

## Haematological Parameter Changes in Per-operative Early Ligation of Splenic Artery during Splenectomy in Children with Hypersplenism

\*Sikdar K,<sup>1</sup> Hossain AZ,<sup>2</sup> Mahammad N,<sup>3</sup> Shimon MS,<sup>4</sup> Sarker B,<sup>5</sup> Hasan GJ<sup>6</sup>

### Abstract

**Background:** Hypersplenism is a clinical syndrome characterized by splenomegaly and reduction in the number of one or more types of blood cells and improvement of cytopenias after splenectomy. Splenic function accelerates and even sequestrates up to 90% of body platelets and 40-50% of the Red cells resulting in increased demand of blood and blood product transfusion.

**Purpose:** To evaluate the changes of blood components per-operatively after early splenic artery ligation during splenectomy in children with hypersplenism.

**Methods:** This quasi experimental study was conducted at the Department of Paediatric Surgery, BSMMU, Dhaka, Bangladesh without interrupting standard care practiced in the department during March 2021 to August 2022. Proper clinical history, physical examinations, initial investigation reports and pre-operative blood transfusion data were recorded in a standard data sheet. Per-operative blood samples just prior to splenic artery ligation and at 5th & 30th minutes after arterial ligation before ligation of splenic vein were collected from peripheral venous blood. Samples were analyzed in the department of Laboratory Medicine, BSMMU. Statistical analyses of the result were obtained by using window based computer software devised with Statistical Packages for Social Sciences (SPSS).

**Results:** Total 16 patients undergoing splenectomy was included and mean age was  $9.12 \pm 3.25$  years and range was 6-14 years. No blood and blood products were transfused in these patients up to 7 days prior to surgery. At 5th and 30th minutes after splenic artery ligation the mean haemoglobin change was  $0.69 \pm 0.85$  gm/dl and  $1.53 \pm 2.06$  gm/dl, mean haematocrit change was  $1.85 \pm 2.84$  % and  $4.36 \pm 6.70$  %, mean RBC count change was  $0.27 \pm 0.40 \times 10^{12}/L$  and  $0.58 \pm 0.94 \times 10^{12}/L$ , mean TLC change was  $7.49 \pm 5.98 \times 10^9/L$  and  $7.91 \pm 6.26 \times 10^9/L$ , mean platelet count change was  $46.44 \pm 49.3 \times 10^9/L$  and  $86.7 \pm 86.4 \times 10^9/L$ . All the parameters analysed depicted significant gain of blood parameters proportionate to allocated time after splenic artery ligation.

**Conclusion:** Early splenic artery ligation during splenectomy in hypersplenism results in auto-transfusion and significant increase of different haematological parameters (Haemoglobin, RBC, Haematocrit, Total leukocytes and Platelets) and helps in reducing blood and blood products transfusion in peri-operative period.

[Shaheed Syed Nazrul Islam Med Col J 2025, Jan; 10 (1):47-53]

DOI: <https://www.doi.org/10.69699/ssnimcj2025v10i1s7>

**Keywords:** Hypersplenism, Portal hypertension (PHTN), extra-hepatic portal vein obstruction (EHPVO), splenectomy

1. \*Dr. Koushik Sikdar, Registrar, Department of Surgery, Shaheed Syed Nazrul Islam Medical College Hospital, Kishoreganj, Bangladesh. [sikdar.9463@gmail.com](mailto:sikdar.9463@gmail.com),
2. Dr. AKM Zahid Hossain, Professor, Department of Paediatric Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.
3. Dr. Noor Mahammad, Assistant Professor, Department of Paediatric Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.
4. Dr. Md. Samiul Huq Shimon, Assistant Registrar, Department of Surgery, Kushtia Medical College Hospital, Kushtia, Bangladesh.
5. Dr. Binita Sarker, Resident Surgeon, Department of Gynaecology & Obstetrics, Shaheed Syed Nazrul Islam Medical College Hospital, Kishoreganj, Bangladesh.
6. Dr. Gazi Jakir Hasan, Assistant Registrar, Department of Surgery, Shaheed Syed Nazrul Islam Medical College Hospital, Kishoreganj, Bangladesh.

\*For correspondence

## Introduction

Hypersplenism is a term that appeared first in 1907 in the thesis of Anatole Chauffard and later in the study of Morawitz and Denecked. It is a disorder that includes an enlarged spleen which causes rapid and premature destruction of blood cells. Splenomegaly and decreased single or multiple types of blood cells in peripheral blood are the predominant clinical presentation of hypersplenism and an important finding in the diagnosis of hypersplenism.

Hypersplenism is defined as a clinical syndrome that is characterized by splenomegaly, cytopenias, improvement of cytopenias following splenectomy, hyperplasia of the precursor cells in the marrow.<sup>1</sup> Haematological hypersplenism means the suppression of a single cell type (haemoglobin < 10g/dl, TLC < 4000/mm<sup>3</sup> and/or platelet < 100000/mm<sup>3</sup>) in the presence of increased reticulocyte count (>2.5%). Clinically significant hypersplenism means haematological hypersplenism along with one or more clinical symptoms.<sup>2</sup>

There are many causes of hypersplenism including medical and surgical causes. Among these, portal hypertension due to extra-hepatic portal vein obstruction (EHPVO), portal vein thrombosis, hepatic cirrhosis, thalassemia, hereditary spherocytosis are relatively common in our setting.

The spleen increases 8-10 times its normal size in hypersplenism and can retain blood cells 5.5-20 times higher than the normal level. In hypersplenism, 50-90% of platelets are retained in the spleen.<sup>3</sup> Spleen becomes hyper functioning resulting in removal of even normally functioning cells.

There is no available data for the incidence of hypersplenism as it acts as an umbrella term covering a number of diseases and it is an effect rather than diagnosis. However, a study conducted in University of California shows

that out of 220000 of total admissions, 2056 patients admitted with splenomegaly due to variety of causes, incidence was 0.9%.<sup>4</sup>

For surgeons, hypersplenism is particularly important as low haemoglobin causes increased blood transfusion requirement in peri-operative period, low platelet count makes chance of bleeding higher and low WBC makes the patient more prone to infections. Low platelet count (thrombocytopenia) is more significant because platelet has a shorter life span of 7-10 days in circulation which is reduced to 3-4 days in stored blood. As a result, correction by platelet transfusion is required in the peri-operative period. Two types of platelet products for transfusion are available – Whole blood platelets (derived from four to five whole blood donations) and apheresis platelets (derived from single donor). Though much safer, apheresis platelets are not easily available everywhere and costly. Although there are many debates regarding platelet count for safe surgery, most studies recommend a platelet count of 50000/mm<sup>3</sup> prior to major surgery and 100000/mm<sup>3</sup> prior to neurosurgery & posterior eye surgery.<sup>5</sup> Also, most experts suggest that blood transfusion to be considered if Hb is below 8 gm/dl and indicated if Hb is below 7 gm/dl. However, decision to transfuse blood and/or platelets should be individualized according to patient's clinical condition.<sup>6</sup>

In the setting of significant splenomegaly, initial ligation of the splenic artery prior to dissection of the organ may be advantageous by decreasing splenic distension and limiting bleeding. Early ligation of splenic artery also helps in splenic decongestion and the pooled blood cells to go into circulation resulting in an increase in haematological parameters. *Bhavsar et al.* showed that early splenic artery ligation and splenic decongestion during splenectomy for portal hypertension results in

significant increase in platelet count by auto-transfusion.<sup>7</sup>

This study aimed at evaluating the changes in haematological parameters in cases of early splenic artery ligation during splenectomy in paediatric patients with hypersplenism by serial blood sample collection per-operatively at pre-set intervals.

### *Objective*

To assess the changes in haematological parameters in cases of early splenic artery ligation during splenectomy in children.

### **Methods**

This quasi experimental study was carried out in the Department of Paediatric Surgery of Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh without interrupting standard care practiced in the department from March 2021 to August 2022. A total of 16 paediatric patients were included in this study. Proper history, physical examinations and initial investigation reports were recorded in a standard data sheet. Paediatric patients with features of hypersplenism undergoing splenectomy were enrolled. Patients in whom 30 minutes splenic decongestion time cannot be allowed due to any cause, any blood transfusion during 30 minutes splenic decongestion time, patients having other significant haematological disorders including bleeding disorders, life-threatening conditions or malignancy and patients unwilling to participate were excluded from the study.

Pre-operative blood samples for haematological parameters were recorded. Peripheral blood samples were taken prior to ligation of splenic artery, at 5<sup>th</sup> and 30<sup>th</sup> minutes of splenic artery ligation and were sent for analysis in the Department of Laboratory Medicine, BSMMU, Dhaka, Bangladesh. Statistical analyses of the results

were obtained by using window based computer software devised with Statistical Packages for Social Sciences (SPSS-22).

### *Study Procedure*

The participants were selected on the basis of selection criteria from the admitted indoor patients in the department of Paediatric Surgery, BSMMU. All the patients in this study underwent open splenectomy. Left subcostal incisions or midline incision or a transverse incision starting off the 11th rib extending medially was used. In general, after identification of the splenic artery, a blood sample (5 ml) from peripheral vein was collected (sample 1) and the splenic artery was ligated at this step. The spleen was mobilized by incising the splenocolic and splenophrenic ligaments, the short gastric vessels were divided and ligated, the splenocolic attachments were divided with cautery or ligatures and these procedures allowed the spleen to decongest and a total period of 30 minutes from the time of splenic artery ligation was allowed for splenic decongestion.<sup>8</sup> Blood samples at 5<sup>th</sup> (sample 2) and 30th minute (sample 3) after splenic artery ligation were collected (5 ml each) & then splenic vein was ligated. The spleen was then removed. The rest of the procedures were performed by conventional methods. All three blood samples were sent to Department of Laboratory Medicine, BSMMU for analysis. These samples were analyzed by Haematology autoanalyser (Sysmex XN-2000) and was rechecked manually.

### *Statistical Analysis*

All the data was compiled and sorted properly and analyzed. The numerical data was present by percentage, mean  $\pm$ SD and p value of  $<0.05$  was considered as significant. Statistical analysis of the results was done by using computer based statistical software, statistical package for social sciences (SPSS), application of standard statistical tool.

Changes of pre-ligation values (prior to splenic artery ligation) and at 5<sup>th</sup> & 30<sup>th</sup> minute post-splenic artery ligation was done with paired t test.

### Results

A total of 16 patients who met the required criteria were registered for the study. Table I shows characteristics of the patients. Mean age of the patients was 9.12 ±3.25 years ranging from 6-14 years. Among them 62.5% (10) were male and 37.5% (6) were female.

Table I: Distribution of study subjects according to age and gender (n=16)

Variables	Value
Age range (Years)	6-14
Age (Years) Mean ± SD	9.12 ± 3.25
Male : Female	1.66:1

Out of 16 patients, 81.2% (13) had hypersplenism due to Thalassemia and 18.2% (3) patients had hypersplenism due to portal HTN as shown in Table II .

Table II: Causes of hypersplenism (n=16)

Cause	Number	Percentage (%)
Thalassemia	13	81.2
Portal HTN	3	18.8
Total	16	100

Table III: Changes in haematological parameters after early splenic artery ligation at 5<sup>th</sup> and 30<sup>th</sup> minutes (n=16)

Variables	Before arterial ligation (Mean ±SD)	Splenic decongestion at 5 <sup>th</sup> min			Splenic decongestion at 30 <sup>th</sup> min		
		Mean ±SD	Mean change ±SD	P value	Mean ±SD	Mean change ±SD	P value
Haemoglobin (g/dl)	8.72 ± 2.13	9.41 ± 1.99	0.69 ±0.85	0.005*	10.25 ± 2.00	1.53 ±2.06	0.010*
Haematocrit (%)	27.76 ± 6.64	29.62 ± 5.83	1.85 ± 2.84	0.020*	32.13 ± 5.94	4.36 ± 6.70	0.020*
RBC count (x 10 <sup>12</sup> /L)	3.72 ± 0.83	3.99 ± 0.69	0.27 ± 0.40	0.017*	4.30 ± 0.78	0.58 ± 0.94	0.027*
TLC (x 10 <sup>9</sup> /L)	10.49 ±7 .40	17.99 ± 1.35	7.49 ± 5.98	<0.001*	18.41± 11.13	7.91± 6.26	<0.001*
Platelet count (x 10 <sup>9</sup> /L)	197.94 ± 132.34	244.38 ± 150.29	46.44 ± 49.3	0.002*	284.69 ± 157.05	86.7 ± 86.4	0.001*

Table III shows the changes of mean values of haematological parameters before early splenic artery ligation and 5<sup>th</sup> and 30<sup>th</sup> minutes after arterial ligation. All the mean changes were statistically significant at both 5<sup>th</sup> and 30<sup>th</sup> minutes.

Among all the patients, only 3 received per-operative transfusion of fresh whole blood after the 30 minutes splenic decongestion time and 2 patients received blood in post operative period. No patients received any transfusion 7 days prior to surgery as evident from table IV below.

Table IV: Blood and blood products transfusion in peri-operative period (n=16)

Variables	Pre-operative (7 days prior to surgery)	Per-operative			Post-operative
		During 30 min. allocated time	After minutes	30 of allocated time	
Fresh whole blood	nil	nil	3		2
PRBC	nil	nil	nil		nil
Platelet	nil	nil	nil		nil

### Discussion

Reduction in one or more of the circulating elements of the blood is often noted in splenic enlargement. Anaemia has been attributed to haemolysis as well as pooling of red blood cells in the enlarged spleen whereas causes of leucopenia and thrombocytopenia in such patients are not well understood. However, thrombocytopenia has been ascribed to bone marrow suppression and to premature destruction of platelets in the enlarged spleen.<sup>8</sup> There is another explanation that circulating platelets enters into the spleen and gets pooled there resulting in thrombocytopenia. Upon entering the spleen, some platelets get trapped and are not exchangeable unless the stimulus is great enough and these serve as to augment the spleen pool.<sup>9</sup>

64% of hypersplenic patients with cirrhotic portal hypertension had more than 2 kinds of cell depletion in peripheral circulation. Among them 43.2% had pancytopenia, 26.7% had thrombocytopenia, 25% had decrease in WBC and 48.3% had decreased RBC.<sup>10</sup>

Splenectomy is regarded as part of therapeutic option in cases of hypersplenism due to portal hypertension and in some instances like hypersplenism due to thalassemia splenectomy serves as a palliative option to improve quality of life of the patients as well as reducing the need of blood transfusion.

There are scanty information and studies regarding per-operative changes of the blood parameters during splenectomy. In one study,

it was observed that, early ligation of splenic artery during splenectomy in patients with hypersplenism due to extrahepatic portal hypertension results in significant gain of platelets.<sup>11</sup> In another study, platelet count was significantly increased at 5<sup>th</sup> and 30<sup>th</sup> minutes after early splenic artery ligation during splenectomy in patients of hypersplenism due to portal hypertension (NCPF, EHPVO or cirrhosis). Splenectomy in hypersplenic patients with cirrhotic portal hypertension is safe and improves all haematological parameters post-operatively with immediate effects.<sup>12</sup> But still, these few studies focused on portal hypertension only and mostly on platelet count.

This study tried to show change of different haematological parameters (i.e. Haemoglobin, Haematocrit, RBC, TLC, Platelet) just before splenic artery ligation and at 5<sup>th</sup> & 30<sup>th</sup> minutes after splenic artery ligation during splenectomy before mobilisation of spleen and ligating splenic vein in patients with hypersplenism.

This study demonstrated changes between mean haemoglobin level just before splenic artery ligation during splenectomy and mean haemoglobin level at 5<sup>th</sup> & 30<sup>th</sup> minutes after splenic artery ligation had been done. Mean change was 0.69±0.85 gm/dl at 5<sup>th</sup> minutes and 1.53±2.06gm/dl at 30<sup>th</sup> minutes. Mean rise of haemoglobin between 5<sup>th</sup> and 30<sup>th</sup> minutes was 0.83±1.39 gm/dl which is equivalent to approximately 1 unit of whole blood transfusion. *Kedia S et al.(2012)* in their study on 33 patients of portal hypertension

undergone splenectomy found that median haemoglobin change was 1.2 gm/dl post-operatively which is close to the result obtained from this study.<sup>12</sup>

In this study changes between mean platelet count just before splenic artery ligation during splenectomy and mean platelet count at 5<sup>th</sup> & 30<sup>th</sup> minutes after splenic artery ligation had been shown. Mean change was  $46.44 \pm 49.3 \times 10^9/L$  5<sup>th</sup> minutes and  $86.7 \pm 86.4 \times 10^9/L$  30<sup>th</sup> minutes. Mean rise of platelet count between 5<sup>th</sup> & 30<sup>th</sup> minutes was  $40.3 \pm 69.1 \times 10^9/L$  which is equivalent to approximately 4 to 8 units of platelet concentrates and was statistically significant. *Bhavsar et al. (2012)* in their study on 54 patients of hypersplenism due to portal hypertension undergone splenectomy also found that mean platelet rise was  $23735 \pm 15417$  per  $mm^3$  at 5<sup>th</sup> min and  $35085 \pm 20458$  per  $mm^3$  at 30<sup>th</sup> minutes which was equivalent to 4 to 6 units of platelet concentrates<sup>7</sup>. Per-operative blood samples showed significant and promising rise of platelets up to 160000/cmm which very much support the purpose of this study.

In this study, mean haematocrit level change was  $1.85 \pm 2.84$  % at 5<sup>th</sup> minutes and  $4.36 \pm 6.70$  % at 30<sup>th</sup> minutes. Mean rise of haematocrit between 5<sup>th</sup> and 30<sup>th</sup> minutes was  $2.51 \pm 4.46$  % which is equivalent to approximately 1 unit of whole blood transfusion. No study was found regarding change of haematocrit to compare. But this change of haematocrit corresponded with the change of haemoglobin and RBC count.

This study showed changes between mean red blood cell (RBC) count was  $0.27 \pm .40 \times 10^{12}/L$  at 5<sup>th</sup> minutes and  $0.58 \pm .94 \times 10^{12}/L$  at 30<sup>th</sup> minutes. Mean rise of haematocrit between 5<sup>th</sup> and 30<sup>th</sup> minutes was  $0.31 \pm 0.62 \times 10^{12}/L$  which is a significant increase in such short period of time. Though no study was found to

compare, but the rise of RBC count was such short time is statistically significant.

In this study changes between mean total leukocyte count (TLC) change was  $7.49 \pm 5.98 \times 10^9/L$  5<sup>th</sup> minutes and  $7.91 \pm 6.26 \times 10^9/L$  30<sup>th</sup> minutes. Mean rise of TLCs between 5<sup>th</sup> and 30<sup>th</sup> minutes was  $0.42 \pm 3.362 \times 10^9/L$ . *Kedia S et al. in 2012* in their study on 33 patients of portal hypertension undergone splenectomy found that median TLC change was  $10.9 \times 10^9/L$  post-operatively<sup>12</sup>. There was significant gain of TLC from baseline to 5<sup>th</sup> & 30<sup>th</sup> minutes after splenic artery ligation state which was close to the results found in above mentioned study. However the change between 5<sup>th</sup> & 30<sup>th</sup> minutes was not much.

In this study, the changes between different haematological parameters at different defined times shows that early splenic artery ligation before ligating the splenic vein during splenectomy in patients with hypersplenism results in significant increase in all the parameters at 5<sup>th</sup> and 30<sup>th</sup> minutes of arterial ligation.

No significant complication was noted at the time of splenectomy as well as per-operative blood sample collection. No study subjects showed any significant post-operative complications during their stay in the hospital.

### Conclusion

Early splenic artery ligation during splenectomy in children with hypersplenism results in auto-transfusion that ultimately culminates into significant changes of different haematological parameters and these can avoid peri-operative transfusions of blood and blood products.

## References

1. Lv Y, Lau WY, Li Y, Deng J, Han X, Gong X, Liu N, Wu H. Hypersplenism: History and current status (Review), Experimental and therapeutic Medicine 2016;12(4):2377-2382
2. Kilambi R, Singh AN, Madhusudhan KS, Pal S, Saxena R, ShalimarDash NR, Shani P. Portal hypertension and hypersplenism in extrahepatic portal venous obstruction: Are they related?. Indian Journal of Gastroenterology 2018; 37(3):202-208
3. Jandl JH, Aster RH, Forkner CE, Fisher AM and Vilter RW. Pooling of Platelets in the Spleen: Role in the Patho-genesis of Hypersplenic Thrombocytopenia. Trans Am Clin Climatol Assoc. 1967; 45(5):645-657.
4. O'reilly RA. Splenomegaly in 2505 patients at a large university medical center from 1913 to 1995. 1912 to 1962: 2056 patients. West j med 1998; 169: 78-87.
5. Estcourt LJ, Malouf R, Doree C, Trivella M, Hopewell S, Birchall J. Prophylactic platelet transfusions prior to surgery for people with a low platelet count. Cochrane Database of Systematic Reviews. 2018(9).
6. Norfolk D. JPAC-Joint United Kingdom (UK) Blood Transfusion and Tissue Transplantation Services Professional Advisory Committee 7.1. 1.2. Red cell transfusion in surgery. Handbook of Transfusion Medicine 5th Edition. London: United Kingdom Blood Services. 2014.
7. Bhavsar MS, Vora HB, Khiria LS, Giriappa VH. Portal Hypertension: Effect of Early Splenic Artery Ligation on Platelets Count During Splenectomy. The Saudi Journal of Gastroenterology 2012; 18(6): 380-383.
8. Jarboe M and Geiger J. Splenectomy. In: Spitz L and Coran AG, editors. Operative Pediatric Surgery. 7<sup>th</sup> edition. Newyork: CRC Press; 2013.p.678-686.
9. Baković D, Eterović D, Saratlija-Novaković X, Palada I, Valić Z, Bilopavlović N et al. Effect of Human Splenic Contraction On Variation In Circulating Blood Cell Counts. Clinical and Experimental Pharmacology and Physiology 2005; 32(11):944-951
10. Lu YF, Li XQ, Han XY, Gong XG, Chang S W. Peripheral blood cell variations in cirrhotic portal hypertension patients with hypersplenism. Asian Pacific Journal of Tropical Medicine 2013; 6(8):663-666.
11. Gazula S, Pawar DK, Seth T, Bal CS, Bhatnagar V. Extrahepatic portal venous obstruction: The effects of early ligation of splenic artery during splenectomy. Journal of Indian Association of Pediatric Surgeons. 2009 Oct 1;14(4):194-9.
12. Kedia S, Goyal R, Mangla V, Kumar A, Shalimar S, Das P, Pal S, Sahnib P, Acharya SK. Splenectomy in cirrhosis with hypersplenism: improvement in cytopenias, child's status and institution of specific treatment for hepatitis C with success. Ann Hepatol 2012; 11(6):921-929