Partial Splenectomy in the Treatment of Splenic Lesions and Disorders in Infants and Children

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Abstract

This study was carried out on 11 infants and children, ranging in age between 26 days and 8 years, with localized benign splenic lesion or splenic disorder indicated for splenectomy. They were one case of wandering spleen, 3 cases of traumatic rupture of the spleen, four cases of thalassemia, one case of Gaucher's disease and one case of splenic cyst. They were treated by partial splenectomy. Lower polar splenectomy was performed in 10 cases while upper polar splenectomy was performed in one case of splenic cyst. All patients passed a smooth post-operative course with no bleeding or life threatening infection. Complications occurred in only 3 cases, one case of traumatic rupture of the spleen suffered in the early post-operative period from atelectasis and left pleural effusion and was treated conservatively while two cases of thalassemia suffered from intra-abdominal collection. In the later two cases, the dexon mesh used to wrap the remaining part of the spleen was accused to invite infection. The platelet count was significantly higher in the early post-operative period (P< 0.001). Three months later, the platelet count was comparable with preoperative value (P> 0.05). There was no increase in the number of pitted cells, Howel-Jolly bodies or Heinz bodies in the early or late post-operative period. The pre-operative serum IgM and IgG levels did not significantly differ from their levels in the early and late postoperative periods (P> 0.05). Tha-lassemic children showed post-operative decrease in transfusion requirements and increased hemoglobin levels. Thus the immunological and hematological functions of the spleen are preserved after partial splenectomy and hence partial splenectomy is considered safe and better alternative to total splenectomy in the treatment of splenic disorders and benign lesions to avoid life threatening infections.

Introduction

The spleen was long believed to be a non-essential organ that could be removed with little consequence. Later, important functions of the spleen have been defined. These include hematopoiesis, antibody production, bacterial clearance and phagocytosis[1]. These functions are more vital as far as the neonates are concerned because the role of the spleen during embryonic life is superseded only by that of the thymus[2,3]. Moreover, the spleen continues to exert its immunological functions, filtration and phagocytosis during infancy and childhood. Thus asplenic infants and children are known to be susceptible to life threatening overwhelming infections[1,2]. These observations have completely changed the traditional approach to the management of splenic injuries and lesions in childhood[4]. Thus, every effort is now directed towards splenic preservation. Different modalities of splenic preservation are known nowadays including spleno-rrhaphy, partial resection of a segment, partial splenic embolization and autogenous splenic implantation[6]. Recently, better understanding of the segmental vasculature of the spleen made partial resection of a traumatized or diseased segment of the spleen possible[6,7,8]. This conservative splenic surgery has become one of the standard procedures in the management of many splenic lesions and disorders[6,7,8].

The aim of this work was to evaluate and clarify that partial splenectomy is possible, safe and a better alternative to total splenectomy in the treatment of splenic lesions and disorders in infants and children to avoid overwhelming post- splenectomy infection.

Subjects and Methods

This study included 11 cases ranging in age between 26 days and 8 years, each with a localized benign splenic lesion or with a splenic disorder indicated for splenectomy. All were subjected to

detailed history taking and thorough clinical examination and were then treated by partial splenectomy. The clinical presentations and indications for partial splenectomy were recorded.

Routine laboratory studies including the hematological picture were carried out. In addition, platelet count and examination of blood film for Heinz bodies, Howell-Jolly bodies and the number of pitted cells were recorded preoperatively and compared with their level in the early and later post-operative period (1 week and 3 month postoperative).[9]

Study of Immunoglobulin M and G (IgM and IgG) was done preoperatively as well as in the early and late post-operative periods.[10] Imaging by abdominal Ultrasonography was done when indicated.

The operative procedure adopted for partial splenectomy is summarized as follows:

1. Ligation of the segmental blood supply to the segment of the spleen to be removed (upper polar or lower polar) which resulted in infarction of that part, with a definite line of demarcation between the healthy and infarcted part. This is based on the understanding of the surgical anatomy of the blood supply of the spleen, which is well known nowadays.[6,7,8] There is a superior and inferior segment of the spleen separated by a relatively avascular plane perpendicular to the axis of the organ. These two vascular territories correspond to the superior and inferior divisions of the splenic artery and the intra-splenic branches of both do not usually anastomose.

   Thus, the segmental blood supply of the spleen is "bisegmental" and in 20% of cases there might be a middle division making the segmental blood supply "trisegmental".[6,7,11]

2. Cut or "splenotomy" was done at the line of demarcation using electrocautery.
3. Control of bleeding from the cut surface of the spleen. This bleeding was usually of 2 sources namely:
   a. Small arterial branches and venous tributaries and these were controlled by transfixation ligation using figure of 8 or running suture. When the bleeding was severe, temporary occlusion of the splenic artery with the thumb and forefinger or by drawing a loop around the splenic artery was used till these vessels were occluded.
   b. Parenchymatous bleeding, usually from the small sinusoids and this was controlled by electrocautery, horizontal mattress suture from one capsular edge of the cut surface to the other edge and the application of available topical hemostatic agents as gelatin sponge (Gelfoam) and/or oxidised cellulose (Oxicell).
4. Wrapping the cut surface and remaining intact part of the spleen by dexon mesh, if available, in addition to the omentum and the spleen was replaced gently in its bed with the adjacent viscera allowed to fall against it. Re-inspection of the spleen after 5-10 minutes was done, during preparation for closure, to ensure that no bleeding has resumed. The peritoneal cavity was drained in all cases for 24-36 hours. All patients were observed in the intensive care unit for at least 48 hours with one unit of cross-matched blood available if needed.

The postoperative course and follow up were recorded.

Results

The clinical varieties of studied patients are presented in table I. They were one case of wandering spleen, 3 cases of traumatic rupture of the spleen, five cases of thalassemia, one case of Gaucher's disease and one case of splenic cyst. They were 3 females and 8 males. The ages of different varieties of cases are shown in table II. Seven cases were treated by partial splenectomy as an elective procedure (cases of thalassemia, Gaucher's disease and splenic cyst), and the remaining 4 cases were subjected to emergency operation (one case of wandering spleen & 3 cases of traumatic rupture) as shown in table III.

Wandering spleen presented as acute abdomen; a picture of internal strangulation and peritonitis. On exploration, the middle part of the ileal loops was found to be gangrenous with perforation and soiling of the peritoneal cavity. The gangrene was due to volvulus of the mid ileal loops which were found amalgamated with a soft tissue mass within it. This mass was found to be a twisted wandering spleen with infarction of its lower two thirds (figure 1). Partial splenectomy was performed after resection of the gangrenous loops with end-to-end anastomosis. The remaining intact healthy part was fixed by multiple

sutures between its capsule and the fundus of the stomach and it was left supplied by the superior polar branch of the splenic artery and short gastric vessels.

The incision for elective procedures was upper left transverse abdominal muscle cutting while for emergency cases, it was an upper right transverse abdominal muscle cutting for the wandering spleen (as it presented as acute abdomen) and an upper mid line incision for two cases of traumatic rupture. The remaining case of traumatic rupture of the spleen was operated upon via an upper left transverse abdominal muscle cutting incision, as it was definitely proved by ultrasonography that the liver was intact and the spleen was the only source of internal hemorrhage.

The percentage of splenic tissue mass removed varied according to the site and extent of the lesion. Resection of the lower 60% of the spleen was done in the case of wandering spleen (figure 1) as it was already infarcted. In cases of traumatic rupture of the spleen, the lower 20 – 40 % of the spleen was removed according to the degree of splenic laceration (figure 2). In cases of thalassemia and Gaucher's disease the lower 40-50% of the spleen was removed (figure 3). In the case of splenic cyst, the cyst was removed with a segment of the upper pole of about 10% of the splenic tissue mass (figure 4). Thus lower polar partial splenectomy was performed in 10 of our study cases (90.9%) while upper polar resection was done in one case (9.1%) (table III).

Blood transfusion was needed for 10 cases during the operative procedure. The baby with splenic cyst was not in need for blood transfusion.

Regarding the hematological data (table IV), a temporary rise in the mean platelet count was found in the early post-operative period when compared with preoperative levels ($P< 0.001$). Three months later, the mean platelet count decreased to near the preoperative levels ($P> 0.05$). Although the number of pitted cells was numerically higher in the early post-operative period; yet, statistical analysis showed no significant differences between the preoperative and both the early and late post-operative mean values ($P> 0.05$ for both). In addition, the percentage of Heinz bodies and Howell-Jolly bodies was less than 1% in all readings.

Recording the hemoglobin percentage of the thalassemic patients before and after the operative procedure revealed a range of 5 – 6 g/dl before and a range of 9-10 g/dl after the procedure. This increase in the hemoglobin level in the early post-operative period could be attributed to the packed red cell transfusion given to these children. . However, in the late post-operative period, the hemoglobin levels showed a stable range from 8-10 gm/dl. Moreover, the transfusion requirements decreased from 20 ml/kg every 2 weeks to about 20 ml/kg every 6-8 weeks.

Early post-operative complication occurred in one child with traumatic rupture of the spleen, who suffered from left pulmonary atelectasis with mild pleural effusion. He was treated conservatively and was discharged free two weeks later. All other patients suffered no complications in the immediate post-operative period and they were discharged free at the 10^{th} post-operative day. On the other hand complications in the late follow up were encountered in 2 cases of thalassemia. One case presented with fever and left subphrenic collection three weeks after discharge. This child was treated by massive antibiotics and while he was prepared for aspiration under sonographic guidance, the collection was drained spontaneously per-rectum and via fistulization into the colon and to the outside through the site of the drain giving a large amount of pus, altered blood and shreds of the dexon mesh. The second patient presented after six weeks by a localized collection in the right side of the lower abdomen, which proved by ultrasonography to be a walled off cyst-like collection stuck to the inner side of the anterior abdominal wall. This case was explored and the collection was drained surgically revealing large amount of serosanguineous fluid which was enclosed within a tough fibrous wall containing part of the dexon mesh.

The pneumococcal vaccine was not available for all cases. It was received by two cases of thalassemia only. However long acting penicillin was advised and was received by all cases.

Table I: Clinical varieties of patients.

Clinical variety	N°.	%
* Wandering spleen	1	9.1
* Traumatic rupture	3	27.3
* Thalassaemia	5	45.4
* Gaucher's disease	1	9.1

* Splenic cyst	1	9.1
Total	11	100

Table II: Age distribution of different clinical varieties.

Age group	No.	%	Clinical variety	Age
Neonate	1	9.1	wandering spleen	26 days
Infants	3	27.3	- splenic cyst - Thalassemia - Gaucher's disease	4 months 9 months 15 months
School age	7	63.6	- Traumatic rupture (3 cases) - Thalassaemia (4 cases)	6,6.5,7 years 6,7,7,8 years

Table III: Type of operative procedure.

Procedure	No.	%
- Emergency - Elective	4 7	36.36 63.64
- Upper polar - Lower polar	1 10	9.1 90.9
Total	11	100

Table IV: Hematological and immunological data before and after partial splenectomy.

	Pre-operative	Early post-operative	Late post-operative
Platelet count			
Mean	212,73	325,00	240,00
SD	46,28	43,76	29,66
t		-5.85*	1.65
p		0.0005	0.057
No. of pitted cells			
Mean	1.23	1.73	1.09
SD	0.65	0.75	0.44
t		-1.67	0.57
p		0.054	0.28
IgM			
Mean	132.73	127.0	126.36
SD	40.07	45.38	38.47
t		0.31	0.37
p		0.37	0.35
IgG			
Mean	1200	1190.9	1195.45
SD	300.83	299.8	198.06
t		0.07	0.04
p		0.47	0.48

t= paired t in comparison with preoperative results.

Discussion:

Since the initial observation of King and Schumacker,[1] who first reported the overwhelming post-splenectomy infection syndrome (OPSI), a number of subsequent studies have demonstrated that splenectomised children have increased susceptibility to serious overwhelming infections mainly caused by pneumococci and meningococci leading to severe pneumonia or meningitis which might end fatally by septicemia, coma and death.[1,2,3,12,13] This overwhelming infection appears to be age related with the younger children having a greater chance of contracting a serious infection and it also appears to be related to the underlying condition for which splenectomy is done.[13,14] Patients with Hodgkin's disease who undergo splenectomy as a staging procedure and patients with hematological disorders like thalassemia have a higher incidence of post-splenectomy infection than do those who require splenectomy for traumatic injuries.[3,13,14,15]

Wandering spleen was the first case reported in this study, the patient was treated by partial splenectomy and actually it was the trigger to initiate and proceed in this work. Splenopexy had been recommended in the past as a treatment for wandering spleen, but the traditional treatment is splenectomy.[16,17,18] On the other hand, in this study, the case of wandering spleen, as previously described, was subjected to partial splenectomy of the infarcted lower two thirds after resection of the gangrenous intestinal loops.

For many years, the most frequent indications for splenectomy in children were trauma and hematologic disease. During the past two decades, the importance of preserving the traumatized spleen in order to maintain host's immunologic response to bacterial challenge has been widely recognized. Likewise incidental splenectomy in infants and children with hematological disorders is similarly avoided whenever possible.[19-22] In this study, 3 cases of traumatic rupture of the spleen were treated by partial splenectomy. Two cases had liver tears in addition to splenic rupture as a source of internal hemorrhage. They were treated by repair of the liver tears and partial splenectomy. The third case had isolated splenic rupture and was treated by partial splenectomy as well as splenorrhaphy of two fissures in the remaining intact spleen. They were discharged free and suffered no problems in the long term follow up. Reviewing the literature revealed that non-operative management have been advocated for splenic injuries in selected cases to avoid OPSI.[19,22] Splenorrhaphy, if possible, will save the child with injured spleen from loss of splenic functions. Partial splenectomy is an established surgical alternative and appears to be gaining popularity.[20,21] However, total splenectomy would be unavoidable if the injury is hilar or the pedicle is completely torn and in this situation, splenic autotransplantation will be the only resort.[19,21,22] In a study from "Mayo-Clinic" the authors in their study on rats, concluded that partial splenectomy is the most appropriate surgical alternative to total splenectomy as it appears to be associated with high antibody titre, better bacterial clearance and increased survival[5].

As far as thalassemia is concerned, splenectomy itself is not curative and it is indicated if hypersplenism occurred leading to frequent blood transfusion.[23,24,25] This will deprive the patient from all immunological functions of the spleen. Moreover, total splenectomy in thalassemia will lead to shift of iron deposition to other vital parenchymatous organs. This arouse the concept of partial splenectomy in selected cases of thalassemia when hemolysis is severe with progressively increasing transfusion requirements.[24,25] In this study the thalassemic children showed higher hemoglobin levels and decreased transfusion requirements after partial splenectomy. It is generally accepted that 40-50% of the spleen is removed in the partial splenectomy procedure for cases of thalassemia.[6,8,11] Clinical and

experimental studies have shown that adequate immunologic functions of the spleen would appear to require preserving around 30% of the splenic tissue mass.[6,11,23] In this study, the amount of splenic mass removed ranged between 40% and 50%.

One case of Gaucher's disease was included in this study and was treated by partial splenectomy to minimize abdominal distension and compression on the diaphragm as well as improving the associated anemia. Rubin and associates have reported the use of partial splenectomy in hypersplenism of Gaucher's disease.[26,27] In their series, seven out of eleven patients had marked improvement in hematological parameters following partial splenectomy. The children grew well following the operation and no infections occurred in 1-3 years follow up.[27] Another series from Los Angeles, California, reported that in many children with Gaucher's disease the spleen may achieve such huge size to comprise 25% of total body weight. Although the traditional treatment by total splenectomy have been successful in alleviating the compression symptoms and the possible hypersplenism, it is commonly followed by accelerated deposition of glucocerebrosides in the liver and bones, with further susceptibility to serious systemic infections. This has provided the rationale for attempts to perform partial splenectomy in those patients.[27,28,29]

Another indication of partial resection of the spleen is localised benign splenic lesion as splenic cyst.[33-36] Splenic cysts of all types are relatively rare and they might be true or pseudocyst. Congenital epidermoid cysts constitute 25% of true non-parasitic cysts and occur primarily in children.[30,31,32,33] These congenital cysts of the spleen are rare and a total of 651 cases have been descried in the literature.[30] Among 500 splenectomies carried out over a 36 years period at the "Mayo Clinic", there were only 4 cases of congenital epidermoid cyst.[30,31] In this work, a case of congenital epidermoid cyst was recorded in a four months old baby. The cyst was excised with a segment of the upper pole of the spleen preserving the rest of the spleen. In a recent report from Boston-Massachusetts, the authors reviewed their series of 19 children with congenital splenic cyst from 1914-1993, to assess the changes in the management of these cases. They reported that all cases treated before 1983 (9 cases), underwent total splenectomy and the remaining 5 cases, between 1983 and 1993, had partial splenectomy or cystectomy.[30,32]

The operative procedure done in this study was disease related. Therefore, lower polar partial splenectomy was done for 10 cases and upper polar partial splenectomy was performed for the remaining one case who had splenic cyst, as it was arising from the upper pole. The sites of ligation of the segmental vessels depend on the mode of branching of the splenic artery, proposed transection site or, in traumatic cases, the nature and the extent of splenic laceration. The main step in lower polar partial splenectomy performed for all cases was ligation of the segmental vessels close to the hilus of the spleen arising from the inferior division of the splenic artery. In one case, this inferior polar branch of the splenic artery was ligated in continuity for more secure hemostasis. The most constant branch of the splenic artery is the superior polar division, which arises one to several centimeters from the hilum as the first branch of the splenic artery before it enters the spleen.[6,8] For lesions of the superior pole, this superior polar artery is doubly tied. For lower polar lesions, if the segmental arteries cannot be identified, some surgeons advised that it might be necessary to tie the main splenic artery distal to the superior polar artery after the latter has been identified.[6] During elective procedure, in 2 cases of the study (1 cases of thalassemia and the case of Gaucher's disease), the splenic artery itself was identified as it courses above the pancreas and a tape was passed around it for temporary occlusion, during the procedure of partial splenectomy. No attempt should be made to isolate the fragile splenic vein, since it will almost invariably result in troublesome venous tear. Some authors might recommend the

use of vascular clamps for temporary occlusion of the splenic artery.[6,8,11,20] However, other surgeons believe that the use of vascular clamps for temporary control of the splenic pedicle is traumatic to the arterial intima and may also result in venous injury.[6] If a choice exists as to which remnant of the spleen can be preserved, we believe that the upper pole is a more suitable one since it can be replaced anatomically in the left upper quadrant against the diaphragm. As previously mentioned in methodology, to control bleeding from the cut surface of the spleen, a figure of 8 or running suture was used. Other procedures like horizontal mattress sutures, electrocautery ball, topical "oxicell" and wrapping the omentum with or without dexon mesh were also used. Other series have used LASER in the splenotomy and metal clips in occluding the mouth of the vessels.[6,7] Modern equipments like CAUSA and Harmonic Scalpel might be also used if available. However we did not depend on these modern tools and we resorted to the basic traditional ways to achieve hemostasis so that the unavailability of this equipment would not be an obstacle in performing the procedure of partial splenectomy especialy in an emergency situation.

It is well known that approximately 30% of circulating platelets are stored in the spleen. With increasing splenic size, this number usually increases. In any patient with asplenia or undergone total splenectomy, the number of platelets may exceed $2,000x10^9$/L.[37] In this work, the early post-operative platelet count was significantly higher than the pre-operative values. In the late post-operative period, although the number was still higher, the difference; was insignificant when compared with preoperative values. In agreement, Brown et al.,[32] found significant elevation of platelet count in the 6th postoperative day compared to the preoperative values. They also found that the platelet count returned to baseline three month later. Same results were confirmed by Kamel et al.,[38] and DeBoer et al.[39]

The elevation of platelet count in the early post-operative period indicates temporary loss of splenic function which returns back to normal 3 month later. Moreover, the comparable number of pitted cells as well as the absence of increased number of Heinz bodies and Howell-Jolly bodies in the peripheral blood indicates adequate phagocytic splenic function.[40,24]

The transfusion requirements of studied thalassemic children decreased after partial splenectomy, Moreover, the hemoglobin percentage increased from 5-6 gm/dl to 8-10 gm/dl after partial splenectomy. This indicates the success of the operation in abolishing the symptoms of hypersplenism. Similarly, Kehila et al., 1994,[41] in their study on thalassemic patients, found a reduction of about half of the transfusion needs after partial splenectomy. They stated that partial splenectomy is indicated to reduce hypersplenism, suppress splenic pain and abdominal distension and above all to preserve both phagocytic and immunologic splenic functions. Tchernia et al., 1993,[24] tried to assess the benificial effect of partial splenectomy in heriditary spherocytosis. They found increase in hemoglobin level, decrease in reticulocytic count and prolonged life span of RBCs. Moreover, they found a normal percentage of pitted RBCs after the operation indicating adequate phagocytic function of the spleen.

It is known from previous studies that after total splenectomy, IgM might be decreased while IgG might be normal or increased.[37,42] In this study, there was no effect of partial splenectomy on the serum levels of IgG & IgM both early and late after the procedure. John et al., 1993,[23] found that after both total and partial splenectomy, the lymphocytes failed to produce IgG in response to Pokeweed mitogen in vitro. However, this ability was restored rapidly after partial splenectomy while it persists up to 10 years after total splenectomy.[23] Clayer et al., 1994,[43] found that the ability of splenic tissue to phagocytose IgG opsonized syngeneic erythrocytes was comparable between partially splenectomized and eusplenic patients. On the other hand, totally splenectomized patients and those after splenic artery ligation had impaired

IgG-mediated phagocytosis. They stated that IgG mediated phagocytosis is proportional to the amount of splenic tissue saved.[43]

Following partial splenectomy, it is generally accepted that long acting penicillin should be given for all cases.[5,44] Moreover, pneumococcal and H. Infleunza vaccine have been recommended for splenectomized children especially those with hematologic disorder. Many authors recommend the administration of the vaccine not only before total splenectomy, but also before partial splenectomy.[5,21,25] This is because overwhelming post-splenectomy sepsis occurred in 1-2% of children following splenectomy for trauma and 40-50% following splenectomy for hematologic disorders.[5,23,25]

The most serious complications following the procedure of partial splenectomy is immediate or delayed post-operative bleeding.[6,8,32] This did not occur in this study. If hemostasis is secure and surgical principles are strictly observed, together with experience and patience of the surgeon, there is no fear of bleeding. The only immediate post operative complication in this series was atelectasis and mild left pleural effusion in a case of traumatic rupture of the spleen and he was discharged free after conservative therapy. On the other hand, in the late follow-up period, two cases of thalassemia suffered from intra-abdominal collection. In both cases the dexon mesh was used in addition to the omentum in wrapping the remaining part of the spleen. The mesh was accused to invite the infection. Thus, from the experience of this study, it is advised that the mesh is better to be avoided and the natural vascularized omentum is definitely a better alternative for wrapping the remaining part of the spleen. Nevertheless, many series reported that many complications may follow the procedure of partial splenectomy exactly like those following total splenectomy.[6,8] They reported that a minimal left pleural effusion is of no concern since it frequently follows any type of major splenic surgery.[6,8] Moreover, subphrenic collection of sterile fluid, which might be infected, and requiring surgical drainage has been reported following total or partial splenectomy.[6,32]

From the above work it is concluded that:

- Partial splenectomy is possible, safe and a better alternative in the treatment of localized benign splenic lesion and splenic disorders in infants and children to avoid overwhelming infection which might occur following total splenectomy.
- The immunological and hematological function of the spleen are preserved to a great extent following partial splenectomy.
- For the operative procedure to be successful, experience, training and good understanding of segmental blood supply of the spleen are needed.
- It is advisable to avoid the use of dexon mesh as it might invite septic collections. The use of the vascularized omentum as a natural wrap is a better alternative.
- The best indications for partial splenectomy are traumatic rupture and benign localised lesions. Cases of thalassemia should be selected, well prepared and strongly protected by pneumococcal vaccine.

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