How to Cite
Srikandi, N. M. P. R., & Suardamana, K. (2024). Aspects of immunology and management of post-splenectomy patients. *International Journal of Health & Medical Sciences*, *7*(3), 59-68. https://doi.org/10.21744/ijhms.v7n3.2289

Aspects of Immunology and Management of Post-Splenectomy Patients

Ni Made Putri Rahayu Srikandi
Internal Medicine Specialist Education Study Program, Faculty of Medicine, Udayana University/RSUP Prof. I.G.N.G Ngoerah, Denpasar, Bali, Indonesia
Corresponding author email: srikandiputrirahayu@gmail.com

Ketut Suardamana
Department/KSM of Internal Medicine, Faculty of Medicine, Udayana University/ RSUP Prof. I.G.N.G Ngoerah, Denpasar, Bali, Indonesia

Abstract---*The spleen is the largest lymphatic organ in the body and plays an important role in fighting infection. It works to remove micro-organisms and their products circulating within the bloodstream and produce antibodies to enhance the immune response. The spleen is an intraperitoneal organ that performs vital haematological and immunological functions. It maintains both innate and adaptive immunity and protects the body from microbial infections. Splenectomy is associated with an impairment in immunoglobulin production, antibody-mediated clearance, and phagocytosis leading to an increased risk of infection and sepsis. Overwhelming post-splenectomy infection (OPSI) is a syndrome of fulminant sepsis occurring in splenectomized (asplenic) individuals that is associated with high mortality and morbidity. Early identification of the at-risk patient, early blood cultures before antibiotic administration, and sepsis bundles should be utilized in these patients. Prompt management and aggressive treatment can alter the course of disease in the at-risk splenectomized patient. Overwhelming post-splenectomy infection can be prevented through vaccination and patient education.*
Keywords---*OPSI, post-splenectomy, sepsis, spleen, vaccine.*

Introduction

The spleen or spleen is the largest lymphoid organ in the body which has the function of filtering blood and coordinating immune responses. Lien is responsible for filtering red blood cells, antigen-antibody complexes, apoptotic bodies, and other damaged cells and regulating immune homeostasis through its ability to connect innate and adaptive immunity in protecting against exposure to infection. The spleen consists of 3 parts, namely the white pulp (pulpa alba) which is the immune system to fight infection, the red pulp (pulpa rubra) is responsible for removing unnecessary materials from the blood such as damaged red blood cells and the marginal zone is the area located in the between the white pulp, *Periarteriolar Lymphoid Sheath (PALS)* and the follicles. The zona marginalis functions as a filter for antigens and pathogens in the systemic circulation and plays an important role in fighting antigens. White pulp is lymphatic tissue consisting of lymphocytes and macrophages. The red pulp consists of venous sinuses and splenic medulla which consists of red blood cells, macrophages, lymphocytes, plasma cells and granulocytes. Special innate immune cells such as B cells, *Natural Killer (NK)* cells, and macrophages reside in the spleen. The spleen remains the only organ in the body that is capable of activating the immune system to eradicate encapsulated bacteria. In the spleen, there is tolerogenic immunity such as $CD8^+$ Treg cells, $F4/80^+$ macrophages, $CD68^+F4/80^+$ red pulp macrophages, $CD169^+$ metallophilic macrophages, $CD8^+CD205^+$ splenic dendritic cells and NKT splenic cells which express chemokines that are regulated by normal T cell activation. expressed and secreted. Splenocytes are extra-thymic autoimmune regulatory gene-expressing cells that regulate the expression of tissue-specific antigens to confer peripheral immune tolerance. Thus, the spleen provides an appropriate site for fighting

ISSN 2632-9433
Submitted: 09 April 2024 |Revised: 18 May 2024 | Accepted: 27 June 2024

autoimmunity. Splenectomy in research animals and humans results in overwhelming infections, especially if infected with encapsulated bacteria (Aliyu et al., 2021; Wintrobe, 2009; Haley, 2017).

The spleen can enlarge in certain circumstances to carry out an adequate cleaning function. Splenic dysfunction is defined as hyposplenism where the disorder is caused by several hematological and immunological diseases. The term asplenia refers to the absence of the spleen due to a congenital condition, post-splenectomy surgery due to trauma or haematological disease and has a higher risk of getting a fatal infection (Vagholkar, 2020). Splenectomy is performed as a life-saving procedure in trauma conditions, a therapeutic procedure in haematological conditions and malignancy. The incidence of splenectomy occurs around 6.4-7.1 per 100,000 per year in the world. Morris and Bullock et al were the first to provide evidence that splenectomy was associated with an increased number of infections and impaired immunity to fight infection. Reports about OPSI began to appear and it became clear that splenectomy was associated with impaired antibody synthesis and production, in addition to other immunological disorders. Prevention through vaccination and antibiotic prophylaxis is the basis of the management of patients who have undergone splenectomy or experienced hyposplenism (Di Sabatino et al., 2011; Luu et al., 2019). The immunological consequences after splenectomy have not been fully explained, so this literature review aims to determine the immunological aspects and management of post-splenectomy patients.

Lien anatomy

The spleen is covered by a 1-2 mm thick connective tissue capsule containing afferent, efferent blood vessels and nerves. From the capsule covered with a thin layer of peritoneal mesolithium, several trabeculae arise and divide the splenic organ into many small but connected compartments. The splenic parenchyma is formed from three types of tissue, namely red pulp tissue, white pulp and marginal zone which is believed to be the initiation area for antigen capture (Luu et al., 2019; Tahir et al., 2020).

The red pulp zone constitutes 75% of the total splenic volume and is involved in erythrocyte maintenance, absorption/storage of cells including erythrocytes, granulocytes and platelets, and iron storage. In the red pulp zone, the spleen is formed from the embryo. The reticular tissue contains splenic sinusoids, splenic cords and perisinusoidal macrophages. Sinusoids have thin walls lined with endothelial cells and no endothelial cavity. In addition, endothelial cells contain the CD8 antigen, usually found in cytotoxic T cells, which may be important in the recognition of infected cells and foreign antigens. The sinusoids are supported by splenic cords (Billroth) which are composed of collagen fibres, reticulin fibres, fibroblasts, lymphocytes and macrophages. The white pulp zone is primary lymphocytic consisting of the remaining 25% of the splenic volume containing B lymphocytes and some T-lymphocytes (Aliyu et al., 2021; Luu et al., 2019; Tahir et al., 2020).

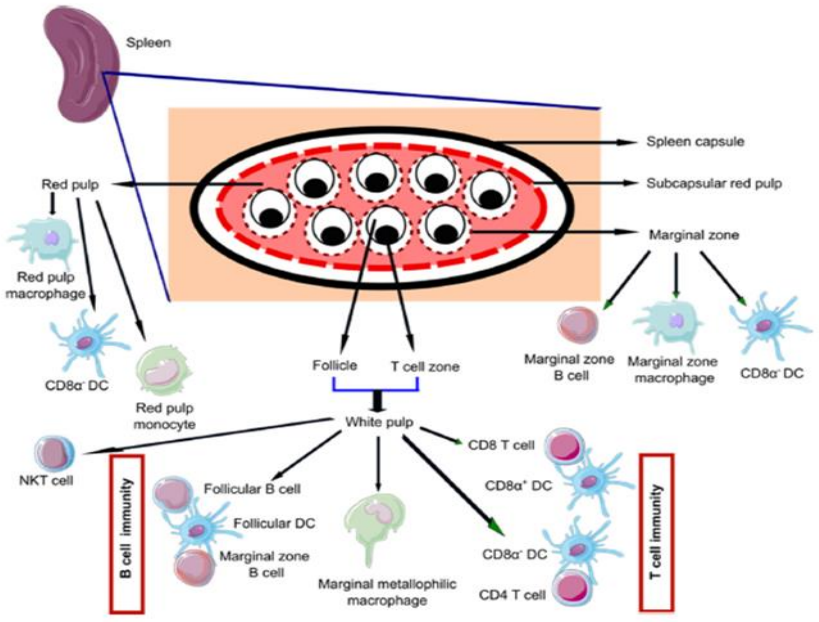

Figure 1. Microanatomy of Lien (Aliyu et al., 2021)

Immunology and Spleen Function

Spleen physiology relates to the role of the human circulation and immune system. As an essential lymphoid organ of the body, the spleen has an important role in the human body's defence against foreign particles and pathogens. The spleen consists of three interrelated compartments, namely the red pulp, white pulp and marginal zone compartments. The red pulp is a sponge-like structure filled with blood that flows through the sinuses and chordate. The white pulp is distributed along the central arterioles which are branches of the splenic artery. T lymphocyte cells form a thin layer around the central arterioles and also surround the B lymphocyte cell follicles. This thin layer is formed by a dark outer zone called the mantle zone, which contains most of the B lymphocytes and a brighter coloured middle part, namely the germinal zone. is an area of selection for B lymphocyte cells. The marginal zone, which contains memory B lymphocyte cells, is the most peripheral area of the white pulp which is directly adjacent to the perifollicular area. Lien functions as a phagocytic filter that degrades old and damaged cells, solid particles of erythrocyte cytoplasm, and blood-borne microorganisms, and also produces antibodies (Di Sabatino et al., 2011; William & Corazza, 2007).

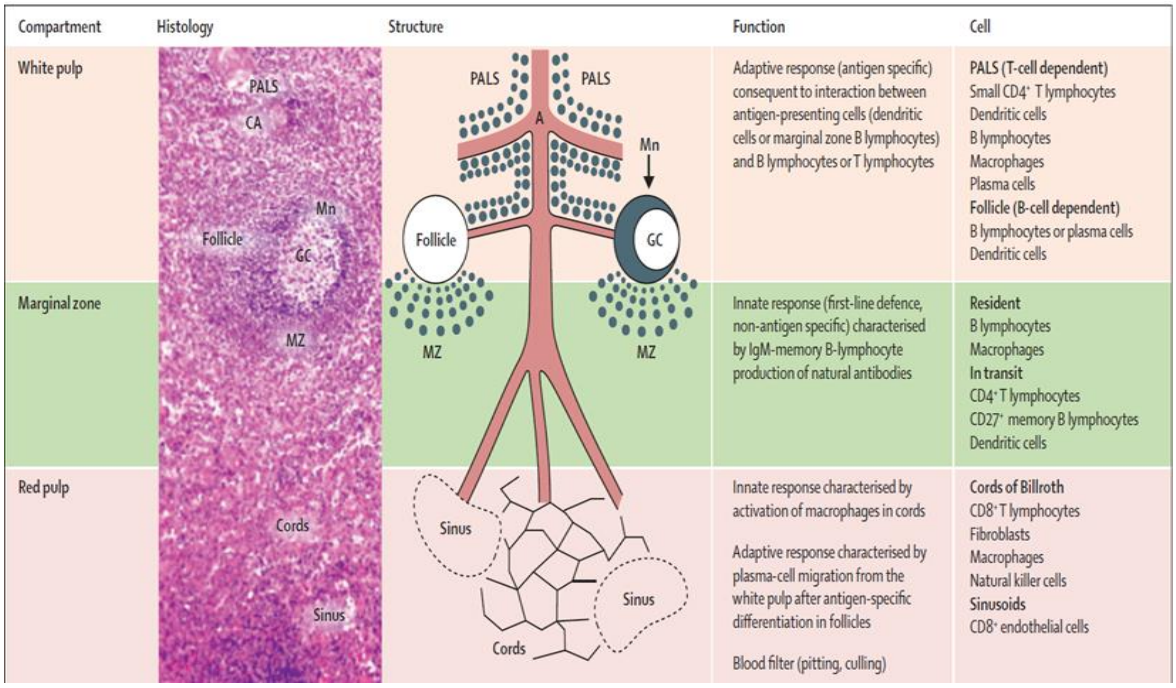

Figure 2. Structure, function and cell population in three compartments (Di Sabatino et al., 2011)

When blood enters the splenic cord from the red pulp and passes through the epithelium into the venous sinus, the flow will slow down and degradation of damaged erythrocytes and bacteria will occur by splenic macrophages. The splenic white pulp is the largest accumulation of lymphoid tissue in the body and functions as a site for the production and activation of lymphocytes, where the lymphocyte cells then migrate to the red pulp to reach the lumen of the splenic sinusoids. Dendritic cells and macrophages in the marginal zone are involved in the capture, processing and presentation of antigens. Splenic macrophages, in particular, are adapted to recognize and destroy opsonized bacteria. Both dendritic cells and T lymphocytes in the spleen show strong immunological activity (Katz & Pachter, 2006).

Antigen enters the spleen through the central arterioles, which terminate in the marginal zone and from here the blood flows in the vascular sinusoids of the red pulp. In the marginal zone and red pulp, the antigen will be processed by macrophages, and a fraction of the antigen can be found in PALS, which is rich in dendritic cells and T lymphocytes. In the case of polysaccharide antigens, they will first be phagocytosed by macrophages in the marginal zone, then carried to the lymphoid follicles where antibody production occurs. In these lymphoid follicles, antigens are stored by follicular dendritic cells for weeks to months. This antigen produces a long-lasting stimulus for memory B lymphocyte cells. In individuals who have been exposed to an antigen, reinoculation with the same

antigen will experience faster formation of immune complexes, which are then immediately phagocytosed and destroyed (Aliyu et al., 2021; Di Sabatino et al., 2011; Katz & Pachter, 2006).

Some bacteria are recognized directly by macrophages, but many require prior opsonization. During opsonization, the bacterial surface is covered by complement or other splenic opsonization molecules such as properdin and tuftsin which then interact with receptors on phagocytes. Bacteria that have undergone opsonization are efficiently eliminated by macrophages in the spleen and liver. However, bacteria that have poor opsonization such as *Streptococcus pneumoniae*, *Neisseria meningitidis*, and *Haemophilus influenzae type b* can prevent complement binding or inhibit the complement in the capsule from interacting with macrophage receptors, resulting in no phagocytic interaction by macrophages. To eliminate these bacteria, during the initial infection, natural antibodies are needed, namely pentameric immunoglobulin M which can facilitate phagocytosis either directly or through complement deposition on the bacterial capsule. These antibodies are produced by a population of memory B cells in the splenic marginal zone (Di Sabatino et al., 2011; Weller et al., 2004).

Antigens that enter the bloodstream will be captured by dendritic cells which act as *Antigen-Presenting Cells (APC).* These cells will activate the T lymphocytes in PALS. T lymphocytes that have been activated will migrate to the marginal zone and form a cluster and this is proven by the presence of clusters of lymphocyte cells that produce cytokines adjacent to B cells. B lymphocyte cells then respond to antigens with the help of T helper lymphocytes that are active in PALS. In the next step, the activated B cells will migrate to the lymphoid follicles and begin to proliferate and form a structure called the germinal center (Di Sabatino et al., 2011).

Once an antibody response is established, B lymphocytes will express immunoglobulin receptors with progressively higher affinity for the antigen. B cells that are unable to recognize antigens will undergo apoptosis. These lymphocyte cells will leave the germinal center and become cells that produce antibodies at high speed in extra-follicular locations such as in the splenic red pulp and the medulla of the lymph nodes. In the germinal center, several B lymphocyte cells do not secrete antibodies but can survive for long periods even without stimulus from antigens. These cells will circulate freely between blood and lymphoid tissue and respond quickly if re-inoculation with the same antigen occurs. These cells are memory cells, which are maintained by antigen stimulation by follicular dendritic cells for months or even years (Aliyu et al., 2021; Di Sabatino et al., 2011).

Splenic macrophages play an important role in the process of destroying bacteria from the blood. For example, pneumococcal polysaccharides can be eliminated very effectively in the spleen, but in the event of splenectomy, this resulted in the accumulation of polysaccharides in the lymph nodes in experiments on mice. There is evidence that germinal zone macrophages can act as APCs against polysaccharides, and present them to B lymphocytes to induce specific anti-polysaccharide IgM antibodies. The key role of the spleen in initiating the immune response against encapsulated bacteria, is indicated by the significant reduction in the number of these IgM memory B cells after splenectomy. This may be caused by a decrease in interferon (IFN) gamma and IL-4 levels in splenectomized patients. An imbalance between Th1 and Th2 type cytokines can be harmful to the host because both cellular and humoral immune responses are decreased. The absence of IFN gamma production can facilitate the entry of intracellular bacteria and viruses due to deficient activation of macrophages or cytotoxic T cells. On the other hand, reduced IL-4 formation can affect antibody production in terms of isotype class exchange and survival of B lymphocytes in the spleen (Aliyu et al., 2021; Di Sabatino et al., 2011; Katz & Pachter, 2006).

Nearly half of the total B cells in the blood express the memory marker CD27 and carry somatic mutations and are therefore considered memory B cells. Two populations of memory B cells have been identified in humans, namely *switch memory B cells* and IgM memory B cells. *Switch memory B cells* are the final product of the germinal center reaction which produces high affinity antibodies and has a protective function against reinfection. Peripheral lymphoid tissue, including the spleen, works on the same principle, capturing antigens from the site of infection and transporting them to lymphocytes, thereby inducing an adaptive immune response (Chaikof & McCabe, 1985; Boam et al., 2017; Bisharat et al., 2001; Davies et al., 2002). These B lymphocyte cells have the unique ability to produce natural antibodies needed to deal with *S. pneumoniae, N. meningitidis,* and *H. Influenzae type B* which can initiate a T cell-independent immune response to infection or vaccination with polysaccharide capsule antigens. A decrease in the number of IgM memory B cells has been reported in children less than 2 years of age due to marginal zone immaturity in patients with immunodeficiency, post-splenectomy and individuals with congenital asplenia or hyposplenism. All these patients have an increased susceptibility to infection by encapsulated bacteria due to their inability to initiate a protective antibody response to the polysaccharide vaccine (Aliyu et al., 2021; Di Sabatino et al., 2011).

Post-Splenectomy immunology disorders

In the post-splenectomy patient population, various abnormalities in immune defenses have been described to contribute to susceptibility to infection. Lien has the function of preventing the transmission of blood-borne pathogens (*encapsulated bacteria*) and is very important in regulating immune homeostasis through its ability to link *innate immunity* (filtration and phagocytosis) and *adaptive immunity* (antibody production). The clearance of antibody- and complement-coated microorganisms by splenic phagocytic cells is very rapid and prevents the spread of infectious organisms to important organs (CNS, kidneys, and lungs). Other post-splenectomy abnormalities are decreased opsonin levels (properdin, tuftsin) and impaired alternative pathway complement activation (Aliyu et al., 2021; Wasserstrom et al., 2008).

Post-splenectomy impairment in antibody production is characterized by decreased serum IgM levels and impaired B cell function in vitro. Splenectomy produces a poor antibody response and indicates an impaired IgM response. In splenectomy conditions there is an increased susceptibility to Streptococcus pneumoniae infection with reduced IgM memory B cells circulating in the splenic marginal zone and identified by the expression of $CD27^{+}$, IgM, and IgD which constitute one third of peripheral B cells. B cell memory is a marker of the adaptive immune response. The final product of the germinal center zone is high-affinity memory B cells. Human memory B cell IgM cannot be detected in post splenectomy patients making the spleen indispensable for their generation and survival and for protection against infection. The fundamental function of this B cell population is to produce a rapid protective response as natural antibodies against T-independent antigens carried by infectious agents such as bacterial polysaccharides and viral repeat surface determinants (Wasserstrom et al., 2008).

Overwhelming Post Splenectomy Infection (OPSI)

OPSI is a serious disease that can progress from mild flu symptoms to fulminant sepsis in a short time. Although relatively rare, OPSI has a high mortality rate with delayed or inadequate treatment progressing with early symptoms (Morgan & Tomich, 2012). Morris and Bullock in 1919 were the first discoverers to provide evidence that splenectomy was associated with an increased number of infections and impaired immunity to fight infection with infects non-splenectomized and splenectomized rodents (Luu et al., 2019). The term OPSI is used to define fulminant sepsis, meningitis, or pneumonia caused primarily by *S. Pneumoniae, N. Meningitidis*, and *H. influenzae type B* organisms in splenectomized or hyposplenic individuals. The incidence of OPSI varies depending on the causative organism and the incidence of serious bacterial infections is approximately 0.23% per year. The most impressive mortality rate is said to be between 38-70% even with adequate therapy. Asplenia patients have varying degrees of OPSI, depending on several factors, the most important being age, indication for splenectomy, and ongoing immunosuppression. The incidence of OPSI occurs in 33% within 10 years after splenectomy and the greatest risk for OPSI occurs in the first 2 years after splenectomy (Morgan & Tomich, 2012; Waghorn, 200; Davidson & Wall, 2001).

Mortality due to OPSI can now be reduced by providing appropriate vaccination and education as well as immediate administration of broad-spectrum antibiotics. The prevalence between children and adults was found to be no different (3.2 vs 3.3%), but the mortality rate in children was higher than in adult patients (1.7 vs 1.3%). The risk of sepsis and death is closely related to the reason for the splenectomy. The most frequent indications for splenectomy are thalassemia major, sickle-cell anaemia, Hodgkin's lymphoma, spherocytosis, splenic trauma, and *idiopathic thrombocytopenic purpura*. 4,15 In one study of 349 episodes of sepsis in patients with asplenia, 57% of infections and 59% of deaths were due to by *S. pneumoniae*. Furthermore, 6% of infections are caused by *H. influenza*, with a mortality rate of 32% (Sinwar, 2014).

The risk of sepsis in asplenia is a permanent condition. Some cases of OPSI have been found to occur 20-40 years after splenic removal. Outside the splenic circulation, antigens consisting of polysaccharides will evoke an immune response. This causes bacteria coated with polysaccharides to evade immune responses and phagocytosis. For this type of bacteria, the body's defense mechanism against bacteria is very dependent on humoral immunity and the production of specific types of antibodies. Sepsis that occurs in asplenia patients can be caused by various kinds of organisms in the form of bacteria, fungi, viruses or protozoa. However, encapsulated organisms are most often associated as a cause of sepsis in splenectomized patients (Morgan & Tomich, 2012).

The diagnosis of OPSI is difficult to establish and requires a careful history to determine the history of splenectomy. The clinical symptoms that may appear initially are mild and non-specific. Symptoms include weakness, myalgia, fever, weight loss, abdominal pain, diarrhea, constipation, nausea and headaches. Prodromal complaints can be followed by symptoms of pneumonia and meningitis. The clinical course can quickly progress to

coma and death within 24-48 hours, caused by shock, hypoglycemia, severe acidosis, electrolyte disturbances, respiratory distress, disseminated intravascular coagulation, and multiple organ failure. The subsequent clinical course often resembles Waterhouse Friderichsen syndrome due to severe *meningococcemia* and at autopsy bilateral adrenal hemorrhages can be found (Morgan & Tomich, 2012; Sinwar, 2014).

The causative mechanisms for OPSI in splenectomized patients are loss of splenic phagocytic function, decreased serum immunoglobulin levels, suppression of lymphocyte sensitivity, or changes in the opsonin system. Encapsulated organisms such as Streptococcus pneumoniae are particularly resistant to phagocytosis, but can be rapidly overcome by the presence of type-specific antibodies, even in small quantities. Without a spleen, proper and rapid production of antibodies to fight new antigens is disrupted so that bacteria can rapidly proliferate. Therefore, the risk of suffering from infectious diseases due to pneumococci is 12-25 times higher in splenectomized patients compared to the general population. Infectious disease in asplenia patients is caused by encapsulated bacteria such as *Streptococcus pneumonia, Neisseria meningitides, Haemophilus influenzae,* and *Streptococcus pyogens, Capnocytophaga canimorsus* which leads to uncontrolled bacterial *overgrowth*, organ dysfunction and failure and death (Morgan & Tomich, 2012; Sinwar, 2014).

Management and Prevention OPSI for Post-Splenectomy Patients

The high mortality rate of OPSI requires preventive strategies in the effective management of splenectomized individuals. The British Committee for Standards in Hematology has established guidelines for the prevention and treatment of infections in the asplenia or hyposplenia population, which can be roughly divided into three categories: patient education, vaccination, and prophylaxis with antibiotics. Patient education is very important, namely explaining that the risk of infection is very high after a patient undergoes a splenectomy, being alert if symptoms of fever, myalgia, headache, stomach pain and vomiting are found, immediately seeking medical treatment if you experience symptoms of infection, animal bites or wounds and routinely to get vaccinated (Tahir et al., 2020).

Management of sepsis due to splenectomy is an emergency action that must be given immediately, *supportive care* is very important to provide. Aggressive optimization of tissue perfusion by administering fluids and vasopressors is the key to OPSI management. *Board spectrum* antibiotics must be given immediately, ideally given after a blood culture examination. The choice of initiation of antibiotics in adults with normal kidney function can use vancomycin 1g every 1 hour and ceftriaxone 2g every 12 hours. In patients who have impaired kidney function with a GFR <60ml/min/1.73m2, the dose of vancomycin can be given at 10-15 mg/kg IV every 12 hours. Vancomycin is good at eliminating gram-positive bacteria including penicillin-resistant *S. Pneumoniae*. Ceftriaxone is used to eliminate gram-positive and gram-negative bacteria for *N. meningitidis* and *H. influenzae*. The use of intravenous immunoglobulin (IVIG) is still controversial in the management of OPSI, some researchers administering immunoglobulin is beneficial at a dose of 0.4 g/kg every 24 hours for 3 days (Sinwar, 2014).

The Australian Therapeutic Guidelines recommend daily antibiotics for at least 2 years post-splenectomy, usually amoxicillin 250-500 mg/day or phenoxymethylpenicillin 250-500 mg twice per day. Amoxicillin is often preferred because it is taken once a day and does not need to be taken on an empty stomach. For patients with penicillin allergies, macrolide antibiotics, such as roxithromycin, are highly recommended (Sinwar, 2014).

Table 1
Antibiotic choices for OPSI (Morgan & Tomich, 2012)

Antibiotic Regimen	
First line regimen	Vancomycin 10-15mg/kg IV every 12 hours if GFR > 60mL/min (estimated 1 g i.v. q 12 hours for a 70 kg adult) PLUS Ceftriaxone 2 g i.v. daily (children = 50 mg/kg i.v. every 12 hours) or Cefotaxime 2 g i.v. every 8 hours (children = 25–50 mg/kg i.v. every 6 hours)
Regimen in case of b-lactam allergy	Vancomycin 10–15 mg/kg i.v. every 12 hours if GFR > 60 mL/min (estimated 1 g i.v. every 12 hours for a 70 kg adult) PLUS Levofloxacin 750 mg i.v. every 24 hours
Add it when it comes to Capnocytophaga canimorsus	Clindamycin 300–600 mg i.v. every 6 hours (children > 1 month old = 25–40 mg/kg/day i.v./i.m. divided Every 6-8 hours with max 4.8 g/day) or Imipinem/cilastatin 500 mg–1 g i.v. every 6 hours (children = 60–100 mg/kg/day i.v. divided every 6 hours with max 2–4 g/day) or Piperacillin/tazobactam 3.375–4.5 g i.v. every 6 hours if CrCl > 40 mL/min (children = 300 mg/kg/day i.v. Every 8 hours)

Long-term antibiotics should be strongly considered for those patients who have additional ongoing immunosuppressive conditions. Patients should maintain an emergency or standby supply of antibiotics. It should be used if symptoms of fever and chills occur (Sinwar, 2014). Prevention of infection and sepsis in post-splenectomy patients must be done by administering vaccination. *The Center for Disease Control and Prevention* recommends that patients undergoing elective splenectomy surgery must receive vaccination 2 weeks (ideally 4-6 weeks) before the splenectomy procedure, but if emergency splenectomy surgery is performed, vaccination must be given 2 weeks after the splenectomy operation. Patients with asplenia must be revaccinated every 3-6 years. Other vaccines that must be given are the *Haemophilus Influenzae type B* vaccine and the *Meningococcal vaccine*. However, this vaccine will not completely protect patients OPSI (William & Corazza, 2007).

Table 2
Prevention of splenectomy patients (Luu et al., 2019)

Vaccination	Pneumococcal	-Pneumococcal 13-valent conjugate vaccine (PCV13) -Pneumococcal 23-valent polysaccharide vaccine (PPSV23)
	Meningococcal	-Monovalent conjugated vaccine against serotype C (MenC) -Tetravalent conjugate vaccine (Men ACWY), -Recombinant meningococcal B vaccine
	Haemophilus influenzae type b Influenza	-Hib vaccine

Pneumococcal vaccination is aimed at the bacterium Streptococcus pneumoniae, where this vaccine contains the polysaccharide form of the pneumococcal capsule. There are 2 types of pneumococci available, namely the 13-valent pneumococcal conjugate vaccine (PCV13), containing 13 types of polysaccharides from various types of S. pneumoniae capsules and the pneumococcal polysaccharide vaccine containing purified polysaccharides from 23 types of pneumococcal capsules (PPSV23). This vaccine is permitted for patients aged >2 years. The strategy for administering the pneumococcal vaccine to asplenia patients is first given the PCV13 vaccine, followed 8 weeks later by administering the PPSV23 vaccine. Some experts recommend repeating 1 dose of PCV13 vaccine after 1 year of

PPSV23 vaccine to restore the memory B cell pool (Lynch & Kapila, 1996; Waghorn & Mayon-White, 1997; Slater et al., 2022).

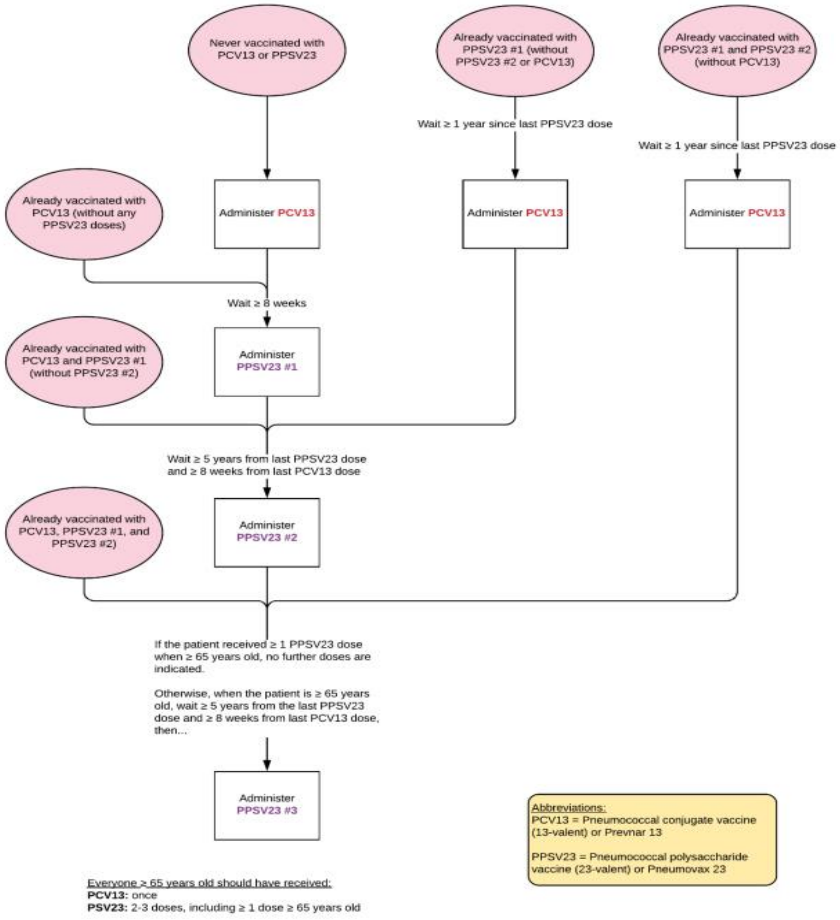

Figure 3. Flow of Pneumoccocal vaccine administration in asplenia patients

In patients who have previously received PCV13, administer PPSV23 at least 8 weeks after PCV13. Repeat one dose of PCV13 if the previous dose was given more than 5 years previously, then give PPSV23 after at least 8 weeks of PCV13 vaccine administration. Administer a second booster dose of PPSV23 vaccine at least 5 years after the first dose of PPSV23. Ideally, patients should receive the pneumococcal vaccine 4 to 6 weeks before undergoing an elective splenectomy. If this is not possible, vaccination must be given at least 2 weeks before surgery in elective cases or at least 2 weeks after surgery in emergency cases. Meningococcus vaccination is recommended for people with asplenia (Rosado et al., 2013; Bonanni et al., 2017; Bronte & Pittet, 2013). In case of emergency splenectomy, vaccination should be given 2 weeks after surgery. Patients with asplenia who have not received the Men ACYW vaccine should receive the Men ACWY primary series of 2 doses given 8-12 weeks apart. Booster doses should be given every 5 years to asplenia patients to maintain high levels of circulating antibodies. Haemophilus influenza type B (Hib) vaccination is used to protect against attacks by H. influenza bacteria. The Hib vaccine should usually be given immediately after a splenectomy. Regarding the timing of administration, Hib vaccination should be given at least 2 weeks before splenectomy in elective cases or at least 2 weeks after surgery in emergency cases (Bonanni et al., 2017; Woolley et al., 2006; Pamela Kusumadewi Putri Thaib & Anny Setijo Rahaju, 2021).

Conclusion

The spleen is essential for the host response to infection by clearing polysaccharide-encapsulated bacteria. This response involves clearing pathogens from the bloodstream as well as accelerating the production of specific antigens. Splenectomy results in an increased risk of sepsis-related complications with a high mortality rate, the most

serious of which is OPSI. The symptoms are non-specific, namely nausea, vomiting, fever and unconsciousness, followed by rapid progression to coma and the characteristics of septic shock. OPSI management must be carried out aggressively.

References

Aliyu, M., Zohora, F., & Saboor-Yaraghi, A. A. (2021). Spleen in innate and adaptive immunity regulation. *AIMS Allergy and Immunology*, *5*(1), 1-17.

Bisharat, N. O. H. L. I. R. R., Omari, H., Lavi, I., & Raz, R. (2001). Risk of infection and death among post-splenectomy patients. *Journal of Infection*, *43*(3), 182-186. https://doi.org/10.1053/jinf.2001.0904

Boam, T., Sellars, P., Isherwood, J., Hollobone, C., Pollard, C., Lloyd, D. M., ... & Garcea, G. (2017). Adherence to vaccination guidelines post splenectomy: a five year follow up study. *Journal of infection and public health*, *10*(6), 803-808. https://doi.org/10.1016/j.jiph.2017.01.006

Bonanni, P., Grazzini, M., Niccolai, G., Paolini, D., Varone, O., Bartoloni, A., ... & Bechini, A. (2017). Recommended vaccinations for asplenic and hyposplenic adult patients. *Human vaccines & immunotherapeutics*, *13*(2), 359-368.

Bonanni, P., Grazzini, M., Niccolai, G., Paolini, D., Varone, O., Bartoloni, A., ... & Bechini, A. (2017). Recommended vaccinations for asplenic and hyposplenic adult patients. *Human vaccines & immunotherapeutics*, *13*(2), 359-368.

Bronte, V., & Pittet, M. J. (2013). The spleen in local and systemic regulation of immunity. *Immunity*, *39*(5), 806-818.

Chaikof, E. L., & McCabe, C. J. (1985). Fatal overwhelming postsplenectomy infection. *The American journal of surgery*, *149*(4), 534-539. https://doi.org/10.1016/S0002-9610(85)80052-0

Davidson, R. N., & Wall, R. A. (2001). Prevention and management of infections in patients without a spleen. *Clinical Microbiology and Infection*, *7*(12), 657-660. https://doi.org/10.1046/j.1198-743x.2001.00355.x

Davies, J. M., Barnes, R., & Milligan, D. (2002). Update of guidelines for the prevention and treatment of infection in patients with an absent or dysfunctional spleen. *Clinical medicine*, *2*(5), 440-443. https://doi.org/10.7861/clinmedicine.2-5-440

Di Sabatino, A., Carsetti, R., & Corazza, G. R. (2011). Post-splenectomy and hyposplenic states. *The Lancet*, *378*(9785), 86-97.

Haley, P. J. (2017). The lymphoid system: a review of species differences. *Journal of toxicologic pathology*, *30*(2), 111-123.

Katz, S. C., & Pachter, H. L. (2006). Indications for splenectomy. *The American Surgeon*, *72*(7), 565-580.

Katz, S. C., & Pachter, H. L. (2006). Indications for splenectomy. *The American Surgeon*, *72*(7), 565-580.

Luu, S., Spelman, D., & Woolley, I. J. (2019). Post-splenectomy sepsis: preventative strategies, challenges, and solutions. *Infection and drug resistance*, 2839-2851.

Lynch, A. M., & Kapila, R. (1996). Overwhelming postsplenectomy infection. *Infectious disease clinics of North America*, *10*(4), 693-707. https://doi.org/10.1016/S0891-5520(05)70322-6

Morgan, T. L., & Tomich, E. B. (2012). Overwhelming post-splenectomy infection (OPSI): a case report and review of the literature. *The Journal of emergency medicine*, *43*(4), 758-763. https://doi.org/10.1016/j.jemermed.2011.10.029

Pamela Kusumadewi Putri Thaib, P., & Anny Setijo Rahaju, A. (2021). Clinicopathological profile of clear cell renal cell carcinoma. *International journal of health & medical sciences*, *5*(1), 91-100.

Rosado, M. M., Gesualdo, F., Marcellini, V., Di Sabatino, A., Corazza, G. R., Smacchia, M. P., ... & Carsetti, R. (2013). Preserved antibody levels and loss of memory B cells against pneumococcus and tetanus after splenectomy: tailoring better vaccination strategies. *European journal of immunology*, *43*(10), 2659-2670.

Sinwar, P. D. (2014). Overwhelming post splenectomy infection syndrome–review study. *International journal of surgery*, *12*(12), 1314-1316.

Slater, S. J., Lukies, M., Kavnoudias, H., Zia, A., Lee, R., Bosco, J. J., ... & Clements, W. (2022). Immune function and the role of vaccination after splenic artery embolization for blunt splenic injury. *Injury*, *53*(1), 112-115. https://doi.org/10.1016/j.injury.2021.09.020

Tahir, F., Ahmed, J., & Malik, F. (2020). Post-splenectomy sepsis: a review of the literature. *Cureus*, *12*(2).

Vagholkar, K. (2020). Dr. Ketan Vagholkar. *International Journal of Surgery*, *4*(2), 218-222.

Waghorn, D. J. (2001). Overwhelming infection in asplenic patients: current best practice preventive measures are not being followed. *Journal of clinical pathology*, *54*(3), 214-218.

Waghorn, D. J., & Mayon-White, R. T. (1997). A study of 42 episodes of overwhelming post-splenectomy infection: is current guidance for asplenic individuals being followed?. *Journal of Infection*, *35*(3), 289-294. https://doi.org/10.1016/S0163-4453(97)93232-1

Wasserstrom, H., Bussel, J., Lim, L. C. L., & Cunningham-Rundles, C. (2008). Memory B cells and pneumococcal antibody after splenectomy. *The Journal of Immunology*, *181*(5), 3684-3689.

Weller, S., Braun, M. C., Tan, B. K., Rosenwald, A., Cordier, C., Conley, M. E., ... & Weill, J. C. (2004). Human blood IgM "memory" B cells are circulating splenic marginal zone B cells harboring a prediversified immunoglobulin repertoire. *Blood*, *104*(12), 3647-3654.

William, B. M., & Corazza, G. R. (2007). Hyposplenism: a comprehensive review. Part I: basic concepts and causes. *Hematology*, *12*(1), 1-13.

Wintrobe, M. M. (2009). *Wintrobe's clinical hematology* (Vol. 1). Lippincott Williams & Wilkins.

Woolley, I., Jones, P., Spelman, D., & Gold, L. (2006). Cost-effectiveness of a post-splenectomy registry for prevention of sepsis in the asplenic. *Australian and New Zealand journal of public health*, *30*(6), 558-561. https://doi.org/10.1111/j.1467-842X.2006.tb00786.x