# Effect of Obesity on The Structure of Spleen in Adult and Senile Rats

*Thesis*

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# List of Contents

# Introduction and Aim of work

Obesity is a metabolic disorder characterized by increase in energy intake and decrease in energy output concerning body weight and glucose metabolism ***(Berrin et al., 2007).*** Obese individuals seem to exhibit poor antibody response to vaccination due to several inherent immune defects ***(Tolerance et al., 2011).*** Studies in obese humans and with obese animal models have repeatedly demonstrated impaired immune function including decreased cytokine production, decreased response to antigen/mitogen stimulation, reduced macrophage and dendritic cell function added to natural killer cell impairment ***(Erik et al., 2010).***

The long-term obesity may reduce the size of the T-cell pool and impair the responsiveness of splenocytes in rats. Not only T-cell, but also B-cell function may be impaired in mice made severely obese. Also, Splenocytes proliferation stimulated by T-cell mitogen and B-cell mitogen was significantly lower in obese rats ***(Sato et al., 2009).***

Current studies indicate that impaired immune function with age is associated with alterations in cell numbers, and also, in humans and in rats with decreased T cell activation and proliferation (***Jun et al., 2010).*** The complexity and

heterogeneity of nutritional status and immune system interactions require an integral study of the immunocompetent cells, their subsets and products ***(Lamas et al., 2002).***

**Thus, it became the aim of our work to demonstrate the structural changes that occurs in the spleen of adult and senile obese rats.**

# Anatomy of the spleen

## I- Position, shape and size:

The spleen represents the largest mass of lymphoid tissue in the body. It lies just beneath the diaphragm close to the $9^{th}$, $10^{th}$, and $11^{th}$ ribs. Its longitudinal axis lies along the shaft of the $10^{th}$ rib. Its anterior pole extends forward only as far as the midaxillary line and cannot be palpated on clinical examination. Its posterior pole lies 2 cm from the body of T10 ***(Snell, 2008).***

It is oval in shape; however its shape varies from a slightly curved wedge to a 'domed' tetrahedron. The shape is mostly determined by its relations to neighboring structures during development. The superolateral aspect is shaped by the left dome of the diaphragm while the inferomedial aspect is influenced mostly by the neighboring splenic flexure of the colon, the left kidney and the stomach ***(Ellis, 2006).***

The spleen is about the size of the cupped hand but its size and weight vary with age and between sexes. In adult it is usually 12 cm long, 7 cm broad and about 3 - 4 cm wide. It tends to diminish in size and weight in senescence. Its average adult weight is about 150 gm although the normal range is wide, between 80 gm and 300 gm, in part reflecting the amount of blood it contains ***(Standring et al., 2005).*** The ratio of

splenic weight to body weight remains fairly constant regardless of age, and in rats, is typically around 0.2% ***(Losco, 1992).***

**II- <u>Relations</u>:**

The spleen has a superolateral diaphragmatic and an inferomedial visceral surface. The diaphragmatic surface is convex and smooth and faces mostly superiorly and laterally although the posterior part may face posteriorly and almost medially as it approaches the inferior border. The diaphragmatic surface is related to the abdominal surface of the left dome of diaphragm which separates it from the basal pleura, the lower lobe of the left lung and the ninth to eleventh left ribs. The pleural costodiaphragmatic recess extends down as far as its inferior border. The visceral surface faces inferomedially towards the abdominal cavity, and is irregular and marked by gastric, renal, pancreatic and colic impressions ***(Standring et al., 2008)*.**

The gastric impression faces anteromedially and is broad and concave where the spleen lies adjacent to the posterior aspect of the fundus, body and greater curvature of the stomach. It is separated from the stomach by a peritoneal recess, which is limited by the gastrosplenic ligament. The renal impression is slightly concave and lies on the lowest part of the visceral

surface, separated from the gastric impression above by a raised strip of splenic tissue and the splenic hilum. It faces inferomedially and slightly backwards, being related to the upper and lateral area of the anterior surface of the left kidney and sometimes to the superior pole of the left suprarenal gland. The colic impression lies at the inferior pole of the spleen and is usually flat. It is related to the splenic flexure of the colon and the phrenicocolic ligament. The pancreatic impression is often small when present and lies between the colic impression and the lateral part of the hilum. It is related to the tail of the pancreas which lies in the lienorenal ligament. The hilum of the spleen is a long fissure pierced by several irregular apertures through which the branches of the splenic artery and the tributaries of the splenic vein as well as nerves and lymphatics enter and leave the spleen; it lies in the visceral surface closer to the inferior and anterior borders ***(Standring et al., 2008)*.**

## III- Peritoneal connections of the spleen:

The spleen is almost entirely covered by peritoneum, which is firmly adherent to its capsule. Recesses of the greater sac separate it from the stomach and the left kidney. It develops in the upper dorsal mesogastrium and remains connected to the posterior abdominal wall, anterolateral abdominal wall and stomach by three folds of peritoneum. The posterior connection is the lienorenal ligament, the anterolateral connection is the

phrenicocolic ligament, and the anterior connection is the gastrosplenic ligament ***(Standring et al., 2005)***.

The lienorenal ligament is formed of two layers of peritoneum. The anterior layer is continuous with the peritoneum of the posterior wall of the lesser sac over the left kidney and is continuous with the peritoneum of the splenic hilum where it runs into the posterior layer of the gastrosplenic ligament. The posterior layer of the lienorenal ligament is continuous with the peritoneum over the inferior surface of the diaphragm and runs onto the splenic surface over the renal impression. The splenic vessels lie between the layers of the lienorenal ligament and the tail of the pancreas is usually present in its lower portion. The length of the lienorenal ligament may vary. Longer ligaments tend to make the spleen more mobile and may predispose it to injury due to rotational shear forces during trauma but also make the mobilization of the spleen easier during surgery. The presence of the pancreatic tail within the lienorenal ligament must be remembered as it can be injured during ligation of the splenic vessels causing pancreatitis or a pancreatic duct fistula ***(Cesta, 2006).***

The gastrosplenic ligament extends between the fundus of the stomach and the hilum of the spleen, and is continuous below with the greater omentum. It consists of two layers of peritoneum, between which pass the short gastric arteries of the

splenic artery, which run to the fundus of the stomach. The structures in the gastrosplenic ligament are the short gastric vessels, left gastroepiploic vessels, lymph vessels, and sympathetic nerves ***(Standring et al., 2005).***

A fold of peritoneum, the phrenicocolic ligament is continued from the left colic flexure to the thoracic diaphragm opposite the tenth and eleventh ribs; it passes below and serves to support the spleen ***(Snell, 2008).***

## IV- Vascular supply and lymphatic drainage:

### A) Splenic artery:

The splenic artery is the largest branch of the celiac trunk. It has a tortuous course as it runs along the upper border of the pancreas ***(Ellis, 2006).***

It lies in multiple loops or even coils which appear above the superior border of the pancreas and descend to lie behind the gland. The splenic artery lies anterior to the left kidney and left suprarenal gland and runs in the lienorenal ligament posterior to the tail of the pancreas. It gives off various branches to the pancreas in its course and gives off short gastric arteries to the stomach just prior to dividing or from its terminal branches. It divides into two or three main branches before entering the hilum of the spleen. As these branches enter the

hilum they divide further into four or five segmental arteries each supply a segment of the splenic tissue. There is a relatively little arterial collateral circulation between the segments, which means that occlusion of a segmental vessel often leads to infarction of part of the spleen. There is, however, considerable venous collateral circulation between the segments, making segmental resection of the spleen practically impossible ***(Standring et al., 2008)*.**

**B) <u>Splenic vein</u>:**

The splenic vein is formed within the lienorenal ligament, close to the tip of the tail of the pancreas, by five or six tributaries that emerge from the hilum of the spleen. The tributaries are thin walled and often spread over several centimeters because the hilum is long and thin. This must be remembered during surgical removal of the spleen because the venous tributaries must be divided close to the hilum to avoid injury to the pancreatic tail. They should be ligated in several groups to prevent the risk of avulsion of the veins from the splenic hilum and consequent profuse bleeding before the resection is complete ***(Moore and Dalley, 2005)*.**

The splenic vein runs in the lienorenal ligament below the splenic artery and posterior to the tail of the pancreas. It descends to the right and crosses the posterior abdominal wall

inferior to the splenic artery and posterior to the body of the pancreas receiving numerous short tributaries from the gland as it does so. It crosses anterior to the left kidney and renal hilum and is separated from the left sympathetic trunk and left crus of the diaphragm by the left renal vessels and from the abdominal aorta by the superior mesenteric artery and the left renal vein. The short gastric and left gastro-epiploic veins drain into the splenic vein through the folds of the gastrosplenic ligament near its origin. It ends behind the neck of the pancreas, where it joins the superior mesenteric vein to form the portal vein ***(Standring et al., 2008).***

**C) <u>Lymphatics of the spleen</u>:**

The splenic lymphatic vessels leave the lymph nodes in the splenic hilum and pass along the splenic vessels to the pancreaticosplenic lymph nodes**.** Spleen lacks afferent lymphatic vessels ***(Balogh et al., 2004).***

**V- <u>Innervation of the spleen</u>:**

The spleen is innervated by the splenic plexus, which consists of branches of the coeliac plexus, left coeliac ganglion and right vagus that accompany the splenic artery. The fibers are mainly sympathetic and terminate around the blood vessels and in the non-striated muscle of the splenic capsule and trabeculae. Most appear to be noradrenergic, vasomotor, and are

concerned with the regulation of blood flow through the spleen. Adrenergic agonists inhibit the concentration of red cells in the splenic blood indicating that sympathetic activity causes an increase in the circulation of the spleen ***(Reilly, 1985).***

# Embryology of the spleen

In the fifth week of gestation, clusters of mesenchymal cells arise in the left side of the dorsal mesogastrium. They enlarge, undergo vascularization, and fuse to constitute a lobulated primitive spleen covered by the primitive coelomic epithelium. Mesenchymal cells give rise to the capsule and the trabecular network of the spleen. The coelomic epithelium provides the serosal peritoneal covering of the spleen**.** Fetal lobulations are lost late in the fetal period but some indentations, or even clefts and lobulations may persist after birth. Moreover, entrapment of the serosa between mesenchymal clusters may give rise to coelomic cysts ***(Skandalakis, 2004).***

The enlarging spleen projects to the left, so that its surfaces are covered by the peritoneum of the mesogastrium on its left aspect, which forms a boundary of the general greater sac. When fusion occurs between the dorsal wall of the lesser sac and the dorsal parietal peritoneum, it does not extend to the left as far as the spleen, which remains connected to the dorsal