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Complications of splenic tissue reimplantation

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Splenic tissue reimplantation employing the omental implantation technique was applied in 23 patients undergoing splenectomy for traumatic or iatrogenic splenic injury. Four complications were encountered after autotransplantation (17.4%). Two of these consisted of small bowel obstruction due to postoperative adhesions and were successfully managed by lysis of the adhesions. The other two complications were aseptic necrosis of the splenic transplants and were treated with ablation of the autolysed transplants.

A case of abnormal splenic tissue reimplantation in a male patient with unsuspected myelofibrosis is also discussed. He underwent an emergency laparotomy for rupture of a subcapsular splenic haematoma.

It is concluded that splenic tissue implantation in the greater omentum is associated with important early morbidity and this should be taken into account whenever application of the method is considered.

The spleen regulates and controls important immunological functions in the human. Experience acquired during the last 15 years, has shown that splenectomy predisposes to an elevated risk of sepsis, especially during childhood and adolescence when immune mechanisms are immature *(1,2)*. The risk of post-splenectomy sepsis has not accurately been defined but it is possible that it also exists for the adult *(2–4)*.

It has been proposed that splenic salvage prevents a series of reactions and/or consequences to the immune system (decreased production of immunoglobulins, decrease in tuftsin and probably of serum complement), which predisposes to a high level of post-splenectomy infection and elevated mortality *(2,4–6)*. Therefore, the preservation of function after traumatic injuries to the spleen is desirable. Splenic repair, partial splenectomy or splenic tissue autotransplantation are all acceptable procedures *(1,7–16)*.

Splenic artery ligation, with or without suturing the splenic rupture site, is a well-documented method, mainly used in children *(17,18)*.

During the last decade a great deal of literature has been published on the hazards of splenectomy and on the contribution of splenic tissue reimplantation in preventing post-splenectomy sepsis *(6,12,13,19–21)*. However, there have been no reports on the clinical complications of splenic tissue autotransplantation. In the present study we report the complications due to reimplantation of splenic tissue in a series of patients undergoing splenectomy for splenic injury.

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Materials and methods

During a 5-year period (1981–1985), 23 patients underwent splenic tissue reimplantation. The group consisted of 18 cases with traumatic rupture of the spleen and 5 cases with iatrogenic splenic injury.

There were 15 males with a mean age of 38.8 years (range 15–77 years); eight patients were female with a mean age of 27 years (range 8–72 years).

The omental implantation technique as described by Kusminsky *et al. (12)* was applied in all cases. Between 30 and 50 g of thinly sliced, macroscopically healthy splenic tissue (preferably 2–3 mm in thickness) was implanted into folded omentum, marked with clips and sewn in place. Special care was taken to avoid excessive compression of the implants or haematoma formation in the omental pouches where the splenic autotransplants were placed.

In the group with iatrogenic injury, less risky manoeuvres (digital compression, splenorrhaphy, partial splenectomy and suture repair, splenic artery ligation) were attempted before recourse to total splenectomy and reimplantation.

All the patients in the study were examined 3 months after splenic autotransplantation in order to evaluate splenic activity. The protocol of the follow-up study was planned to include splenic scan with ^{99m}Tc sulphur colloid, haematologic studies (blood cell counts, Howell–Jolly bodies), serum immunoglobulin levels (IgM, IgA, IgG), serum complement (C_3–C_4), neutrophil phagocytic activity, serum tuftsin levels and cell-mediated immunity (Multitest CMI skin test) *(2,3,5,22,23)*. The data are presented elsewhere *(24)*.

Results

Surgical complications after the omental implantation technique for salvage of the spleen were observed in four (17.4%) patients (Table I).

The first patient, a 51-year-old female, underwent surgery for rupture of a splenic artery aneurysm; she underwent laparotomy 15 days later for an acute abdomen and was found to have aseptic necrosis of the splenic implants.

The second patient, a 72-year-old female, who underwent splenectomy for injury sustained during a partial gastrectomy for benign gastric ulcer underwent further surgical exploration 20 days later for an acute abdomen and was found to have aseptic necrosis of the splenic autotransplants. In both patients, the necrosis was confirmed by biopsy of the implants.

The remaining two male patients, 15 and 55 years of age, underwent emergency reoperation for small bowel obstruction 12 days and 75 days, respectively, after the initial operation. Jejunal loops were found to be adherent to the splenic implants resulting in intestinal obstruction. The adhesions were lysed and, in the second case, enterectomy plus end-to-end anastomosis was also carried out.

At follow-up 3 months after the transplantation, the splenic scintiscan of the 15-year-old patient demonstrated normal imaging of the splenic autotransplants; however, in the case of the 55-year-old patient, the splenic tissue was not visualised until 9 months after the reimplantation. The 55-year-old patient had a second episode of small bowel obstruction 1 year after the initial operation due to jejunal adhesions in the splenic transplant area. Again, the treatment was lysis of the adhesions and biopsy of the splenic autotransplants. Biopsy examination was also carried out during the reoperation of the 15-year-old patient. In both cases, the biopsy specimens were macroscopically and microscopically compatible with splenic tissue.

Of note in this series is a 52-year-old male patient who underwent emergency laparotomy for rupture of a subcapsular splenic haematoma that was treated with splenectomy and omental implantation of splenic tissue. At operation the spleen was of normal size and appearance. The biopsy report on the surgical specimen, in conjunction with other haematological parameters, revealed myelofibrosis with secondary hypersplenism. The patient had no previous symptoms. On admission to hospital his blood count revealed increased white blood cells (16 000/mm^3); platelets were 500 000/mm^3; these were attributed to the splenic rupture. Three months later, splenic scintiscans demonstrated radiocolloid localisation and visualisation of the autotransplants (Fig. 1). Since the splenic reimplantation the patient has not been transfused and his blood counts are within normal limits.

Discussion

Numerous reports have substantiated the fact that splenectomy, after an unpredictable length of time, is followed by a risk of serious infection which is associated with a high mortality *(1–4)*. This risk is substantial in childhood and puberty, while the risk is less in the adult *(21,23)*. A large number of studies have shown that the immune response of animals and man is altered in a variety of ways when the spleen is absent, or when an inadequate amount of splenic tissue is present *(2,3,5,6,20,21,25)*.

Table I. Complications of the omental implantation of splenic tissue

No	*Sex*	*Age*	*Indication for splenectomy and reimplantation*	*Complication*	*Management*
1	Female	51	Rupture of splenic artery aneurysm	Aseptic necrosis of splenic implants	Ablation of the necrotised implants
2	Female	72	Iatrogenic injury	Aseptic necrosis of splenic implants	Ablation of the necrotised implants
3	Male	15	Traumatic injury	Adhesions/intestinal obstruction	Lysis of adhesions
4	Male	55	Traumatic injury	Adhesions/intestinal obstruction	Lysis of adhesions/ enterectomy

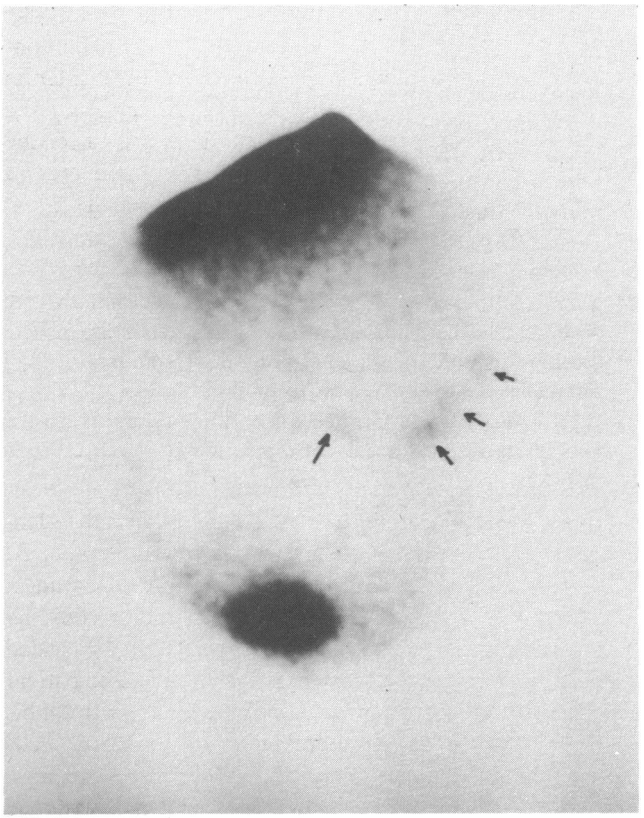

Figure 1. Scintiscan of the splenic implants (arrows) in the patient with myelofibrosis 3 months after reimplantation.

The reimplantation of splenic tissue is one of the methods proposed for preserving splenic function. When repair of the injured spleen is not possible and preservation of splenic function is desired, the omental implantation technique offers a simple, fast and reasonable alternative *(12)*. However, there are controversies on the usefulness of splenic tissue transplants, because of the possibility of accessory spleens or splenosis and/or the importance of a critical mass of residual splenic tissue *(5,7,14,20–23,25)*. In addition, the complications of the method must be considered.

Clinical complications after surgery for splenic injury and omental implantation of splenic slices were encountered in four patients, accounting for 17.4% of the patients in this series. This group of patients included two cases of aseptic necrosis confirmed both macroscopically and microscopically and two cases of intestinal obstruction due to adhesions of jejunal loops to the splenic implants.

Although it is well established that the splenic transplants are subject to an initial partial necrosis followed by regeneration originating in the outer layer *(21)*, meticulous microscopic examination of the transplanted specimens in the first two cases revealed complete necrosis of the splenic tissue. In the remaining two patients with intestinal obstruction, the biopsy was compatible with splenic tissue.

Thus, even though the maintenance of the size and weight of the splenic slices to an optimum (the so-called 'critical mass') and decapsulation of the splenic transplants are both essential measures to prevent massive splenic transplant necrosis, strict adherence to the above measures does not guarantee a favourable outcome.

A major factor in overwhelming post-splenectomy infection is that bacteria such as *Pneumococcus* and *Haemophilus influenzae* are cleared by the phagocytic activity of white cells, and this probably requires 50% of splenic tissue to be effective, a ratio rarely, if ever, achieved by autotransplantation *(23,25)*. The so-called streaming effect also relies on the specifics of blood supply to the normal spleen and it is highly unlikely that this is achieved in the autotransplanted situation. Furthermore, intestinal obstruction due to adhesions seems to be another important, though not common, complication of the omental implantation method.

Omental implantation of unknown pathologic splenic tissue in patients with splenic injury is a complication which cannot be foreseen while the patient is prepared for emergency laparotomy. The patient's past history and the finding of splenomegaly during laparotomy (spleen size and weight above upper normal limits) are the most important criteria that should trigger suspicion of a pathological spleen. The solution to this problem will be frozen section biopsy. In our case of splenic tissue reimplantation in a patient with myelofibrosis the periodical evaluation of splenic transplant function may assess the evolution of the disease which is minimally altered by splenectomy.

References

1 Oakes DD. Splenic trauma. *Curr Probl Surg* 1981;**28**:346–401.

2 Francke EL, New HC. Postsplenectomy infections. *Surg Clin North Am* 1981;**61**:135–55.

3 O'Neal BJ, McDonald JC. The risk of sepsis in the asplenic adult. *Ann Surg* 1981;**194**:775–8.

4 Schumacker HB Jr. Splenectomy and postsplenectomy sepsis. *Surgical Rounds* 1986;February:57–63.

5 Orda R, Barak J, Baron J, Spirer Z, Wiznitzer T. Postsplenectomy splenic activity. *Ann Surg* 1981;**194**:771–4.

6 Sullivan JL, Ochs HD, Schiffman G *et al.* Immune response after splenectomy. *Lancet* 1978;**28**:178–81.

7 Cooney DR, Dearth JC, Swanson SE, Dewanjee MK, Terlander PL. Relative merits of partial splenectomy, splenic reimplantation and immunization in preventing postsplenectomy infection. *Surgery* 1979;**86**:561–9.

8 Tzoracoleftherakis E, Alivizatos V, Karvelas F, Androulakis J. Splenectomy or splenic salvage; Indications and results (It.). *Florence Journal of Surgery (Firenze Chirurgica)* 1985;**3**:11–15.

9 Alivizatos V, Tzoracoleftherakis E. Management of splenic injuries today (Gr.). *Iatrika Chronika* 1985;**8**:795–800.

10 Morgenstern L. Conservation of the injured spleen. *Surgical Rounds* 1980;July:13–20.

11 Haller JA Jr. A new philosophy of pediatric splenic surgery: save our spleens. *Surgical Rounds* 1980;July:23–6.

12 Kusminsky RE, Chang Ho-Huang, Hosino H, Zekan SE, Boland JP. An omental implantation technique for salvage of the spleen. *Surg Gynecol Obstet* 1982;**155**:407–8.

13 Sherman R. Rationale for the methods of splenic preservation following trauma. *Surg Clin North Am* 1981;**61**:127–34.
14 Patel J, Williams J, Schmigel B, Hinshaw J. Preservation of splenic function by autotransplantation of traumatized spleen in man. *Surgery* 1981;**90**:683–8.
15 Morgenstern L. Let the preserver of spleen beware (Editorial). *Surg Gynecol Obstet* 1982;**154**:81.
16 Oakes DD, Morgenstern L. Surgical Pros and Cons. *Surg Gynecol Obstet* 1983;**156**:79–80.
17 Keramidas D. The ligation of the splenic artery in the treatment of traumatic rupture of the spleen. *Surgery* 1979;**85**:530–3.
18 Keramidas DC, Voyatzis N, Anagnostou D, Stavrides J, Koutoulides C, Ziros A. Ligation of the splenic artery; effects on the injured spleen and its function. *J Pediatr Surg* 1980;**15**:38–41.
19 Chu DZJ, Nishioka K, Tawfik El-H, Hopfer RL, Romsdahl MM. Effects of tuftsin on postsplenectomy sepsis. *Surgery* 1985;**97**:701–6.
20 Cooney DR, Michalak WA, Michalak DM, Fisher JE. Comparative methods of splenic preservation. *J. Pediatr Surg* 1981;**16**:327–38.
21 Christenson JT, Owunwanne A, Al-Hassan EE, Ryd W. Regeneration and function of autotransplantation of splenic tissue after splenectomy. *World J Surg* 1986;**10**:860–6.
22 Pearson HA, Johnson D, Smith KA, Touloukian RJ. The born again spleen. Return of splenic function after splenectomy for trauma. *N Engl J Med* 1978;**298**:1389–92.
23 Deitch EA, O'Neal B. Neutrophil function in adults after traumatic splenectomy. *J Surg Res* 1982;**33**:98–102.
24 Tzoracoleftherakis E, Alivizatos V, Rathosis S, Kalfarentzos F, Androulakis J. The overall evaluation of splenic function after splenectomy for splenic injury. In: J Skandalakis ed. *The Spleen* (in press).
25 West KW, Grosfeld JL. Postsplenectomy sepsis: Historical background and current concepts. *World J Surg* 1985;**9**: 477–82.

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Notes on books

Spinal Surgery: Science and Practice edited by Robert A Dickson. 560 pages, illustrated. Butterworth, London. 1990. £140.00. ISBN 0 407 01791 7

This is a major new book devoted to spinal surgery. The authors are all well known in their field and contribute authoritative chapters, each well illustrated and well referenced. The subtitle, *Science and Practice*, is stressed throughout and this is an important feature of the book. There are twenty-eight chapters covering every aspect of spinal surgery, both orthopaedic and neurological. Although the volume is principally addressed to those in training, there seems little doubt that established surgeons will also find a great deal of interest in its pages. Spinal surgeons everywhere, please note and look at this book—you will need to buy it for your departmental library.

Bowel Obstruction: Differential Diagnosis and Clinical Management edited by John P Welch. 711 pages, illustrated. W B Saunders Company, Philadelphia. 1990. £68.00. ISBN 0 7216 1963 0

This is an important new book and a major addition to the surgical literature. Every aspect of intestinal obstruction, both small bowel and large bowel, is covered in detail, with authority and with extensive reference to the world literature. For example, chapter 1, on the history of intestinal obstruction, has over four hundred references and some chapters more than this. Pathophysiology, diagnosis, causation, treatment are all covered with numerous informative illustrations. Rare conditions are covered as well as the more common. This book is likely to become a much-thumbed volume on surgical library shelves everywhere.

Surgical Pathology of Non-Neoplastic Lung Disease edited by A L A Katzenstein and F B Askin. 2nd edition. 603 pages, illustrated. W B Saunders Company, Philadelphia. 1990. £50.00. ISBN 0 7216 1852 9

The second edition of an authoritative and comprehensive book written to help the surgical pathologist in the interpretation of lung biopsy. It has become a basic reference book and this new edition has been extensively revised throughout to bring it completely up-to-date. Nearly 1500 new references and over 100 new photomicrographs have been added.

Inflammatory Bowel Diseases 1990 edited by D Rachmilewitz and J Zimmerman. 277 pages, illustrated. Kluwer Academic Publishers, Dordrecht. £62.50. ISBN 0 7923 0657 0

The Proceedings of the Third International Symposium on inflammatory bowel diseases held in Jerusalem in 1989. Five sections headed Aetiology, Pathogenesis, Clinical Assessment, Nutrition and Medical Management. Why nothing on Surgery? Another book that is printed from camera-ready copy for speed of publication.

Anesthesiology and the Heart edited by T H Stanley and R J Sperry. 346 pages, illustrated. Kluwer Academic Publishers, Dordrecht. 1990. £72.50. ISBN 0 7923 0634 1

The Proceedings of the 35th Annual Course in Anaesthesiology held in Utah in February 1990. Twenty-eight papers printed from camera-ready copy.