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Saint Jerome at Prayer: Splenic Rupture After Blunt Trauma

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Abstract

Blunt trauma when leading to splenic rupture may necessitate splenectomy. Other indications for performing splenectomy are malignancy, benign hematological diseases and iatrogenic injury. Because the spleen plays a major role in filtering encapsulated bacteria from the blood and is important for the antibody response against these bacteria, splenectomy causes an increased susceptibility for invasive diseases with encapsulated bacteria. Specific vaccinations against pneumococci, H. influenzae type b and meningococci are thus indicated. Next to that prophylactic antibiotics are needed during the first period after splenectomy, and ready access to emergency antibiotics in the period afterwards. Raising awareness of both the patients as well as clinicians of the risk of infection and the need for vaccination of these patients is needed.

Introduction and Prologue

One of the four, western Church Fathers was Saint Jerome, who lived in the fourth century. His magnus opus is the translation of the Bible into Latin. After having published this work, at the age of thirty-eight years, he left the public life in Rome and went to Palestine to live an ascetic life in the desert. In the painting of Jheronimus Bosch of Saint Jerome at Prayer (Figure 1), he has taken a prone position, amidst a chaos of strange plants, tree stumps and rocks. He is half-naked, sunken in prayer, with a crucifix in his hands. The lion, the usual attribute of the Saint, has metamorphosed by Bosch into a small pet animal. Although the office of cardinal did not exist in Jerome's lifetime, he is often depicted with a cardinal's hat and robe, referring to his service to the Pope and his posthumous status as a doctor of the church [1].

Many artists have depicted a penitent Saint Jerome, and on a number of those paintings he has a stone in his hand, either held against the sternum or lower below the ribcage. In the (unfinished) painting of Leonardo da Vinci of Saint Jerome, the penance has caused a clearly visible trauma on the lower left side of the chest, the proximity of the spleen (Figure 2). In the Bosch' painting, the bare chest of Saint Jerome shows no visible signs of the regular self-penance with the stone. The impact of the stone on the abdomen caused a blunt trauma, which can lead to rupture of the spleen.

Figure 1: Jheronimus Bosch. Saint Jerome in the wilderness (around 1500). Museum of Fine Arts, Ghent, Belgium.

https://commons.wikimedia.org/wiki/File:Hieronymus_Bosch_012FXD.jpg

Blunt splenic trauma today is commonly caused by car accident victims and may result in extensive internal bleeding [2]. Also bicycle accidents, when the handlebar impacts the left subcostal margin can lead to splenic injury [3,4]. The degree of injury ranges from subcapsular hematoma to splenic rupture [5]. In latter case treatment consists of complete or partial removal of the spleen: splenectomy.

Figure 2: Leonardo da Vinci. Saint Jerome in penitence (ca 1480), Pinacoteca Vaticana, Vatican Museums, Rome, Italy. Saint Jerome, holding a stone in his right hand, clearly shows signs of traumatic injury of the left upper abdominal region.

https://commons.wikimedia.org/wiki/File:Leonardo_da_Vinci,_Saint_Jerome.jpg

The Spleen: Architecture and Function

The spleen is a bean-shaped organ about the size of a fist, located on the upper left side of the abdomen, just below the diaphragm. During an infection, or otherwise during reactivity, the spleen may increase in size and become palpable below the costal margin [6]. The spleen is the largest secondary lymphoid organ of the body and it is estimated that circa 25% of the total number of lymphocytes are present in the spleen. The spleen is surrounded by a solid capsule of connective tissue. From this capsule, trabeculae penetrate the splenic tissue, thereby providing solidity to the organ. Macroscopically, the splenic tissue can be divided into a blood-filled red pulp, and a lymphoid white pulp (Figure 3). The red pulp forms the largest part of the spleen. Microscopically, there is red pulp from open blood sinuses (sinusoids) with tissue strands intertwined (strands by of Billroth) in which especially many macrophages, but also lymphocytes and plasma cells are found. Blood is supplied to the spleen by one large splenic artery. The splenic artery branches through the trabeculae and from the trabeculae, smaller arterioles penetrate spleen tissue. A portion of the blood is poured out directly in the blood of the sinuses, of the red pulp. The largest part of the incoming blood enters the strands of Billroth. While this blood slowly trickles in the direct of the sinuses, the extended macrophage system of the strands of Billroth passes through and is filtered, in order to be discharged again via the sinuses.

The white pulp forms the organized lymphoid compartment of the spleen and consist mainly of T- and B-lymphocytes. The white pulp is organized around the arterioles that invade the spleen tissue from the trabeculae. Surrounding the smaller arterioles, T-lymphocytes are found in the Peri-Arteriolar Lymphatic Sheath (PALS). Also some B-lymphocytes (especially on the periphery of the PALS) and a large number of antigen-presenting cells, dendritic cells are found in the PALS (interdigitating cells) [7]. B-lymphocytes are organized into two distinct compartments: the follicles and the marginal zone (Figure 3). Follicles are located in close proximity of the PALS. Under steady-state conditions, the follicles mainly contain naive B-lymphocytes that express B Cell Receptors (BCR) with IgM (IgM-BCR) and IgD-BCR. Under the influence of antigenic stimulation, germinal centers may develop in the follicles [8]. Follicles that contain one or more germinal centers are called secondary follicles. A Germinal Center (GC) is a temporary microstructure within a follicle where the response of activated B-lymphocytes takes place. The GC has two different functional compartments: the dark zone and the light zone. In the Dark Zone (DZ) the B-lymphocytes are activated with the help of follicular dendritic cells and T follicular helper cells. During the proliferation (clonal expansion) somatic hypermutation may lead to BCR affinity maturation. Terminal B-lymphocyte differentiation will lead to generation of antibody producing plasma cells as well as memory B-lymphocytes. In the light-zone the B-lymphocytes undergo class-switch recombination, generating B-lymphocytes with IgG-, IgA-, or IgE-BCR, capable to differentiate into plasma cells producing antibodies of the corresponding immunoglobulin class.

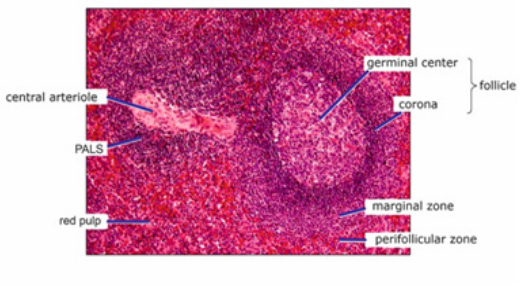

Figure 3: Histological architecture of the spleen. Lymphocytes are mainly localized in the white pulp, which consists of the T-cell area (PALS: peri arteriolar lymphocyte sheath) and the B-cell areas (follicles and marginal zone). The red pulp mainly is composed of venous blood sinuses, with interposed strands of Billroth, where many macrophages are located. Blood vessels open into the perifollicular areas, thus forming a border area between the marginal zone and the rest of the red pulp.

A specific B-cell compartment within the white pulp is the so-called marginal zone. The marginal zone is located mainly around the follicles, and to a much lesser extent to the PALS, and therefore borders the red pulp. The marginal zone is predominantly populated by a particular subpopulation of B-lymphocytes: the Marginal-Zone (MZ) B-lymphocytes [9,10]. MZ B-lymphocytes differ from follicular B-lymphocytes in a number of characteristics. MZ B-lymphocytes (re)circulate less than follicular B-lymphocytes, which is due to the high expression of integrins such as LFA-1 (CD11a/CD18). Many MZ B-lymphocytes express CD27, which is a feature of memory B-lymphocytes [9]. Functionally, MZ B-lymphocytes are mainly involved in immune responses to carbohydrates and other T-cell independent antigens. These antigens are mainly found on the surface of encapsulated bacteria, such as pneumococci and meningococci. Relevant in this context is the high expression on these cells of the complement receptor type 2 (CD21).

The polysaccharides of encapsulated bacteria can activate the complement system, resulting in the deposition of C3d on the polysaccharide [11]. C3d is the ligand for CD21. Simultaneous binding of the polysaccharide by the BCR of a specific B-lymphocyte and co-ligation of CD21 provides the B-lymphocyte with the necessary co-stimulatory signal to drive proliferation and differentiation into antibody producing cell. The importance of CD21 for the response to polysaccharides is illustrated by the finding that B-lymphocytes on children below the age of 2 years, when they are unable to produce anti-polysaccharide antibodies, do not express CD21 [12]. In the marginal zone of the spleen, in addition to the MZ B-lymphocytes, a variable number of recirculating B-lymphocytes, CD4+ T-lymphocytes and a subpopulation of special MZ macrophages are found. Directly around the marginal zone, there is an area in which the central arterioles debouch. This region, known as perifollicular zone, can be considered as part of the red pulp, and is the region where the MZ macrophages can take up and remove bacteria from the circulation. The marginal zone therefore is the structure in the spleen where blood is filtered and the antibody response to encapsulated bacteria initiated.

Splenectomy and its Consequences

Splenectomy can be performed in otherwise healthy patients after trauma when there is splenic rupture. Splenic rupture can occur also

spontaneously in case of splenomegaly. Overall, trauma is the cause for splenectomy in 20% of cases. In 35% of cases, splenectomy is performed because of malignancy, such as Hodgkin's and non-Hodgkin's lymphoma. Benign hematological diseases including idiopathic thrombocytic purpora, spherocytosis and hemolytic anemia, account for 11% of splenectomies. Intraoperative iatrogenic injury of the spleen in 12%, and other causes form 22% of splenectomies [13]. In most cases the splenectomy is complete, although partial splenectomy also is an option or splenic auto transplantation [14] Complications of splenectomy may include venous and arterial thrombosis, pulmonary hypertension, atherosclerosis, but the most prominent, long-term consequence of splenectomy is the increased susceptibility for bacterial infections. In the period following splenectomy there is an increased risk for an Overwhelming Post-Splenectomy Infection (OPSI). The OPSI rate is approximately 4% and mortality can be as high as 50% [15]. The majority of these infections concern invasive Streptococcus pneumoniae infections (70%), as well as infections with Haemophilus influenza type b (10-15%) and Neisseria meningitidis (10-15%). These are all encapsulated bacteria, not surprising giving the central position of the spleen in filtering these types of bacteria from the blood and in generating an anti-polysaccharide antibody response.

Vaccination against encapsulated bacteria therefore is recommended in most guidelines [16]. Recommended vaccines for splenectomy patients include pneumococcal vaccines, which can be either the 23-valent Pneumococcal Polysaccharide Vaccine (PPV) or the 13-valent Pneumococcal Conjugate Vaccine (PCV). After initial PCV vaccination, booster vaccinations with PPV are given every 5 years. This sequence (first PCV, then PPV) can also be reversed (first PPV, followed by booster vaccinations with PPV). Vaccination with the Haemophilus influenzae type b conjugate vaccine and the tetravalent meningococcal ACWY conjugate vaccine also is recommended. Annual seasonal influenza vaccination also is recommended for splenectomized patients. When possible, the first dosage of theses vaccines should be given before the planned splenectomy. Randomized controlled studies on the effectivity of vaccination have not been performed. However, from the data compiled by Casciani et al. it can be concluded that (the various) vaccination (schedules) results in 83% (range 79-88%) protection against OPSI and severe sepsis [17].

The risk for OPSI is the highest immediately postoperatively and during the first year. Therefore, daily antibiotic prophylaxis is recommended during this period. For high risk-groups, such as children under the age of 5 years, vaccination non-responders, or ongoing immunosuppression, antibiotic prophylaxis is continued over a longer period. Patients should be well informed about the characteristics of their condition and the signs and symptoms of sepsis [18,19]. When not on prophylaxis, patients should carry emergency broad-spectrum antibiotics for immediate use in case of the first signs of systemic infection.

Concluding Remarks and Epilogue

Splenic rupture due to blunt trauma may necessitate splenectomy. Because this poses a risk for invasive infections with encapsulated bacteria in the period after splenectomy, adequate vaccination is needed and recommended. Although the uptake of the initial series of vaccinations is high, this is much lower for booster vaccinations [13]. From what is known of the life of Saint Jerome, it is possible that the self-inflicted trauma could have caused splenic injury. It has to be admitted that on the Da Vinci painting, the model for Saint Jerome was a servant of da Vinci, who helped him mixing colors for the frescos of the Santa Maria Novella church. The man developed COPD and severe dyspnea. After his death, Da Vinci performed autopsy and found lung emphysema [20]. The spasmodic contractions of the musculature of face, neck and chest of Saint Jerome thus were not caused by self-inflicted blunt trauma but by the occupational disease of the model.

For obvious reasons, the most common causes of traumatic spleen injuries today (motorcycle or bicycle accidents, contact sports, domestic violence) could not have affected St. Jerome. The invention of the bicycle, by Baron Karl von Dra, would take at least another 14 centuries and automobiles even longer. And the advantage of living as a hermit reduces the risk of becoming victim of domestic violence. Saint Jerome died at the age of 73 years on September 30 in the year 420. In 4th and 5th century Greece, the life expectancy of the wealthy bourgeoisie was a (surprisingly high) 71±13 years [21]. A hermit lifestyle therefore apparently did not have a negative impact on life expectancy.

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GT Rijkers is the sole author of this manuscript.

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