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## CURRENT THOUGHTS AND APPROACHES OF THE MANAGEMENT TO THE INJURED SPLEEN

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### Abstract

The spleen is not considered any more to be dispensable<sup>1</sup>. By the end of the last century, virtually none of the dogma believed to be unequivocally true 25 years earlier in the management of the injured spleen was practiced. In this review several changes in the management of injuries to the spleen, in particularly blunt injuries are presented. These includes: diagnosis, attempts of operative splenic salvage, nonoperative management, and emphasis of preventing postsplenectomy infection versus controlling bleeding.

Recently and during a period of less than two months, six patients with injury to the spleen (five with blunt trauma and one atraumatic spontaneous rupture) were admitted under the care of the present author. They are briefly presented before the rest of the review. As these cases have had different presentation and management, it was thought that the discussion will give a further account of the diversity of the management of injuries to this solid abdominal organ.

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### PRESENTATION OF CASES

#### Case one

A 62 year old lady, who was well known to the medical and psychiatric teams and regularly attended the emergency department with panic attacks and cardiac-like pain, had been seen and discharged twice in the previous week before her last attendance. On both occasions she presented with left sided chest pain and routine investigations were normal. On this last presentation the pain became acute and pleuritic-like, radiating to the left arm and epigastrium for which she had an urgent medical and then surgical review. The patient was also complaining from chronic, dry cough, which had become worse during the last week and exacerbated the pain. There was no history of fever, haemoptysis, calf pain or suggestion of viral infection. Her past medical history included ischaemic heart

disease, end-stage cardiomyopathy, chronic obstructive airway disease and severe depression. The patient was on cardiac medications, inhaled steroids and anti depressants. Her surgical history revealed colonic diverticulosis and polyps, and ischaemic bowel. On examination she was distressed secondary to the pain and hypotensive. There was tenderness and diffuse fullness over the epigastrium and left upper quadrant regions. Initial blood tests, ECG and radiology were normal. The patient became shocked after intravenous morphine. Intravenous fluids and dopamine infusion were commenced. Arterial blood gas analysis revealed a metabolic acidosis and Haemoglobin of 85 g/L. A CT scan of the pulmonary arteries, abdomen and pelvis revealed normal pulmonary arteries and a large

subcapsular splenic haematoma, with free intra-peritoneal fluid, which was assumed to be blood; the spleen was noted to be of normal size and radiographic appearance. In the early hours of the morning the patient was taken directly from the emergency department to the operating theatre with a systolic pressure around 50-60 mm Hg. At laparotomy through a left subcostal incision, 3.5 L of blood and clots were found in the abdomen. A splenectomy was performed. The spleen was macroscopically normal in size and texture, but friable with a large, deep laceration through it (Grade III – Table I and Reference 2). No other abnormality

or injury to the other viscera was found. The abdomen was closed without drainage. The patient suffered a perioperative myocardial infarction and was troubled with depression and anxiety during her hospital stay, but eventually made full recovery. Triple vaccinations (Pneumococcal, Meningococcal, and *Haemophilus Influenza*) were given before discharging the patient home. The histology of the spleen showed minor, non specific changes, and therefore we were unable to identify the aetiology of this, what appears to be atraumatic, spontaneous rupture of the spleen.

**Table I: AAST (American Association for the Surgery of Trauma) Splenic Injury Scale (1994 Revision)**

<b>Grade</b>	<b>Type</b>	<b>Description of Injury</b>
I	Haematoma	Subcapsular, <10% surface area
	Laceration	Capsular tear, <1 cm parenchymal depth
II	Haematoma	Subcapsular, 10%-50% surface area; intraparenchymal, <5 cm in diameter
	Laceration	1-3 cm parenchymal depth; does not involve a trabecular vessel
III	Haematoma	Subcapsular, >50% surface area or expanding; ruptured subcapsular or parenchymal Haematoma
	Laceration	>3 cm parenchymal depth or involved trabecular vessels
IV	Laceration	Laceration involving segmental or hilar vessels and producing major devascularization (>25% of spleen)
V	Laceration	Completely shattered spleen
	Vascular	Hilar vascular injury that devascularizes spleen

### **Case two**

A 34 year old healthy man was admitted urgently through the emergency department after he was involved in a car accident. He was fully conscious and haemodynamically stable. He was complaining from pain at the lower left side of the chest and left upper quadrant of the abdomen. There was minimal tenderness in that region with no features suggestive of peritoneal irritation. Initial blood tests including the level of Haemoglobin were within normal and plain radiography revealed fracture of the left last three ribs. CT scan of the chest, abdomen and pelvis confirmed the presence of injury to the spleen with

subscapular haematoma and parenchymal injury, which was thought to be Grade II. There was also minimal intraperitoneal fluid and no other features suggestive of injury to the rest of the abdominal organs/viscera. The patient was treated non-operatively (NO) with strict bed rest for three days and then gradual, non stressful movements. He had an insignificant fall in the Haemoglobin level but didn't require blood transfusion. A follow up CT scan after one week showed no expansion of the haematoma and signs of resolution and healing of the spleen. Minimal reaction at the base of the left lung and minimal pleural effusion at that side were also seen. The patient

remained stable and therefore discharged home on the 10<sup>th</sup> post injury day. Follow up CT scan after 3 weeks showed good healing of the injured splenic area. The patient remained well during a follow up of two months.

### **Case three**

A 36 year old man was admitted urgently from the emergency department to the ICU after been involved in a car accident. He was fully conscious but hypotensive and short of breath. The patient was bruised and tender over the lower front and both lower sides of the chest, besides tender over the left upper quadrant of the abdomen and lower abdomen. His blood tests showed fall in the Haemoglobin to below the normal level and series of plain radiography and CT scan confirmed multiple findings. These included widening of the anterior mediastinum without evidence of injury to the major vessels, fracture of the lower three thoracic vertebrae, fracture of the lower three ribs and haemothorax on both sides. There was also soft tissue haematoma on both lower chest and flanks areas, injury to the spleen, which was thought to be Grade II, intraperitoneal fluid, and separation of the pubic symphysis for few centimeters. The patient was attended by the general surgery, ICU and orthopaedics teams. His condition was stabilized with O<sub>2</sub> mask, blood transfusion and intravenous fluids. His urine initially was blood stained but then cleared and the output was satisfactory. The patient was known to have mild lymphocytic leukaemia during the last few years for which he was followed by the haematologists who decided to observe his condition without specific medication. Due to the multiple injuries and the stability of the condition a decision was taken to treat the splenic injury NO with strict observation. The patient's haematologist was informed

about the new incident. There was some controversy between the orthopaedics team as whether the injury to the pubic symphysis will be treated NO or operatively. However, finally a decision was taken to adopt the NO treatment and closely observe the patient's general condition. The patient continued to have a steady progress and a follow up CT scan finding was promising. By day seven he needed a total of six units of blood transfusion. The slow blood loss was thought to be multifactorial. Suddenly on day 10 after midnight the patient became short of breath and shocked. He was resuscitated and urgent CT scan of the chest, abdomen and pelvis revealed dramatic changes with significant right haemothorax, and large amount of blood around the spleen and intraperitoneally. Urgent insertion of right chest tube was performed in the ICU and approximately 2.5 L of blood was removed before taking the patient to the theatre. Splenectomy through a left subcostal incision was performed and there was approximately 3.5 L of blood and clots. No other injury was seen. The capsule of the spleen was completely stripped after the rupture of the subcapsular haematoma and there were deep parenchymal lacerations, which didn't involve the pedicle. The abdomen was closed without drainage. The patient was kept on ventilator for few days. Triple vaccinations (Pneumococcal, Meningococcal and *H Influenza*) were given. The soft tissue involvement and swelling on both flanks was observed for compartment syndrome but fortunately release incisions were unnecessary. The chest tube was removed and the patient continued to make good progress. A careful histological examination of the spleen confirmed it's involvement with the leukaemia. The patient was discharged home and followed by the orthopaedics team and his haematologist.

#### **Case four**

A 46 year old man who weighed 180 kg was transferred from a small, peripheral hospital after he was observed over night following car accident. He was complaining from pain at the left lower chest and left upper side of the abdomen. His initial chest x-ray taken at the peripheral hospital revealed fracture of the left 12<sup>th</sup> rib with minimal reaction at the base of the left lung. The patient was in a stable general condition and didn't require analgesia. He had normal blood tests including the level of Haemoglobin and therefore didn't receive blood transfusion. CT scan of the chest, abdomen and pelvis showed the presence of splenic injury, which was thought to be Grade II with a contained small subcapsular haematoma. Minimal amount of fluid was demonstrated intraperitoneally and no other features suggestive of other intra-abdominal injury. The patient was therefore treated NO and continued to progress well during the next few days. On day six he was found to be uncomfortable, dropped his blood pressure and had distended abdomen without irritation. He was resuscitated and urgent CT scan revealed dramatic changes in the region of the spleen with significant amount of blood intraperitoneally. Splenectomy through a left subcostal incision was performed. The spleen was found to be of normal size but shattered. Approximately 5.0 L of blood and clots were removed. No other injury was found and the wound was closed without drainage. Triple vaccinations were given and the patient made an uneventful recovery. He went home on the fifth postoperative day. The histology of the spleen didn't show any abnormality. According to the operative finding of the spleen, the patient should have had an initial, immediate laparotomy, therefore the CT scan finding or its

interpretation was considered to be deceiving.

#### **Case five**

A 28 year old man tourist from Germany was transferred from a small, peripheral hospital after been involved in a car accident. He had stable general condition with a lower normal level of Haemoglobin. His chest x-ray showed displaced fracture of the left last two ribs with some disruption of the left dome of the diaphragm. CT scan of the chest, abdomen and pelvis showed an injury to the spleen, which was thought to be Grade III. There was minimal amount of intraperitoneal fluid, besides reaction at the base of the left lung and obscured left costophrenic angle. Due to the displaced fractured ribs, the changes in the diaphragm and severity of the splenic injury it was decided to explore the abdomen through a left subcostal incision. Less than a Liter of blood and clots was found and no active bleeding from the spleen was found. There was deep, long laceration with an intact capsule. An approximately 5.0 cm tear was found in the left diaphragm, which was repaired with interrupted, nonabsorbable suture. It was decided to preserve the spleen. Absorbable (Dexon-polyglycolic acid) mesh was out of stock and therefore it was decided to free a sufficient length of vascularised omentum and completely wrapping the completely mobilized, injured spleen after applying Surgicel over the lacerated areas. The wound was closed without drainage and the patient received antibiotics for few days. He made an uneventful recovery and a follow up CT scan after one week showed promising findings with healing. The patient was discharged to a hostel and was seen weekly for three weeks at which time a follow up CT scan was very satisfactory and therefore he was allowed to make arrangement for traveling back to

Germany. The patient was given full operative and clinical reports for his doctor at home to follow up his progress.

#### **Case six**

A 32 year old man was admitted through the emergency department because of persistent left upper abdominal pain of one day duration. He gave a history of a fall when his bicycle hit a stone on the road and lost control while he was returning back from work a day before his admission. The patient experienced minimal pain after the fall but was able to resume his bike comfortably to his home, took a shower and had a reasonable over night sleep. Next day he was fairly well and did his normal activities but because he felt a little bit uncomfortable he decided to seek medical advice. There was no significant past medical history and the patient was comfortable with normal vital signs. There was some degree of tenderness at the left upper abdomen with some guarding. The rest of the abdomen was unremarkable. Blood tests were within normal as well as the plain abdominal film. His chest x-ray showed the presence of fractured left last two ribs with some reaction at the base of the left lung. Chest, abdomen, and pelvis CT scan confirmed Grade II splenic injury with contained haematoma, and minimal reaction and pleural effusion on the left side. The patient was treated NO and he progressed well without the need of blood transfusion despite his Haemoglobin dropped to just below the normal lower level. A follow up ultrasound scan showed no expansion of the haematoma and features of healing. The patient was discharged home after one week and seen regularly at the outpatient clinic with regular ultrasound scans. He remained well with complete healing and resolution of the pleural effusion.

#### **DIAGNOSIS OF SPLENIC INJURY**

Although careful medical history and thorough physical examination remain an essential part in predicting a possible diagnosis of splenic injury, currently diagnosis relies primarily on imaging techniques. Although abdominal ultrasound has proved extremely useful for detecting blood in the peritoneal cavity it lacks specificity in terms of predicting the source of blood and cannot grade organ injuries<sup>3</sup>. CT scanning has become the gold standard for diagnosis of solid organ injury<sup>3,4</sup>. It also allows reasonably accurate splenic injury grade (Table I) and estimate the quantity of the haemoperitoneum. In a multiinstitutional trials committee of the Eastern Association for the Surgery of Trauma (EAST) contributed by 27 trauma centres<sup>5</sup> the volume of the haemoperitoneum was quantified in 1020/1488 (69%) of the abdominal trauma patients studied using the findings in abdominal and pelvis CT scan. A small haemoperitoneum was defined as perisplenic blood or blood in Morrison's pouch. A moderate haemoperitoneum was indicated by the presence of blood in one or both pericolic gutters. A large haemoperitoneum was defined as the additional finding of blood in the pelvis. When oral contrast was given in addition to the intravenous contrast, CT scan could give additional information, which might help in excluding visceral injuries. Also CT scan is mandatory in patients who are going to be treated NO. However, CT scan findings should be interpreted carefully. Based on organ injury grades by CT scan and operation findings, Shapiro and colleagues<sup>6</sup> had an in-depth analysis of risk factors on patients with blunt abdominal trauma requiring immediate surgery and those who failed NO management of blunt splenic trauma.

They concluded that although these patients can be safely observed in a dedicated trauma centres, there are certain risk factors in those requiring immediate surgery and those failing NO management. The CT scan may underestimate injury, possibly related to progression of bleeding found at the time of operation<sup>6</sup>.

### **PRESERVATION OF THE INJURED SPLEEN**

There are three different ways of attempts to preserve the spleen: (1) Non-operative (NO) management, (2) Selective arteriography and embolization of bleeding of splenic artery radicals, and (3) Operative attempts of splenic salvage.

#### **Non-operative management**

NO treatment of the injured spleen was reported from the Hospital of Sick children in Toronto in 1970<sup>7</sup>. Interestingly this approach was instituted on the basis of the observation of a child who was suspected of having an injury to the spleen in the past and who was found at autopsy (for another reason) to have a healed transaction of the spleen<sup>7,8</sup>. The authors reported 16 other children with a high likelihood of injury to the spleen, based on clinical grounds, who were treated by observation and who recovered successfully (without operation)<sup>8</sup>. Subsequent reports included larger number of children documented successful observation and healing of the spleen with a follow up radioisotope studies<sup>8,9</sup>. The result of several studies<sup>3,5,8</sup> have shown that 75% to 93% of children with blunt injury to the spleen can be treated by observation. The failure rate of NO treatment of blunt trauma to the spleen in children is 2%. In contrast, 35% to 65% of adult patients with blunt splenic trauma can be managed NO, with current failure rate of approximately 10%<sup>3</sup>. The criteria for NO management

may vary somewhat among institutions but generally include haemodynamic stability and lack of evidence of visceral injuries<sup>3,8,10</sup>. Peitzman and colleagues<sup>5</sup> in their large multiinstitutional study of blunt injury to the spleen in adults concluded that successful NO management was associated with higher blood pressure and haematocrit, and less severe injury based on ISS (Injury Severity Scale), Glasgow Coma Scale (GCS), grade of splenic injury, and quantity of haemoperitoneum. However, in a more recent large retrospective study to determine factors associated with failure of NO management of patients with blunt splenic injury, 2243 patients met the criteria for inclusion in that study<sup>11</sup>. The authors concluded that being older than 55 years and having an ISS higher than 25 along with admission to a level III or IV trauma hospital were associated with a significant risk of failure of NO management. The GCS, associated injuries, and presenting haemodynamics were not predictive of failure<sup>11</sup>. Conflicting reports discouraged widespread application of NO management of patients >55 years who sustained blunt splenic injury<sup>3,8</sup>. However, subsequent studies concluded that the grade of splenic injury, not patient age, increases the risk of failure of this line of management<sup>12</sup>.

It was thought that the better outcome of NO management of splenic injuries in children compared to adults was due to the relatively thicker capsule of the spleen in children compared to that of the adult<sup>8,13</sup>. In addition the parenchyma of the spleen in children seems to contain more smooth muscle than in adults<sup>8,14</sup>. Powell and colleagues<sup>14</sup> also reported significant differences in the mechanism of injury when comparing 293 adults with 118 children. Generally adults are injured with a greater force than children. Adults

were more haemodynamically unstable while children had lower ISS scores and higher GCS score. In adults the presence of ISS >15, haemodynamic instability, higher energy mechanism, extravasation of contrast in CT scan and the presence of higher volumes of haemoperitoneum predicted the need for laparotomy<sup>8,14</sup>.

A critical factor to treat patients with splenic injuries NO is a definition of the risk of failure of NO treatment. A strict definition thought to be essential<sup>8</sup>. Peitzman and colleagues defined failed NO treatment as the treatment of any patient who was admitted to the intensive care unit or the surgical ward with the diagnosis of blunt injury to the spleen with planned NO treatment who, later required laparotomy<sup>8</sup>. Several predictors of failure of NO treatment have been examined, although there are no universally accepted recommendations for management of patients who might be at higher risk for failure. Reviewing CT scan findings, several studies noted a "contrast blush" in two-thirds of the spleens<sup>15</sup>, and subsequent reports demonstrated vascular lesions within the spleen<sup>16</sup> in patients who failed NO management. These studies emphasize the importance of the CT scan in detection of these abnormalities, which might help in better selection of patients undergoing NO management.

The time of failure of NO management was reviewed in several studies where such data were available<sup>3</sup>. The EAST study<sup>5</sup> confirmed that NO management that failed usually did so within 96 hours, but it failed in 7 patients after day nine. Other reports noted failure of NO management at various days from 6 to 36<sup>17,18</sup>. The question whether these patients who failed NO management were inappropriately selected and should not initially undergo that line of treatment is

another important issue, which must be clearly defined.

### **Selective Splenic Arteriography and Embolization**

Active haemorrhage can be diagnosed on CT on the basis of increased radio-density compared with surrounding tissue, which results from extravasation of intravascular contrast agent<sup>19,20</sup>. The exact bleeding rate required for this finding is unknown, but thought clinically to represent a significant feature that may require immediate surgical or interventional therapy<sup>19,20</sup>. Scalfani and colleagues<sup>21</sup> introduced the concept of embolization of splenic artery injuries. In their study patients who were haemodynamically stable and had intravenous contrast CT signs of extravasation underwent diagnostic arteriography on admission. A total of 150 patients with all grades of splenic injuries underwent the examination. Ninety patients had negative angiograms and were observed only; 60 had embolization with a total salvage rate of 98.5%<sup>21</sup>, which is the highest reported in the literature<sup>3</sup>. On the other hand Haan and associates<sup>22</sup> presented more detailed data from four institutions that performed splenic embolization from 1997 to 2002. The positive CT findings included significant haemoperitoneum outside the perisplenic area, contrast extravasation, splenic artery pseudoaneurysm, and aorticovenous fistula. They reported a failure rate of 13.5%; with an overall mortality rate of 5%, although none appeared related to the injured spleen. However, there were 20% complications, which included haemorrhage, missed injuries, and infection<sup>3,22</sup>.

False positive findings mimicking splenic vascular lesions were recognized and included: islands of enhancing splenic parenchyma surrounded by low-attenuating splenic lacerations or

contusions and intact intrasplenic vessels traversing the center or periphery of parenchymal lacerations simulating haemorrhage surrounding a focal pseudoaneurysm<sup>20</sup>. On the other hand failure to detect splenic vascular lesions (i.e. false negative) with contrast-enhanced CT can be related to suboptimal contrast material enhancement, particularly in obese patients with decreased tissue contrast resolution or to delay scanning well beyond the peak of splenic parenchymal enhancement, with “washout” of extravasated contrast material by non-enhanced blood<sup>20</sup>. Furthermore, the technique of embolization has also been debated, as whether the main artery is embolized or adopting more distal embolization for active bleeding areas<sup>3</sup>. The first technique may render the whole spleen ischaemic while with the latter technique there is potential of rebleeding, because the vessels may be in spasm at the time of initial angiogram<sup>3</sup>. Another important point, which was questioned by Richardson<sup>3</sup> that although splenic embolization has been advocated to preserve the spleen, no studies document its effects on the organ’s immunologic function. Because the perfusion of the sinusoids of the spleen is driven by arterial pressure, it is unclear if thrombosis of the artery will alter normal splenic function<sup>3</sup>. Lastly the service and expertise of embolization even if it is going to be accepted is not available in every institute.

#### **Operative attempts at splenic salvage**

On the basis of arteriograms in both animals and human cadaver experiments, the spleen has a segmental blood supply<sup>8,23</sup>. Any rupture that runs along these segmental vessels, but does not cross them, is expected to cause minimal bleeding. Healing in this type of injury is favourable without infarction. A review

of the anatomy of 850 spleen specimens Liu and colleagues<sup>24</sup> demonstrated that the splenic artery was supra-pancreatic in 95% of cases and infra-pancreatic in 5% of cases. Most of the spleens (86%) exhibited two primary lobes: superior and inferior. Twelve percent of the spleens revealed an accessory lobe. Generally the superior lobar artery supplied segments 1 and 2; the lower lobar or accessory artery branched into segmental branches to segments 3 and 4 (in the spleens with 4 segments) or segment 5 (in spleens with 5 segments). Ninety four of the spleens displayed 3 to 5 segmental arteries, while 6% had 6 or more segmental arteries. The common splenic artery and the lobar arteries run with their associated veins. Unlike the arteries, in the splenic subsegments, the veins are interconnected and do not follow a predictable pattern of distribution. Relative avascular planes were found between lobes or segments<sup>24</sup>. Understanding the blood supply distribution is essential in attempting successful splenic salvage procedures. The sequence in such procedures includes: an ample abdominal incision that allows good exposure, once inside the abdomen all blood and clots should be removed as quickly as possible, which enable visualization of the field and control of splenic arterial inflow, and thorough and full mobilization of the spleen<sup>1,8</sup>. Once this achieved then depending on the type and extent of the injury a decision will be undertaken as to whether splenic salvage should be attempted or not. There are several methods used to tamponade the spleen if preservation by splenorraphy or partial splenectomy is thought to be feasible<sup>1,3,8,17</sup>. These includes: ligation of the vessels of the injured lobe or segment, transaction of the splenic parenchyma, the use of several topical haemostatic materials (includes: microfibrillar collagen ‘Avitene®’, gelatin foam



'Gelfoam®', Oxidized cellulose 'Surgicel®', fibrin sealant, fibrin glue, and argon beam), wrap application using absorbable mesh, wrap application with omentum, oversewing the cut surface of the spleen or the use of TA stapler for haemostasis, and partial splenectomy<sup>1,3,8,17,25,26</sup>. Recently an animal experimental study using 10 white male Landrace pigs in which radiofrequency ablation technology was used to stop the bleeding of produced grade IV spleen trauma<sup>27</sup>. The authors reported that all bleeding sites were controlled without any adverse outcome<sup>27</sup>. Long-term splenic function in patients with salvaged spleens depends on the residual splenic mass for which blood supply is critical. One third of the spleen should be functioning to achieve immunocompetence. As a general rule one half of the spleen should be preserved, with the hope to achieve immunocompetence. If this is unable to be achieved then the risk of attempting splenorrhaphy may not be justified<sup>1,3,8</sup>. Although high success rate of operative splenic salvage was achieved in many centres, several studies show considerable variations in the rate of attempts at splenic salvage between trauma and non-trauma centres<sup>3,28</sup>. When NO management became more acceptable, operative salvage procedures began to decline, although they are still useful when operation is required. However, NO failures are usually treated by splenectomy<sup>3</sup>. It was thought that if there is no enough splenic mass that can be salvaged then splenic autotransplantation by using several methods was advocated by several groups<sup>3,8,29,30</sup>. However, in spite of several animal studies it was debated whether these transplanted fragments retain their immunological function. The ultimate usefulness of splenic

autotransplantation after splenectomy depends on the ability of the residual splenic tissue to prevent or reduce the incidence of infection caused by encapsulated organisms. Traub and colleagues<sup>31</sup> compared various treatment options in 51 patients with splenic injury after abdominal trauma. They found that autotransplantation was less effective in preserving reticuloendothelial function than the other approaches of splenic preservation. Furthermore, the long-term effects and benefits of splenic autotransplantation have not been fully explored, but there are reports showing a strikingly high fatal sepsis in groups of patients studied, which definitely questioning the long-term benefits of this approach<sup>32,33</sup>. Therefore currently because of the uncertainty regarding the function of the autotransplanted splenic tissue these patients should be treated as if they are asplenic<sup>3,8</sup>.

### **LIFE-THREATENING POST-SPLENECTOMY INFECTION PREVENTION**

Recognition of the spleen's role in the resistance to infection was known for most of the 20<sup>th</sup> century. In 1952 King and Shumacker<sup>34</sup> published their classic review of 100 splenectomy patients and documented 5 additional cases of Overwhelming Postsplenectomy Infection (OPSI) in children. Diamond<sup>35</sup> introduced the term OPSI in 1969 and described the incident in detail: the syndrome of OPSI is unlike most fulminating bacteraemias and septicaemias in ordinary (spleen-containing) individuals. Very few of patients with bacteraemia progress from good health to death in less than 24 hours, whereas the OPSI syndrome constitute a distinct entity, which often lasts only 12 to 18 hours. It may begin abruptly with slight sore throat, fever, and 'feeling or looking sick,' proceed to headache,

vomiting and hyperpyrexia; and be followed in a very few hours by convulsions or coma and death<sup>35</sup>. In 1973 Singer reviewed 2795 asplenic patients of all ages collected from 23 series in addition to 6 patients from the Texas Children's Hospital<sup>36</sup>. In this report it was found that the age at the time of splenectomy and indication for the operation predicted the risk of major sepsis. Haematologic indications for the splenectomy resulted in the highest incidence of major sepsis and death, which ranges from 1.68% to as high as 10.15% depending on the diagnosis of the haematologic disease<sup>8,36</sup>. The 688 patients who undergone splenectomy for trauma, developed serious infection (1.45%) and resultant death (0.58%) much less frequently than those patients who had undergone splenectomy for haematologic diseases. Singer concluded that the risk of OPSI is infrequent but definite regardless the age of the patient and indication, and younger patients especially infants are most susceptible<sup>36</sup>. The infections observed in patients without spleen are mainly due to encapsulated bacteria *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Neisseria meningitidis* with an incidence that is 10-50 times higher than normal population<sup>37,38</sup>. Other pathogens associated with infection are *Salmonella* spp., streptococci and enterococci, *Capnocytophaga canimorsus*, *Babesia microti*, *Plasmodium* spp.<sup>38</sup>. Nearly 15% of the infections are polymicrobial with the blood, skin and lungs are the commonly involved sites<sup>38</sup>. Although several reports have now documented the hazard of OPSI in adults<sup>39</sup> one problem with these reports is the overlap in the results and the inclusion of the same patients previously reported in other studies<sup>3</sup>. On the other hand there is a good possibility that there were many other patients who developed OPSI but

for one reason or another never been reported. Therefore it seems to be difficult to ascertain exactly how many cases have been actually affected with OPSI. Richardson<sup>3</sup> concluded that based on the cases reported in best reports with better follow up<sup>39,40,41</sup> there are less than 70 cases worldwide, with a death rate of about 30%. Despite this low rate of OPSI in adults, it was one important factor of several others that initiated a shift from routine splenectomy as the treatment of choice in patients sustained splenic injuries to splenic conservation. In addition to OPSI, other general postoperative infection complications have also been reported to be more frequent in patients who undergo splenectomy compared with patients who undergo exploratory laparotomy alone<sup>3,8,42</sup>. Furthermore, the mortality rate in general appears to be higher in patients undergoing splenectomy than in the normal population<sup>3,8,42</sup>.

### **Recommendations for prevention of life-threatening infections**

Waghorn<sup>39</sup> reported that the currently accepted best practices for managing asplenic patients are not applied in a significant percentage of patients. Prevention of these infections should be achieved by: (1) patient and family education, (2) prophylaxis by means of vaccination, (3) antibiotics prophylaxis, and (4) delay of elective splenectomy or use of methods aiming at splenic conservation.

**Patient and family education:** Patients and their families must be informed that the patient is at risk of developing life-threatening infection. The risk is higher after 2 years of the splenectomy but could be life long. Patients should avoid traveling to endemic regions with certain diseases like Malaria or take the necessary prophylaxis. A possibility of the patient wearing a bracelet that he/she

is asplenic is also discussed, and it is necessary to inform doctors taking care of the patient about this life-threatening risk. Finally it should be noted that long-term compliance with these instructions is important.

**Vaccination:** The effectiveness of vaccination in preventing OPSI depends on its adequacy to create sufficient response after splenectomy. In patients undergoing elective splenectomy, vaccination should be given two weeks before the operation to obtain an optimal response. In case of emergency splenectomy the patient should receive the vaccine as soon after operation before discharging the patient from the hospital<sup>18,37,38</sup>.

Immunization against *S. pneumoniae*: At present, two vaccines are available [38]: 'the conventional polysaccharide vaccine including 23 bacterial serotypes (PPV23) responsible for 90% of bacteraemic pneumococcal disease encountered, and the new tetanus-conjugate heptavalent vaccine (PCV7). In healthy adults younger than 55 years of age the pneumococcal vaccine may be more than 90% effective. Response is generally less effective, actually absent before the age of 2 year of age<sup>8,37,38</sup>. The antibody response to the capsular polysaccharide in normal adults consist of both IgM and IgG2 subclasses. Children younger than two years old are unable to produce much IgG2<sup>8,37</sup>. There are no data about immunogenicity of PCV7 in this group of patients<sup>38</sup>. Therefore for patients younger than two year of age, it is probably better to rely on antibiotic prophylaxis and to immunize the child after the second birthday<sup>43</sup>. Revaccination every 3 to 5 years is advocated<sup>37,43</sup>. There are several limitations to the polyvalent pneumococcal vaccine: it does not provide protection against all of the recognized 84 serotypes of *S. pneumoniae*,

even though the 23 covered serotypes accounts for 90% of the clinical episodes<sup>37</sup>, bacteria other than pneumococcus might account for at least 50% of OPSI<sup>8,38,44</sup>, also the most virulent serotypes tends to be the least immunogenic, and the efficacy of the vaccine is poorest in younger patients who are at a higher risk<sup>8,37,43</sup>. The safety of the vaccine was not studied in pregnant women and therefore it shouldn't be given to healthy pregnant women<sup>8,38</sup>.

Immunization against *H. influenzae* Type B: Many children may have received the *H Influenza* Type B as part of their immunization, and most adults over the age of 18 have usually acquired some degree of immunity to the organism through natural exposure. However, this immunity is not long-lasting and therefore may not provide adequate protection in asplenia setting, therefore immunization is recommended<sup>37</sup>. Although the efficacy of the conjugated anti *Haemophilus* vaccine has been documented in splenectomized patients and thus routinely given<sup>38,45</sup> its use and efficacy was thought to be less clear and less defined than that of the pneumococcus vaccine<sup>8</sup>. There is also no general agreement on reimmunization after receiving the first dose<sup>8,37,38</sup>.

Immunization against *N meningitidis*: The anti-meningococcal vaccine currently available is a quadrivalent polysaccharide against A/C/Y/W-135 strains but misses other strains of meningococcus such as type B<sup>8,38</sup>. Immunity diminishes after few years, therefore frequent vaccinations are necessary. A conjugated vaccine is under development, which could provide a longer lasting immunity. The efficacy and usefulness of the vaccine in patients after splenectomy is undefined because of poor safety, lack of response in children and does not cover serotype B. Therefore its

routine use is not universally accepted<sup>8,37,38,43</sup>.

Antibiotics prophylaxis: As vaccination does not completely protect against infection caused by capsulated bacteria the use of antibiotics prophylaxis have been recommended. The patients population that require antibiotics prophylaxis, the particular antibiotic used, and the duration of the prophylaxis remain controversial. The risk of OPSI caused by pneumococcal and *Haemophilus influenzae type B* are highest when antibodies against these organisms have not been acquired naturally. Overall 50% to 70% of serious infections occur within two years after splenectomy. In younger children more than 80% of infections occur during this period of time. However, it is also clear that some risk persist through life<sup>8,40</sup>. The relative rarity of OPSI makes it difficult to study the effectiveness of prophylactic antibiotics after splenectomy, especially in adults. Antibiotic prophylaxis using oral penicillin has been proven to reduce the incidence of pneumococcal infection by 84% in children with sickle cell anaemia<sup>46</sup>. Based on these data it is suggested that daily antibiotic prophylaxis should also be beneficial in children<sup>8,37,38,46</sup> after splenectomy for trauma. Traditionally the regime for antibiotic prophylaxis consists of a single dose of penicillin or amoxillin, the latter being more preferred in recent literature<sup>37</sup>. However, amoxillin is less tolerated in children and more expensive than penicillin. An alternative prophylaxis, which may be used in certain circumstances such as allergy are parenteral ceftriaxone, and trimethoprim<sup>8</sup>. Although there are more agreements for antibiotic prophylaxis in asplenic children than in adults, the duration of prophylaxis remains controversial, with recommendations ranging from two years

after splenectomy to 21 years of age<sup>8,47</sup>. The disadvantages of antibiotic prophylaxis are related to poor compliance, possibility of failure of prophylaxis, emergence of resistance, and feeling of false sense of security while forgetting other principles for the prevention of OPSI<sup>8,38</sup>. An alternative to daily antibiotic prophylaxis is the administration of antibiotics at the first signs of infection, the so called: stand-by antibiotics<sup>8</sup>. Although a  $\beta$ -lactamase-resistance antibiotic, such as amoxillin, was recommended, there is no proof that such treatment will reduce the incidence of OPSI<sup>8</sup>.

### **CONCLUDING REMARKS**

Among the several conditions and diseases that the spleen is affected with, trauma is the most common condition with blunt injury being the commonest type. Mortality rate from splenic injuries has not changed for 40 years, generally of less than 1%.

It is well studied and documented that the spleen is involved in several immunological processes and pathways. Therefore, serious attempts had been developed to find alternative practice to the routine splenectomy in blunt trauma. The possibility of certain groups of patients in particularly children who are vulnerable to develop OPSI was another reason for trying to save the injured spleen. It was also reported that other possible long term risks in asplenic patients (in particularly for haemolytic indications) may include increased risk of thrombosis and increased risks of death from atherosclerotic heart disease<sup>48</sup>.

The organisms responsible for OPSI were most commonly encapsulated organisms, with pneumococcus, meningococcus, and *Haemophilus influenza* accounting for 70% of the cases in the series. Postsplenectomy vaccination to prevent

or minimize the incidence of infection by these three organisms is routinely given in this set of patients. However, there remain several controversial issues in regards to the type of vaccination, the age of the patient and the frequency of revaccination. Postsplenectomy antibiotic prophylaxis has its role in spite of some controversial issues including how long it should be continued. Therefore, organized studies to determine the exact incidence of infection in posttraumatic asplenia and other clarifications are needed to help in implementing proper recommendations and protocols regarding these undefined matters.

Splenic preservation is currently well accepted way of management in blunt trauma to the spleen. The structural differences between the spleen of children and adults and the segmental blood supply of the spleen are key issues in the management of the injured spleen. Advances in better care and imaging techniques coupled with our understanding of splenic anatomy helped in better selection of patients involved in blunt trauma to attempt preserving their spleens. There are also documented reports of improved outcome following this line of treatment. Interpretation of CT scan finding is important and the possible benefits of selective splenic angiography and embolization should not be over estimated.

Nonoperative treatment of patients involved in blunt injuries to the spleen gained increasing acceptance by surgeons dealing with these patients. Currently success rate of NO management of blunt splenic trauma ranges from 75% to 93% of children, and approximately 60% of adults. However, it is vital to remember, that patients who are deemed to be haemodynamically unstable and/or have abdominal clinical features suggestive of possible visceral injuries, should be

treated by prompt laparotomy. These important issues were clearly highlighted in a most recent report (J Am Coll Surg, August 2005) by Peitzman and colleagues<sup>49</sup>. This report presented in detail the results of a subgroup of 78 adult patients who failed NO management out of a large group of patients studied from 27 trauma centres previously reported<sup>5</sup>. They categorized these patients according to their haemodynamic status. Three groups were identified: 44% were stable, 31% had transient hypotension or tachycardia that resolved with intravenous fluids (responders); and 25% were unstable. Two thirds of the unstable patients required laparotomy within 12 hours of admission, and all had laparotomy within 72 hours. This means that these patients should not be considered to have failed NO management because clearly their correct initial treatment should be laparotomy<sup>49</sup>. Mortality was significantly different when comparing the stable to the unstable and responder groups: stable (3%), responders (8%), and unstable (37%), despite similar age and only modest difference in the ISS. The authors also found that eight CT scans were misinterpreted initially, and of the 26 Focused Abdominal Sonography for Trauma (FAST) studies, 11 (42.3%) were false negative<sup>49</sup>. In addition abnormal abdominal findings were noted in 67.7% of patients on admission. Ten patients died (12.8%), and 60% of the deaths were caused largely by delayed treatment of splenic or other abdominal injuries; one patient died in the responders group and five unstable patients died. The authors concluded that 30% to 40% of the patients who had unsuccessful NO management in their study were selected inappropriately because of either haemodynamic instability or initial misinterpretations of diagnostic studies<sup>49</sup>.

As a consequence, the majority of deaths were from delayed treatment of intra-abdominal injuries. Therefore persistent with NO management of patients with negative (or interpreted as negative) diagnostic studies, despite the presence of positive clinical (abdominal), signs was not appropriate and is certainly a disservice to these patients. It is therefore

recommended that an implementation of written protocols to decrease variability in surgeons practice, adherence to sound clinical judgment, and timely and accurate interpretation of radiologic studies would introduce guidelines as to whether an attempt of preservation of the injured spleen by NO treatment is appropriate<sup>49</sup>.

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