blasts that migrate from the white pulp after antigen specific differentiation.

Filtering the blood

From the cords, the blood passes into the venous sinuses of the red pulp (Figure 2). These sinuses are lined by endothelium that has an unusual discontinuous structure, with stress fibers extending underneath the basal plasma membrane, running parallel to the cellular axis. The contractility of the stress fibers might also aid in the retention of erythrocytes in the spleen (as has been observed in various mammals, such as dogs and horses), thereby forming a reservoir of erythrocytes and reducing stress on the heart by reducing the viscosity of the blood during rest.

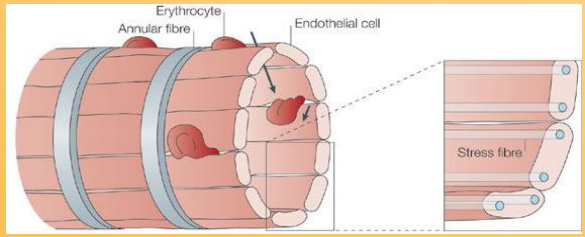

Figure 2. Venous sinuses in the red pulp of the spleen. Schema of a venous sinus located in the cords of the red pulp. Blood from the cords collects in the sinuses (shown by arrows). The venous sinuses consist of a lining of endothelial cells that are positioned in parallel and connected by stress fibers to annular fibers, which are composed of extracellular-matrix components. The stress fibers run along the long axis of the endothelial cells and are most prominent where the endothelial cells are in contact. Contractility of the stress fibers allows the formation of slits between the endothelial cells, thereby regulating the passage of blood and blood cells from the red-pulp cords into the sinuses and back into the venous system. Because the red-pulp cords contain a large number of macrophages, ageing erythrocytes that are no longer able to pass through the slits are phagocytosed.

Recycling iron

Erythrophagocytosis is important for the turnover of erythrocytes, and recycling of iron is an important task of splenic macrophages. The release of iron from its storage in splenic macrophages is regulated by the requirements of the bone marrow.

Producing antibodies

The red pulp is also known to be a site where plasma blasts and plasma cells lodge.

The White Pulp consists of **lymphatic tissue cords** (mostly accumulation of **lymphocytes**) surrounding course of an artery in some places interrupted by **lymphatic nodules**. In hematoxylin-eosin stained slides, white pulp appears **basophilic** because of the dense heterochromatin the nuclei of the numerous lymphocytes (Figure 3). Branches of the *splenic artery* enter the white pulp from trabeculae. Within the white pulp, these arteries are called the *central arteries*. Branches of the *central arteries* constitute a capillary network supplying the white pulp and marginal zone. Lymphocytes that aggregate around the central artery (**mostly T-lymphocytes**) create the **periarterial lymphatic sheath (PALS)**. Contrarily, the lymphatic nodules are formed chiefly by **B-lymphocytes**. These nodules usually contain **germinal centers** developed by proliferation of B-lymphocytes after their activation. In humans, the germinal center develops within 24 hours after antigen exposure.

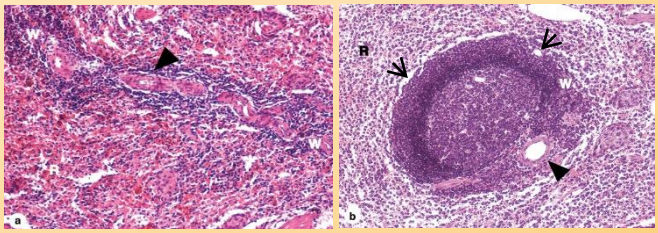

Figure 3. The splenic white pulp consists of lymphoid tissue surrounding the central arterioles as the periarteriolar lymphoid sheath (PALS) and the nodules of proliferating B cells in this sheath. (a): Longitudinal section of white pulp (W) in a PALS and the central arteriole (arrowhead) it surrounds. Surrounding the PALS is much red pulp (R); (b): A large nodule with a germinal center forms in the PALS and the central arteriole (arrowhead) is displaced to the nodule's periphery. Small sinuses can be seen at the margin between white and red pulp (arrows).

Conclusion

The most important functions of spleen are **proliferation and differentiation of lymphocytes** and **destruction of erythrocytes**. It also serves as **storage of blood** which can be used in hypovolemia (decreased blood volume due to bleeding or long-lasting physical strain).

Proliferation and differentiation of lymphocytes

Proliferation and differentiation of lymphocytes occur in the white pulp. Then, these cells migrate through marginal zone into the red pulp venous sinusoids and are released into blood. Spleen removes antigens from blood and provides antigen presentation by antigen presenting cells. Due to that, B lymphocytes are activated and they transform into antibodies secreting plasma cells. There are also present the memory B cells which are able to rapidly activate the secretion of antibodies after exposure to the specific antigen.

Destruction of erythrocytes

The median lifetime of erythrocytes is about 120 days. During this time, erythrocytes are exposed to many adverse effects (e.g. oxidative stress) and that leads to their damage and exhaustion. Erythrocytes have no molecular biology technique to repair their own damaged proteins and these damages gradually accumulate. Subsequently, the function of erythrocytes is also affected. The red pulp removes senescent, damaged or abnormal erythrocytes. Removed erythrocytes are broken down by phagocytes.

Storage of blood

Spleen can release up to 100 ml of blood in case of emergency. This blood is stored in the venous sinuses and pulp. In contrast to other blood reservoir, the release of splenic reserve increases hematocrit by 1-2 %.