Does Splenic Preservation Treatment (Embolization, Splenorrhaphy, and Partial Splenectomy) Improve Immunologic Function and Long-Term Prognosis After Splenic Injury?

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Background: To assess the immunologic alteration and long-term prognosis after splenic injury from preservation treatment (PT) (embolization, splenorrhaphy, partial splenectomy) and to compare with splenectomy (SN).

Methods: The long-term prognosis of patients with blunt splenic injury treated at seven tertiary emergency centers in Japan was retrospectively studied. Patients were followed up by telephone interview and written questionnaire. Blood samples and abdominal computer tomography scans were taken from patients who consented, and immunologic indices and the remaining volume of the spleen were measured.

Results: There was no episode of severe infection requiring hospitalization among the 66 SN patients (760 patient-year) and the 34 PT (213 patient-year) patients. Blood tests from 58 patients (24 SN vs. 34 PT) revealed significant differences in platelet count, Howell-Jolly body positive rate (SN 87% vs. PT 3%), white blood cells, total lymphocyte count, T-cell count, B-cell count, and serum IgG level. There was no significant difference in serum levels of IgM or specific IgG antibodies against 14 types of Streptococcus pneumoniae capsular polysaccharide, C3, C4, high-sensitivity C-reactive protein, and B-cell subset (surface marker immunoglobulins: IgA, IgG, and IgM). Most patients had anti-S. pneumoniae antibody levels less than that of the reference level for multiple serotypes (average 3 in SN and 4 in PT). A computer tomography scan was taken from 33 PT patients; the volume of spleen remaining averaged 130 mL (range, 48–287 mL).

Conclusion: PT did not show discernible advantage over SN in immunologic indices including IgM and 14 serotypes of anti-S. pneumoniae antibodies, suggesting prophylactic measures and close follow-up are necessary after PT and SN.

Key Words: Spleen, Trauma, IgM, anti-Streptococcus pneumoniae IgG antibodies, Howell-Jolly body.

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Splenic function is required, and the critical splenic mass that confers immunocompetence needs to be identified.\textsuperscript{14–16}

The present investigation was conducted to study whether splenic PT actually reduces the occurrence of severe infection and is beneficial for maintaining immunologic function. Thus, the long-term prognosis, immunologic function, and volume of spleen remaining in patients after PTs were retrospectively studied, along with those after SN, to evaluate the effects of the different treatment modalities for patients with blunt splenic injury.

**PATIENTS AND METHODS**

A total of 450 patients were treated at seven urban tertiary Emergency Centers in Japan between 1982 and 2005. The period for each hospital had the patients enrolled for ranged from 5 years (from 2000 to 2004) to 21 years (from 1982 to 2002). Among the 450 patients, 362 survived and were discharged from the hospital (Fig. 1). One hundred patients underwent SN, whereas 124 received splenic PT, including 81 with splenic artery embolization and 43 with splenorrhaphy or partial SN. One hundred thirty-eight patients were treated without surgical or radiologic intervention.

One hundred of these patients were contacted by phone. Follow-up was made by telephone interview and/or written questionnaire regarding any complications that had occurred, their general health condition, and any episodes of infection. From this, 58 patients (24 SN and 34 PT) were consented for further consultation and blood sampling, and 33 of the PT patients also agreed to undergo abdominal computer tomography (CT) scans to measure the volume of remaining spleen. Hospital visits for consultation, blood sampling, and CT scan were arranged between June 2006 and May 2007. Written informed consent was obtained for the blood tests and CT. None of these 58 patients had received pneumococcal vaccination before or after their splenic injury, as had been the customary practice in Japan.

Splenic injury was classified using the Japanese Association for the Surgery of Trauma (JAST) spleen injury classification (1997).\textsuperscript{17} In short, the classification is based on form and shape of the injured spleen, obtained from operative and/or diagnostic imaging. Category I (subcapsular) injury consists of subcapsular hematoma or intrasplenic hematoma with intact capsule. Category II (capsular) injury is such that the injury is limited to the capsule and superficial parenchyma (3 mm or less). Category III (parenchymal) injury is divided into four types: (a) simple, (b) transected, (c) complex, and (d) fragmented. Injury to the hilar vessels (HV) is classified as category IV (HV) injury. In general, the severity of injury progresses with category (i.e., category I < II < III). When there are multiple injuries, the more severe category is adopted, with the exception of when an injury is associated with category IV (HV), where both injuries are described (i.e., IIIc + HV).

Blood samples were collected for measurement of complete blood count, Howell-Jolly (H-J) body search, blood chemistry (serum aspartate aminotransferase, alanine aminotransferase, lactate dehydrogenase, alkaline phosphatase, choline esterase, total cholesterol, and total bilirubin), high-sensitivity C-reactive protein (hs-CRP), immunoglobulins (serum IgA, IgG, and IgM), complement (C3, C4, complement hemolytic activity [CH50]), lymphocyte subsets (CD3, CD4, CD8, and CD19), B-cell subsets (surface immunoglobulins: IgA, IgG, and IgM), and specific anticapsular antibodies against 14 serotypes of \textit{S. pneumoniae} (types 1, 3, 4, 5, 6B, 7F, 8, 9N, 9V, 12F, 14, 18C, 19F, and 23F).

Blood smears were stained by the May–Grünwald–Giemsa method for H-J bodies. Lymphocyte subsets and B-cell surface immunoglobulins were measured using flow cytometry. Ig-G antibodies to 14 purified antigens of \textit{S. pneumoniae} were measured by an immunoarray assay technique through a commercially available laboratory service (Specialty Laboratories, Valencia, CA).\textsuperscript{18} All serum specimens were pretreated with pneumococcal cell wall polysaccharide (C-PS) to remove anticell wall polysaccharide-specific antibody. The reference range of the \textit{S. pneumoniae} antibodies was more than 1.0 mg/mL for all serotypes.\textsuperscript{10,18} Serum antibody concentrations greater than 1.0 mg/mL are considered to be protective against invasive \textit{S. pneumoniae} infection.\textsuperscript{18–21}

The section of the body trunk containing the spleen (from the top of the diaphragm to the lower pole of the kidney) was scanned using multidetector-row CT at each hospital. Slice intervals were set at 5 mm, except for three cases that were set at 7 mm. The volume of the remaining spleen was obtained as the sum of its area multiplied by the slice interval ($\Sigma$A $\times$ d; where A = area of the spleen on each slice, d = slice interval). The area was measured by setting the margin of the spleen as the region of interest for each slice.

Numeric values are shown as the mean ± SD. Statistical analysis was performed using SPSS version 13.0J (SPSS Japan Inc., Tokyo, Japan). Unpaired t-tests were conducted to compare the measured values of the SN and PT groups. $\chi^2$ test (or Fisher’s exact test where applicable) was used to compare the presence of H-J bodies between the two groups. Difference was regarded as significant when $p$ values (two-sided) were <0.05.

The protocol was approved by the Institutional Review Board of the Osaka University Hospital and all other participating facilities.
TABLE 1. Patient Demographics

<table>
<thead>
<tr>
<th></th>
<th>Splenectomy</th>
<th>Preservation Treatment</th>
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</thead>
<tbody>
<tr>
<td>No. patients</td>
<td>24</td>
<td>34</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>18/6</td>
<td>25/9</td>
</tr>
<tr>
<td>Age</td>
<td>30.4 ± 13.7</td>
<td>31.7 ± 18.4</td>
</tr>
<tr>
<td>Injury severity score</td>
<td>24.0 ± 14.7</td>
<td>18.0 ± 9.1</td>
</tr>
<tr>
<td>Follow-up years (range)</td>
<td>6.7 ± 5.3 (0.7–18.5)</td>
<td>5.7 ± 4.6 (0.6–19.1)</td>
</tr>
<tr>
<td>No. blood tests</td>
<td>24</td>
<td>34</td>
</tr>
<tr>
<td>No. CT scan</td>
<td>0</td>
<td>33</td>
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TABLE 2. CBC and Howell-Jolly Bodies

<table>
<thead>
<tr>
<th></th>
<th>SN</th>
<th>PT</th>
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<tbody>
<tr>
<td>WBC (per µL)*</td>
<td>6900 ± 2100</td>
<td>5800 ± 1700</td>
</tr>
<tr>
<td>Band (per µL)</td>
<td>330 ± 340</td>
<td>280 ± 240</td>
</tr>
<tr>
<td>Segmented (per µL)</td>
<td>2800 ± 1200</td>
<td>2900 ± 1100</td>
</tr>
<tr>
<td>Lymphocyte (per µL)</td>
<td>2800 ± 1100</td>
<td>2100 ± 850</td>
</tr>
<tr>
<td>RBC (10^6/µL)</td>
<td>4.7 ± 0.31</td>
<td>4.8 ± 0.40</td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>15.1 ± 11.1</td>
<td>14 ± 13.3</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>45 ± 3.6</td>
<td>45 ± 3.7</td>
</tr>
<tr>
<td>Platelet (10^9/µL)</td>
<td>320 ± 55</td>
<td>260 ± 50</td>
</tr>
<tr>
<td>Howell-Jolly body positive</td>
<td>87% (20/23)</td>
<td>3.1% (1/32)</td>
</tr>
</tbody>
</table>

* p < 0.05.
† p < 0.01.
‡ p < 0.001.
§ Smear sample was not suitable for analysis in 3 cases.

RESULTS

Telephone Interview

One hundred patients (66 with SN and 34 with PT) were contacted by phone. Among these SN (760 patient-year) and PT (213 patient-year) patients, there had been no episodes of severe infection requiring hospitalization.

Gender, Age, and Years of Treatment

A total of 58 patients, 24 of whom underwent SN and the other 34 underwent PT, consented for further interview, blood tests and CT scan. CT study was performed only for patients with PT. Gender, average age, Injury Severity Score, and years of follow-up are shown in Table 1. No significant difference was found between the two groups for these parameters.

Hematologic Examination

White blood cell (WBC) counts (6880 vs. 5830/µL), lymphocyte counts (2830 vs. 2130/µL), and platelet counts (321,000 vs. 255,000/µL) in SN were significantly higher than those of PT (Table 2). Red blood cells (RBC), hemoglobin, hematocrit, and the actual number of band and segmented neutrophils were equivalent between the two treatments. H-J bodies were observed in 87% (20 of 23) of the SN patients, whereas they were observed only in 3.1% (1 of 32) of the PT patients (p < 0.001, Fisher’s exact test). The blood smear specimen was not suitable for examination in three cases.

Blood chemistry tests are summarized in Table 3. All measured values in each test were within the reference range, and no significant difference was observed between the two groups.

Humoral Immunity

The indices of humoral immunity, including serum levels of C3, C4, CH50, IgA and IgM, were also equivalent between the SN and PT groups, all being within the reference range (Table 4). However, the IgG level of the SN was higher than that of the PT (p < 0.01). hs-CRP was measured to detect the possible subclinical chronic inflammation. hs-CRP is very sensitive; 3,000 ng/mL corresponds to 0.30 mg/dL, which is the unit usually used for CRP test. There was no statistically significant difference between the groups, whereas an hs-CRP value of a case in the SN group was excluded as an extreme outlier (59,200 ng/mL). The patient also had elevated WBC count (11,400 /µL), but other laboratory tests and physical examination did not show signs of inflammation. In all, five patients (two PT and three SN) had elevated values of hs-CRP (more than 2,000 ng/mL) without apparent signs of inflammation. The level of hs-CRP was not correlated with immunoglobulin level, complement concentration, WBC counts, or platelet counts.

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TABLE 5. Cellular Immunity

<table>
<thead>
<tr>
<th></th>
<th>SN</th>
<th>PT</th>
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<tbody>
<tr>
<td>CD3 (per µL)</td>
<td>1930 ± 750</td>
<td>1560 ± 663</td>
</tr>
<tr>
<td>CD4 (per µL)*</td>
<td>1090 ± 394</td>
<td>867 ± 340</td>
</tr>
<tr>
<td>CD8 (per µL)</td>
<td>973 ± 479</td>
<td>748 ± 365</td>
</tr>
<tr>
<td>CD4/CD8 ratio</td>
<td>1.24 ± 0.50</td>
<td>1.25 ± 0.38</td>
</tr>
<tr>
<td>CD19 (per µL)</td>
<td>327 ± 252</td>
<td>171 ± 131</td>
</tr>
<tr>
<td>B-cell Sm-IgA (%)</td>
<td>1.0 ± 0.1</td>
<td>1.0 ± 0.2</td>
</tr>
<tr>
<td>B-cell Sm-IgG (%)</td>
<td>1.0 ± 0.1</td>
<td>1.0 ± 0.1</td>
</tr>
<tr>
<td>B-cell Sm-IgM (%)</td>
<td>5.7 ± 3.6</td>
<td>4.3 ± 2.7</td>
</tr>
</tbody>
</table>

B-cell Sm-Ig A, B-cell surface IgA; SN, splenectomy; PT, preservation treatment.

* p < 0.05.
† p < 0.01.

**Cellular Immunity**

The profiles of cellular immunity are presented in Table 5. There was no significant difference in T-lymphocyte (CD3) counts between the groups, although the percentage of T cells was higher in PT (72 vs. 67%, p < 0.05). The helper T-cell (CD4) counts were significantly higher in the SN (1090 vs. 870/µL, p < 0.05), although the suppressor/killer T-cell (CD8) counts and CD4/CD8 ratio were not different. The percentage and counts of B lymphocytes (CD19) from the two groups were within the reference range, but those of the SN group (11% and 330/µL, respectively) were significantly higher than those of PT (7.8% and 170/µL, respectively). B-cell subsets (surface immunoglobulins: IgA, IgG and IgM) were within the reference range and equivalent in both groups.

**CT Examination**

CT scan examination was performed for 33 patients with PT, and splenosis was observed in three patients. The average volume of the remaining spleen was 130 mL ± 56 mL (mean ± SD), ranging from 48 mL to 287 mL. The measured volumes are plotted for each JAST splenic injury category (Fig. 2). There were no patients classified as category II (capsular injury), partly because imaging of such injury is difficult. There was no apparent relationship between volume of the spleen and injury category, suggesting that the category does not necessarily predict the mass of viable spleen. The volume of the spleen was not correlated between volume of the spleen and injury category, suggesting that the category does not necessarily predict the mass of viable spleen. The volume of the spleen was not correlated with platelet count, WBC count, or other indices measured.

**S. Pneumoniae Serotyping**

Comparison of specific IgG anticapsular antibodies against the 14 serotypes of *S. pneumoniae* showed no significant difference between the two groups. However, the concentration of antibodies varied markedly among serotypes and between individuals. The highest average concentration was for serotype 5 (SN: 3.9 ± 5.4 µg/mL and PT: 2.1 ± 2.8 µg/mL) and lowest for type 4 (SN: 0.28 ± 0.42 µg/mL and PT: 0.21 ± 0.27 µg/mL). Some patients showed very high antibody levels to a few serotypes (maximum, 11.9 µg/mL), which would suggest that prior exposure to those types of pathogen had occurred. For all serotypes, the reference range (protective concentration) is ≥1.0 µg/mL, and most patients had insufficient levels of antibody for multiple serotypes. All patients had antibody levels more than the reference range for serotype 1, but more than 75% (18 of 24) of the SN and 65% (22 of 34) of the PT patients had insufficient levels for serotype 4 (Fig. 3). SN, splenectomy; PT, preservation treatment.

![Figure 2. Splenic injury classification (JAST) and remaining volume. Measured spleen volume was plotted against the splenic injury classification of the JAST (see Patients and Methods Section for the classification). Arrow indicates the only PT patient with Howell-Jolly body present.](image)

![Figure 3. Patients with insufficient antibody for each serotype. For all serotypes, antibody levels lower than the reference range (>1.0 µg/mL) were regarded as insufficient. For serotype 1, all patients had antibody levels more the reference range, but more than 75% (18 of 24) of the SN and 65% (22 of 34) of the PT patients had insufficient levels for serotype 4 (Fig. 3). SN, splenectomy; PT, preservation treatment.](image)
patients received pneumococcus vaccination before or after the splenic injury. However, judging from the antibody levels, the patients with PT seem to be equally or possibly more susceptible to *S. pneumoniae* infection, at least when they are not vaccinated.

**DISCUSSION**

Owing to the recognition of the indispensable role of the spleen in immune response, greater efforts are now made to preserve the spleen after injury, because of the fear of the potentially fatal infection “postsplenectomy infection” (OPS1) occurring. However, it is not yet clear whether employment of splenic salvage maneuvers per se retains sufficient immune function and conveys immunity from severe infection. Thus, apart from the controversy regarding the indications and immediate complications of each treatment modality, this study focused on the concerns regarding immunocompetence and long-term prognosis of the patients treated with splenic PT (splenorrhaphy, partial SN, and splenic artery embolization), compared with those treated by SN.

Four hundred fifty patients with blunt splenic injury treated at seven urban tertiary Emergency Centers in Japan between 1982 and 2005 were enlisted (Fig. 1). Among these patients, one hundred (66 with SN and 34 with PT) were contacted by phone. There had been no episode of severe infection requiring hospitalization among these SN (760 patient-year) and PT (213 patient-year) patients. From this data, it is not yet possible to comment on whether PT actually prevents later infection and/or improves long-term prognosis. Detailed examinations, including blood sampling and CT scan, were made in 58 patients (24 with SN and 34 with PT) between June 2006 and May 2007, which allowed a maximum follow-up of 25 years.

Hematologic examination revealed that WBC, lymphocyte, and platelet counts were higher in the SN group, suggesting impaired phagocytic and filtering function, although other factors such as opsonin levels, time after surgery, effects of blood transfusion, and the hepatic RE system need to be considered.6 The presence of H-J bodies was significantly different between the two groups (20 of 23 vs. 1 of 32, *p* < 0.001), but there were also four exceptional cases (three SN patients without H-J bodies and one PT patient with H-J bodies). The three SN patients had sustained injury of JAST classification IIc + HV, IIId, and IIIc + HV, all of whom were in the most severe category, suggestive of possible splenosis. The PT patient with H-J bodies present was tested 6.3 years after the injury had occurred, and had a splenic volume of 76 mL, which was the 5th smallest size. Thus, the presence of H-J bodies is a reliable indicator of impaired phagocytic function, although it is not suitable for quantitative assessment, and the critical splenic mass required to prevent the presence of H-J bodies has not yet been elucidated.14,19 RBCPT is another indicator of decreased splenic function and allows quantitative assessment of active function.14 Its usefulness has been tested in various disease conditions including splenic injury. However, it is also still controversial whether a normal result on a pit test should be interpreted as representing immunocompetence, because it does not necessarily reflect other involved factors such as antibody and complement.

Serum immunoglobulin levels have been widely investigated in patients sustaining SN for various causes including trauma.4–6,14,15,24,25 Most previous studies reported decreased IgM level in patients splenectomized after trauma.4–6,14,15 However, it is hard to tell if this decrease is significant. Some studies have reported that IgM level is indeed significantly depressed compared with controls, but all reported levels were within the normal range, and in other reports, the normal range was not shown. This current study did not find a significant difference in IgM level between the SN (93 ± 48 mg/dL) and PT (101 ± 51 mg/dL) groups, and all levels were within the reference range (F: 46–260 mg/dL, M: 33–190 mg/dL). However, the IgM level of the two groups could still be regarded as being decreased, as the majority of the antibody levels were within the lower half of the reference range (IgM <110 mg/dL in 17 of 24 of SN and 23 of 34 of PT patients). Demeter et al. reported that the serum levels of IgG, IgA, and IgM were significantly greater in posttraumatic SN patients than in healthy controls.24 This team has previously reported a serial increase in IgM level during the 1 year post-SN period, which turned out to be caused by HCV infection contracted from a blood transfusion.25 The study was conducted before the local blood bank started HCV screening in 1989. A preliminary study revealed that elevated serum IgM level returned to the reference range after 10 years of follow-up in three of the four patients who had HCV infection and a high IgM level at 1 year after SN, except for one patient suffering from chronic active hepatitis (unpublished data, 1999). In the present study, patients enrolled...
between 1982 and 1989 who received blood transfusions during that period might have contracted HCV, but the HCV antibody assay was not included in the protocol, therefore this is unknown.

Serum IgM is an opsonin, and its level would be related to immunocompetence of the RE system. However, an immunologically significant difference in IgM for each individual is one thing, and the statistically significant difference between the groups might be another because of the wide variance in the reference range.

Non-specific immunoglobulin levels (such as serum IgG) do not seem to be consistently correlated to immunocompetence, but specific immunoglobulins against various types of pneumococcal capsular antigen might. Most of the studies on specific antibody production have focused on the prevaccination/postvaccination response and few have solely been based on prevaccination levels. This is partly because vaccination is recommended for splenectomized patients, in which case what really needs to be known is postvaccination status; and it is partly because there was variance in the protective levels of antibodies found depending on the method used for quantitative analysis, as well as vaccines used and the age of the patient. Some patients showed very high antibody levels to a few serotypes (maximum, 11.9 µg/mL), which would suggest prior exposure to those types of pathogens. Of note was the fact that the concentration of serum antibody varied markedly between serotypes and among individuals. For example, all patients had antibody levels more than the reference level for serotype 1, but more than 75% (18 of 24) of the SN and 65% (22 of 34) of the PT patients had insufficient levels for serotype 4 (Fig. 3). As such, discussion based on the average antibody concentration of the group would not be appropriate. The number of serotypes to which there was an insufficient antibody response in specific individuals was then focused on. The PT patients tend to have an insufficient antibody response to more serotypes compared with the SN (Fig. 4).

This current study is valuable, because none of the patients had been vaccinated, and the follow-up period was variable, but longer (mean of 6 years) than the previous reports that studied a period of 14 days, or 3 months after SN. The importance of splenic preservation became widely recognized in the early 1980s in Japan, a vaccine (Pneumovax) became commercially available in 1988, but somehow vaccination after SN or splenic repair failed to become the customary practice. Our recent questionnaire to nationwide tertiary emergency centers also revealed that routine pneumococcal vaccination for splenectomized patients was made only in 25% of the centers that answered (data presented at the 22nd Annual Meeting of the Japanese Association for the Surgery of Trauma, 2008).

Judging from the data of specific IgG antibodies in conjunction with non-specific IgG and IgM levels and B-lymphocyte counts, the patients with PT would not be in a better condition with regard to antibody levels, and they might even be more susceptible to infection than the SN patients. The profiles of cellular immunity also suggest that PT is not associated with more favorable cellular immunity, and that PT might even have less advantage over SN (Table 5). Therefore, vaccination would equally be needed for patients with PT, although vaccination for patients treated with options for splenic salvage is not currently commonplace.

The patients with PT seem to be similarly immunocompromised to SN, even though they had a mean splenic mass of 130 ± 56 mL (ranging from 48 to 287 mL). The critical splenic mass required to confer immunocompetence needs to be determined.

Corazza et al. examined the spleen using heat damaged 99mTc-labeled red blood cells and reported that at least 20 mL to 30 mL of splenic tissue is needed to ensure satisfactory function of the spleen, represented by low counts (<16.2%) of pitted red cells. This article mentioned that the presence of splenic tissue was not necessarily associated with splenic function. Resende et al. performed splenic auto-transplantation by attaching 22 small segments measuring 1 × 1 × 1 cm to the greater omentum in patients with severe trauma that required SN. Phagocytic function of the autoimplant was confirmed by abdominal scintigraphy using technetium 99m sulfur colloid at 3 months after SN. None of the patients with autoimplantation showed H-J bodies in their peripheral blood, whereas all patients with SN alone had H-J bodies present. In this report, the splenic tissue (autotransplant) was associated with the absence of H-J bodies. However, Moore et al. performed proximal splenic artery embolization for patients who had suffered blunt splenic injury and measured the volume of the remaining spleen using ultrasound 6 months to 63 months later. The average splenic volume (corrected volume) was found to be 106 mL, ranging from 29 mL to 239 mL, and H-J bodies were present in 2 of the 24 patients. The splenic volume of these two patients was not shown. Sass et al. reported a case of OPSI after SN, despite the fact that some spleen remained and splenosis had occurred. Thus, the presence of the splenic tissue does not necessarily mean that splenic function exists, and the question still remains: what function (antibody production, phagocytosis, etc.) or its indicator (Ig-M, specific antipneumococcus IgG, H-J bodies, RBC pit test, colloid uptake, RBC clearance, etc.) should be looked into, to look for patterns in these indicators that may correlate with outcome (survival without infection, occurrence of fatal infection, etc.).

Although we measured hs-CRP to detect the possible subclinical chronic inflammation, there was no statistically significant difference between the groups. All but five cases had hs-CRP values <2,000 ng/mL, which corresponds to conventional CRP value of 0.20 mg/dL. The five cases include one extreme outlier (59,100 ng/mL) with elevated WBC count (11,400/µL) and those with mildly elevated levels (2,140, 3,300, 3,800, and 6,400 ng/mL). However, no other laboratory and physical examinations showed apparent signs of inflammation. hs-CRP value was not correlated with…
immunoglobulin level, complement concentration, WBC count, or platelet counts. Thus, detection of possible subclinical chronic inflammation using hs-CRP might not be applicable for postsplenectomy patients.

Limitations of this study include the retrospective aspect and lack of follow-up information for all the 450 patients. As such, it is not yet possible to comment on whether PT actually prevents later infection. Another limitation is the absence of a more appropriate control group, which should be patients with splenic injury who were observed successfully without any intervention. Originally, we chose the SN and PT groups to directly compare the effects of the treatment modality, but it is now clear that we cannot critically analyze them without knowing the contributions of the splenic injury alone.

Until now, every effort to salvage the spleen has been made, with the assumption that splenic function is also preserved. In the present study, splenic PT did not show discernible advantage over SN in immunologic indices including levels of IgM and 14 serotypes of anti-S. pneumoniae antibodies, which suggests that prophylactic measures, and close follow-up are equally necessary for patients treated with PT, as for splenectomized patients.

REFERENCES


DISCUSSION

Dr. Andrew B. Peitzman (Pittsburgh, Pennsylvania): Good morning. Thank you for the opportunity to discuss this interesting study. I would also like to thank Dr. L.D. Britt and the Program Committee for putting together an outstanding program.

I compliment the authors for completing a study which required a great deal of work. This is a retrospective study which asks if splenic conservation treatment by angioembolization or splenorrhaphy reduced the occurrence of severe infection and is beneficial in the maintenance of immunologic function.

There were 450 total patients with 362 survivors. Of these 100 underwent total splenectomy; 81 underwent angioembolization; 43 underwent splenorrhaphy; and there were 136 patients who were observed.

One hundred patients were contacted by telephone and comprised the study group. Of these 58 consented to blood sampling and abdominal CT. Interestingly, as he mentioned, no patient received pneumococcal vaccine before or after the injury.
The results are nicely presented by the authors. No patient had a severe infection during follow up of 760 patient years for splenectomy or 213 patient years for splenic preservation.

I will not reiterate the results of this study. My questions are, Number 1, what are the ages of your patients? Are these all adults or have you included children as well?

Number 2, why wasn’t the observation group studied as well? I would think this would serve as a control group as you measure the immunologic function in these patients.

Third, do the immunologic parameters that you studied reflect what the patients’ immuno-competence will be? Are the results predictive of how a patient will respond to bacterial challenge?

Four, none of your patients received pneumococcal vaccine. You have a golden opportunity to vaccinate these patients, study them and see what the differences are between the groups. Do you plan to do so?

Again, congratulations on a thorough, interesting study. And we invite everyone in the audience to join us in Pittsburgh for the AAST next year. Thank you very much.

Dr. Ajai K. Malhotra (Richmond, Virginia): I enjoyed that paper but we have done a similar study which unfortunately did not make it to the program.

And my question is, why did you not include a normal person, normal people with normal spleen and compared their function to the splenectomized patient to show that your tests were actually discriminatory for the splenectomized state and then compare those positive and negative controls with whom you preserved?

Secondly, preservation by splenorrhaphy is very different from preservation by angioembolization, especially if the main splenic artery is taken. So lumping them together I think is the wrong way to go and they should be treated separately to see if angioembolization affects immunologic function. Thank you.

Dr. Michael L. Hawkins (Augusta, Georgia): I enjoyed this very much. I want to ask you if you believe your results. If you’re going to operate on somebody for a splenic injury do you just go ahead and take it out, make no effort to save it at all based on your results?

Dr. Haruhiko Nakae (Japan): Thank you, Dr. Peitzman and other doctors for question and suggestions.

In this study all patients were aged above 15 at injury time. And no patient who did not require intervention at all is not included in this study.

And as for the prediction of these patients at risk, it is easy to show the difference of the group but prediction of individual risk is rather very difficult.

But our data of specific anti-pneumococcus antibodies would tell who is at higher risk to reach which certain sero-types of pneumococcus.

As for the future plan of vaccination to the patients, should be, at this moment the measured major is, but we difficulty is, insurance, Institutional Review Board because it would involve intervention to the patients, both and another program problem is the cost for antibody measurement.

Again, I would like to emphasize that preservation treatment did not have discernable advantage over SN and we should pay equal attention to the SN patient. Thank you very much.