

INTRODUCTION

Trauma is the fourth cause of death in the overall population and the first one in individuals below the age of 40. Abdominal trauma can be classified as blunt or penetrating according to the agent and its mechanism of action.

During the last century, the management of blunt force trauma to the spleen has changed from observation and expectant management in the early part of the 1900s to operative intervention for all injuries, to the current practice of selective operative and non-operative management (*Bill Roth, 1991*).

Splenic injury which is often times the first or second most commonly injured solid organ in the abdomen along with the liver. The injury most commonly occurs following blunt trauma due to motor vehicle collisions (driver, passenger, or pedestrian). However, blunt splenic injury can also result from falls, sport-related activities, or assault (*Renzulli et al., 2010*).

Non-operative management (NOM) has become the standard of care for the hemodynamically stable patient with a blunt splenic injury. Patients who have peritonitis or those who are hemodynamically unstable with evidence of intraperitoneal hemorrhage a positive focused assessment with sonography for trauma (FAST) examination result or positive *Diagnostic*

peritoneal lavage (DPL) should undergo immediate exploratory laparotomy (Marmery et al., 2007).

The current non-operative paradigm in adults was stimulated by the success of non-operative management of solid-organ injuries in hemodynamically stable children *(Mayglothling, 2009).*

Non-operative management is the treatment of choice for grade I, II and III blunt splenic injuries and the average hospital stay is lower in the NOM group than in the operative management group and it requires significantly fewer transfusions, and few patients in the NOM group require admission to the intensive care unit. Splenectomy was the chosen technique in patients who met exclusion criteria for NOM, as well as for patients with grade IV and V injury *(Cirocchi et al., 2014).*

Non-operative management represents the progression of save our spleens (S.O.S) concept, which was initially used for children and later on extended to adults *(Wallis et al., 2010).*

The advantages of non-operative management include lower hospital cost, earlier discharge, avoiding non therapeutic celiotomies (and their associated cost and morbidity), fewer intra-abdominal complications, and reduced transfusion rates associated with an overall improvement in mortality of these injuries *(Clancy et al., 2006).*

AIM OF THE WORK

The aim of this study is to focus on the conservative measures in treatment of splenic injuries in blunt trauma to the abdomen.

Chapter (1)

ANATOMY OF THE SPLEEN

The spleen consists of a large encapsulated mass of vascular and lymphoid tissue situated in the left upper quadrant of the abdominal cavity between the fundus of the stomach and the diaphragm. 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 with the inferomedial aspect being influenced mostly by the neighboring splenic flexure of the colon, the right kidney and stomach. Its long axis lies approximately in the plane of the tenth rib. Its posterior border is 4cm from the mid-dorsal line at the level of the tenth thoracic vertebral spine. Its anterior border usually reaches the mid-axillary line (*Gray, 2005*).

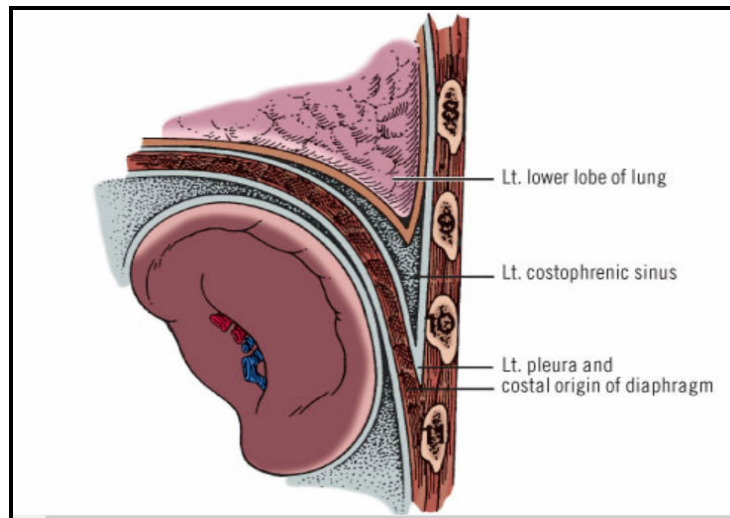


Figure (1): Location of the spleen (*Skandalakis et al., 2014*).

The spleen, in healthy adult humans, is approximately 7 centimeters to 14centimeters in length. It usually weighs between 150grams and 200grams (*David et al., 2009*).

Development:

The spleen develops in the cephalic part of dorsal mesogastrium (from its left layer; during the sixth week of intrauterine life) into a number of nodules that fuse and form a lobulated spleen. Notching of the superior border of the adult spleen is evidence of its multiple origin (*Sadler et al., 2009*).

Surface anatomy of the spleen:

The spleen lies beneath the ninth, tenth and eleventh ribs on the left side. Its surface markings can be delineated on the lower posterior thoracic wall by defining its axis, which extends from a point 5 cm to the left of the midline at the level of the tenth thoracic spine, and passes laterally along the line of the tenth rib to the midaxillary line (*Schwartz, 2015*).

Surfaces and borders of the spleen:

The spleen has a superolateral diaphragmatic and an inferomedial visceral surface. There are superior and inferior borders and anterior and posterior extremities or poles. 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 the 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 (*Gray, 2005*).

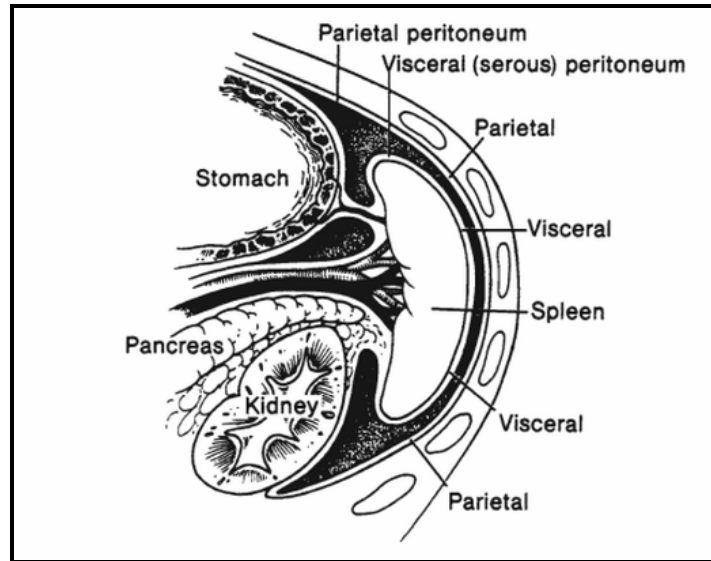


Figure (2): Sagittal view of peritoneum covering the spleen (*Skandalakis et al., 2014*).

The visceral surface faces inferomedially towards the abdominal cavity and is irregular. It is marked by gastric, renal, pancreatic and colic impressions. The gastric impression faces anteromedially and is broad and concave where the spleen lies adjacent to the posterior aspect of the fundus, upper body and upper greater curvature of the stomach. It is separated from the stomach by a peritoneal recess, which is limited by the gastrosplenic ligament (*Tarantino et al., 2011*).

The renal impression is slightly concave and lies on the lowest part of the visceral surface. It is 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 splenorenal ligament (*Gray, 2005*).

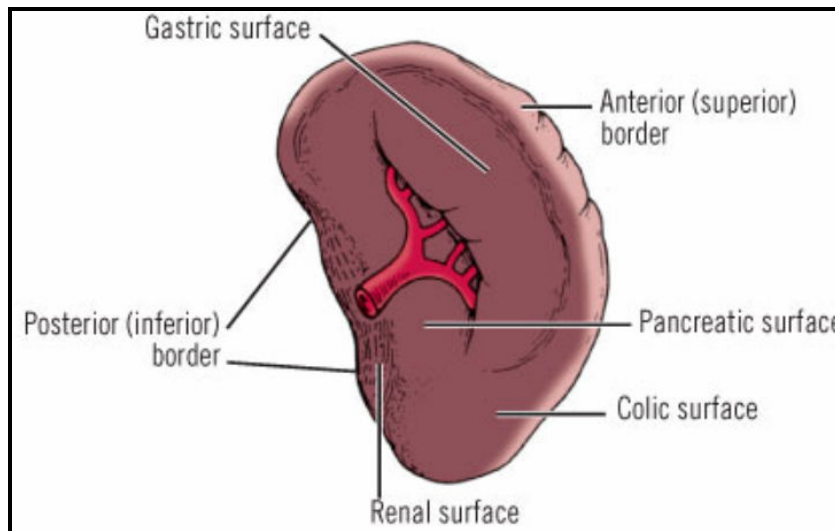


Figure (3): Surfaces of spleen (*Skandalakis et al., 2014*).

The hilum can be found on the inferomedial part of the gastric impression. The hilum transmits the splenic vessels and nerves and provides attachment to the gastrosplenic and splenorenal (lienorenal) ligaments (*Snell et al., 2007*).

The spleen's superior border separates the diaphragmatic surface from the gastric impression of the visceral surface and often contains one or two notches, which are particularly pronounced when the spleen is greatly enlarged (*Tarantino et al., 2011*).

The inferior border separates the renal impression from the diaphragmatic surface and lies between the diaphragm and the upper part of the lateral border of the left kidney. It is more blunt and rounded than the superior border and corresponds in position to the eleventh rib's lower margin. The posterior extremity, or superior pole, usually faces the rounded vertebral column. The anterior extremity, or inferior pole, is larger and less angulated than the posterior extremity and connects the lateral ends of the superior and inferior borders. It is related to the colic impression and may lie adjacent to the splenic flexure and the Phrenicocolic ligament (*Gray, 2005*).

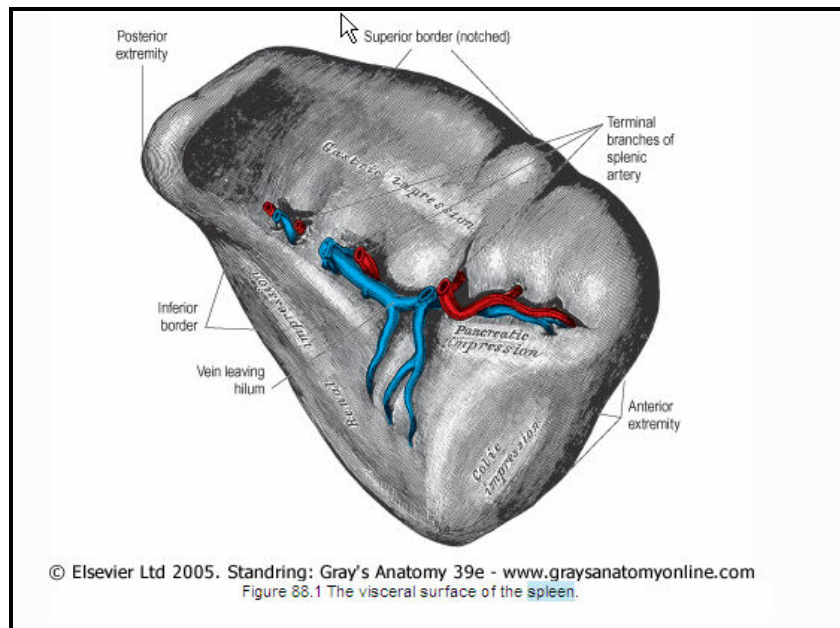


Figure (4): The visceral surface of the spleen (*Skandalakis et al., 2006*).

Ligaments of the spleen:

Several ligaments maintain the spleen in its fixed position in the left upper quadrant. Three of these ligaments are virtually always present and two may be present to variable extents, depending on the individual patient and the disease process. The first ligament that is constant is the gastro-splenic ligament, which is a left-sided superior extension of the greater omentum along the proximal greater curvature of the stomach. Within this area supplied by the left gastroepiploic vessels and short gastric vessels that branch to the upper pole of the spleen and often provide the upper two thirds of the spleen with an alternative blood supply (*Gray, 2005*).

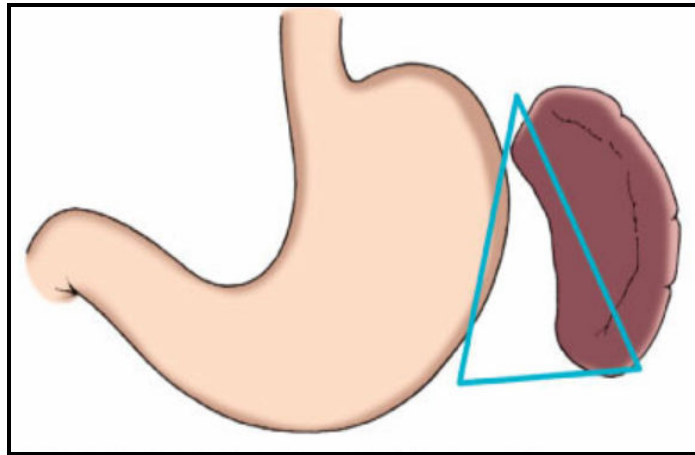


Figure (5): The gastrosplenic ligament (*Skandalakis et al., 2006*).

The second and very important ligament is the lienorenal ligament, which runs parallel to the posterolateral border of the spleen and attaches to the superior pole of the left kidney. This ligament is divided when mobilizing the spleen during splenectomy and allows reflection of the spleen with or without the tail of the pancreas medially. The splenocolic ligament is short and may be avascular or have small blood vessels that go from the inferior tip of the spleen to the splenic flexure of the colon. This ligament may be divided by cautery or may have vessels that need to be controlled with ties or clips during mobilization of the splenic flexure of the colon (*Michael et al., 2006*).

Two ligaments that are variably present are the splenoportal attachments and the splenophrenic attachments. The free part of the greater omentum may have variable

association with the splenic capsule along the inferior pole. There are often small vessels that can be controlled by electrocautery. There may be direct ligaments connecting the spleen to the diaphragm, identified as splenophrenic ligaments. These typically are present to a greater degree when the spleen is diseased or enlarged. They may be avascular or may have branches of vessels parasitized from the diaphragm blood supply, especially with large spleens (*Michael et al., 2006*).

The phrenicocolic ligament extends from the splenic flexure of the colon to the diaphragm at the level of the eleventh rib. It extends inferiorly and laterally and is continuous with the peritoneum of the lateral end of the transverse mesocolon at the lateral margin of the pancreatic tail, and the splenorenal ligament at the hilum of the spleen. If the peritoneal attachments of the spleen are not recognized surgery may risk injury to the splenic capsule and subsequent serious bleeding. Downward traction on the phrenicocolic ligament during handling of the descending colon, especially during mobilization of the splenic flexure, may cause rupture of the splenic capsule. This is less likely if traction on the phrenicocolic ligament is made laterally or medially (*Al Ameen, 2013*).

The superior border and anterior diaphragmatic surface are often adherent to the peritoneum of the greater omentum. Medial traction on the omentum during surgery may cause capsular injury which is less likely if any limited traction

required is applied inferiorly. The diaphragmatic surface of the spleen is occasionally adherent to the peritoneum over the inferior surface of the diaphragm. These adhesions often occur after inflammation in the spleen but may also be present congenitally (*Gray, 2005*).

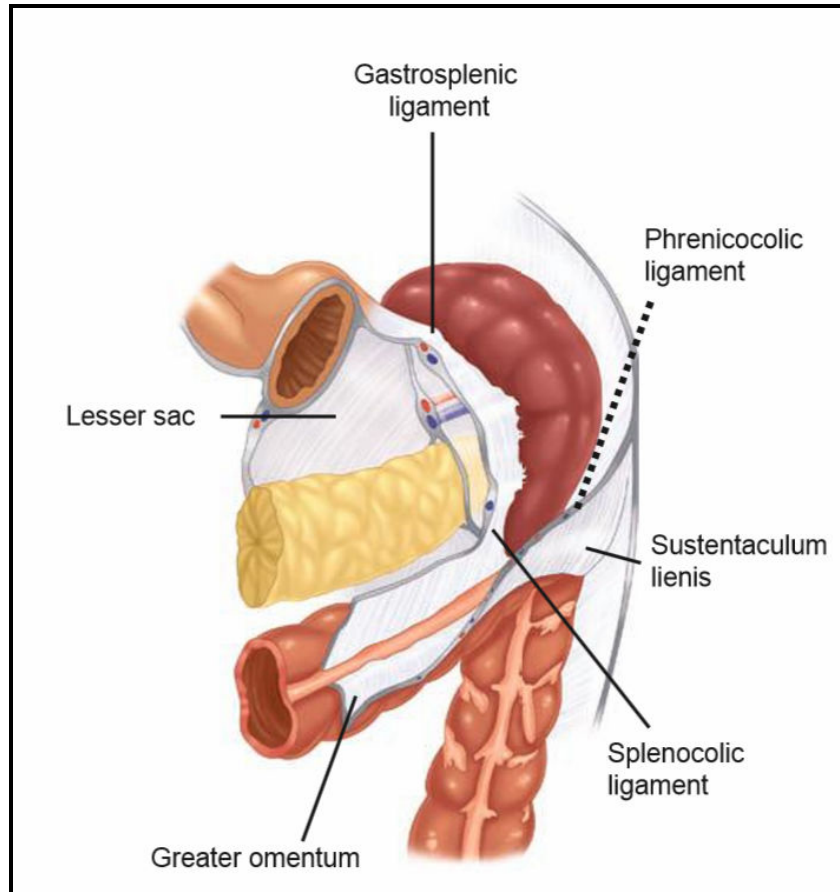


Figure (6): Suspensory ligaments of the spleen (*Schwartz, 2015*).

Segmental Anatomy:

The spleen is supplied by the terminal branches of the splenic artery. It is commonly considered that as the splenic artery approaches the spleen it divides into a superior and inferior terminal branch, in some cases middle terminal artery is also present. The terminal branches undergo several subdivisions, finally giving the hilar arteries which penetrate into the spleen. The branches of splenic artery entering into spleen through poles of the spleen are called polar arteries i.e. superior and inferior polar arteries (*Susan, 2008*).

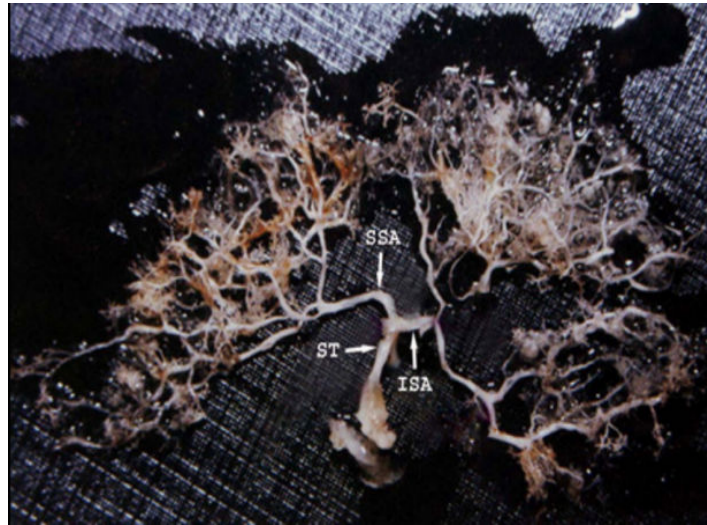


Figure (7): Two divisions of splenic artery

ST: Splenic Trunk.

SSA: Superior Splenic Artery.

ISA: Inferior Splenic Artery. (*Al Ameen, 2013*).

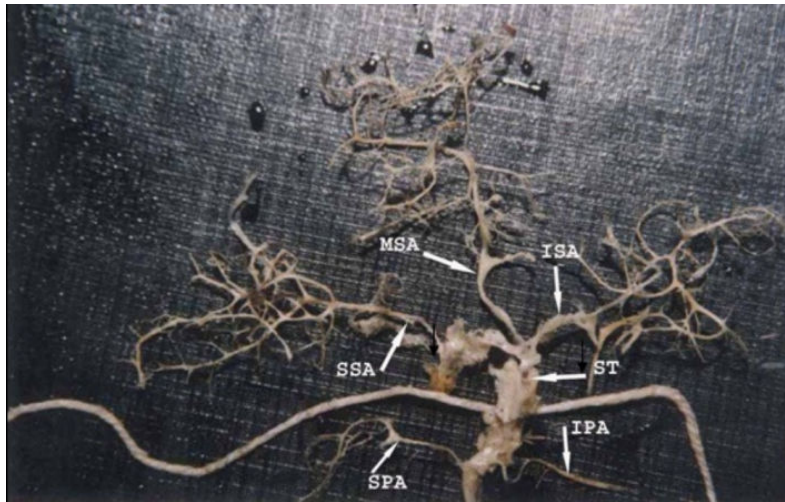


Figure (8): Three divisions of splenic artery

ST: Splenic Trunk.

SSA: Superior Splenic Artery.

ISA: Inferior Splenic Artery. (*Al Ameen, 2013*).

Since the pioneering studies of Kyber, numerous researches have shown that the spleen is divided into vascular compartments, with each compartments or segment being supplied by segmental artery. The spleen shows segmentation due to the fibrous septae. However, the nature and precise pattern of the arterial splenic segments are still controversial. In addition to its basic interest, research on this topic could increase the success of partial splenectomies, which are specially indicated in some surgical repair of the spleen in children (*Al Ameen, 2013*).

The splenic artery trunk was bifurcated in 80%, trifurcated in 16.66% and quadrifurcated in 3.3 %. Lobar artery was bifurcated in 63.33%, trifurcated in 33.33 and

quadrifurcated in 3.33%. Segmental artery was bifurcated in 93.33% and trifurcated in 6.66 % (*Morita, 2007*).

The number of segments or segmental arteries varies considerably from three to eight segmental arteries, 83% of the spleens has polar arteries. The vasculature of each segment appears to be largely independent of that of its neighboring segments (*Skandalakis et al., 2006*).

There is confusion about the terms splenic lobe, pole, and segment. Extrasplenic bifurcation of the splenic artery will produce two lobes, superior and inferior. However, further bifurcation or trifurcation often occurs and this gives rise to the vasculature of segments and poles. The term segments can be used when referring to splenic parts separated by avascular planes, elsewhere called lobes. In surgery (splenic segmentectomy not lobectomy or polectomy) (*Skandalakis et al., 2006*).

The planes separating segments or subsegments are usually obliquely situated with respect to the long axis, and often do not traverse the full thickness of the spleen from the visceral to the parietal surface (*Chakravarty et al., 2003*).