REVIEW ARTICLE

Malign effects of splenectomy—the place of conservative treatment

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Summary

In this review article the incidence is discussed of overwhelming post-splenectomy infection (OPSI), which is especially likely to occur in children and when splenectomy is carried out for haematological disorders. Long-term broad spectrum antibiotics or the use of polyvalent pneumococcal vaccine are often advocated as prophylactic measures under these circumstances.

After mild splenic trauma, conservative surgery or partial splenectomy may be indicated in some cases. Where trauma is more severe and the spleen cannot safely be preserved there may be a place for auto-transplantation of splenic slices, for example into a pocket of omentum, and there is some experimental support for this technique.

Overwhelming post-splenectomy infection

When splenectomy first became a routine procedure for trauma of the spleen little was known about the functions of this organ, except that its removal resulted in some minor changes in the blood picture which were not considered important (Moynihan, 1921; Tarnuzi and Smiley, 1967). Morris and Bullock (1919) were among the few alert observers who recognized that some caution should be exercised while removing the spleen. When experimenting on rats infected with the bacillus of rat plague, mortality in the splenectomy group was 80% compared to 38% in the control group of animals. Their conclusion was that 'it is not improbable that the human body deprived of its spleen, shows a similar increased susceptibility to infection'.

Marine and Manley (1920) are considered to be the first to have suggested a method of protection against post-splenectomy infection by transplanting fragments of spleen to subcutaneous pockets in rabbits after splenectomy. They thought that 'the spleen is most important in early life (an observation

to be confirmed later on), and after sexual maturity is either unimportant or its functions may be assumed by other haemopoietic tissues'.

With the exception of very few experimental studies (Motohashi, 1922; Perla and Marmorston-Gottesman, 1930; Perla, 1936) it was not until 30 years later that clinical reports appeared which related fatal infections to splenectomy (King and Schumacker, 1952). In recent years, owing to an increase in road accidents, gunshot wounds, sporting injuries, and in the number of elective operations during which incidental splenectomy is performed for technical reasons or for surgical trauma (Klaue, Eckert and Kern, 1979), splenectomy has become a relatively common operation. Only when Singer (1973) collected several thousand cases of splenectomized patients and showed the very high incidence of sepsis amongst them as compared to the general population was overwhelming post-splenectomy infection (OPSI) recognized (Krivit, Giebink and Leonard, 1979). This risk is considered to be 50-fold greater following splenectomy for trauma than in the general population, and is even greater for patients undergoing splenectomy for haematological disorders. Although children are more prone to OPSI, adults are affected as well (Ein *et al.*, 1977; Robinette and Fraumeni, 1977).

Splenic function

There is now a revival of interest in the spleen and its functions and this has led to accumulation of experimental and clinical information.

The spleen is the first line of defence in clearing small numbers of bacteria from the circulation after intravenous injection (Leung, Szal and Drachman, 1972; Smith and Johnston, 1979). It initiates immune responses against particulate antigens (bacteria) by producing IgG and IgM (Likhite, 1975, 1978). Part of the IgG is a specific cell bound leucophilic gamma globulin fraction (leucokinin or tuftsin) which is essential for maximal stimulation of the phagocytic activity of neutrophilic leucocytes

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(Najjar and Nishioka, 1970). The splenic macrophages act on an intravenous challenge of bacteria after their opsonization (Smith and Johnston, 1979; Likhite, 1979). The spleen plays a major role in opsonization by synthesizing early antibody and complement factors (properdin) (Krivit *et al.*, 1979; Smith and Johnston, 1979). The local and systemic effects are combined and are dependent on splenic tissue mass and adequate blood supply (Leung *et al.*, 1972; Cooney *et al.*, 1979).

The need to conserve splenic tissue

When the spleen is removed for medical indications, such as hereditary spherocytosis, for staging of Hodgkin's disease or during renal transplantation, no attempt will usually be made to conserve splenic tissue. It is after traumatic injury (accidental or iatrogenic) that efforts have been made to conserve the spleen or part of it or to transplant splenic tissue.

Previously, when confronted with a splenic rupture, the surgeon had no choice but to remove the bleeding organ. When overwhelming post-splenectomy infection was recognized to be a definite entity, the need to conserve the spleen was advocated (Dickerman, 1976; Leading Article, 1978) and an alternative line of management of splenic trauma was sought. In view of changing concepts of the role of the spleen in host defence, the idea of conserving the spleen should no longer be regarded as an oddity. There is now better understanding of the splenic arterial vasculature and it is possible to conserve part or the whole of the spleen in a number of cases following splenic trauma. There is evidence that the spleen in man consists of separate compartments or segments, each supplied by one of the hilar branches of the splenic artery and drained by one of the hilar tributaries of the splenic vein. The blood vessels enter and leave at the hilum. Although arterial distribution is variable, bifurcation almost always occurs outside the spleen and therefore control of bleeding from a particular segment by ligation (Tsapogas *et al.*, 1973) and/or partial splenectomy (Sherman and Asch, 1978) are feasible procedures.

Splenic transplantation studies

Following the pioneering work of Marine and Manley (1920), Perla and Marmorston-Gottesman (1930) continued transplantation experiments in rats and found that at least 7 weeks have to elapse before the transplant can protect these animals from *Bartonella muris* haemolytic anaemia. Detailed histological studies in rats (Tavassoli, Ratzan and Crosby, 1973) showed that splenic fragments, auto-transplanted into subcutaneous tissue in the abdomen, undergo at first almost complete necrosis except for a shell of splenic tissue at the surface of

the implant, consistent with connective tissue cells. These cells differentiate later into splenic reticular cells that evolve into red and white pulp as time progresses. This regeneration is reminiscent of splenic embryogenesis. By the end of 5 weeks the implant has a rather thick capsule but is otherwise similar to normal splenic tissue. The final weight of the implant is approximately equal to that of the original transplanted tissue. Blood supply to these implants comes mainly from neo-vascularization by small arterioles from the surrounding tissues. It seems important to measure the blood flow through them, as the filtering effect of the spleen was shown to be important in clearing the circulation of bacteria (Whitaker, 1968). The fate of these implants is not known.

Since this preliminary work, auto-transplantation of the spleen has been performed in various other laboratory animals and in different sites, such as in subcutaneous pockets (Likhite, 1974), retroperitoneal pockets (Cooney *et al.*, 1979) and the peritoneal cavity (Crosby and Benjamin, 1961). The spleen has been macerated (Schwartz *et al.*, 1978), cut into small pieces (Crosby and Benjamin, 1961) or fragmented (Leung *et al.*, 1972). These models served to test resistance to bacterial contamination, usually using *Streptococcus pneumoniae* (Cobb, Dickerman and Boulton, 1978; Schwartz *et al.*, 1978) and *Haemophilus influenzae* (Moxon, Goldthorne and Schwartz, 1980), which are the most frequent infecting organisms in splenectomized patients (Singer, 1973; Dickerman, 1976). Some of the experiments (Cooney *et al.*, 1979; Fasching and Cooney, 1980) prove that auto-transplanted spleens have immunological activity and this is proved by lower mortality rates in infected auto-transplanted animals as compared to splenectomized ones. There are, however, several reports (Crosby and Benjamin, 1961; Schwartz *et al.*, 1978) denying these protective effects and showing, in fact, similar mortality rates in splenectomized and auto-transplanted animals after pneumococcal infection. These conflicting results could be explained by the mass of transplanted spleen involved, as a minimum of one-third of the original weight has been shown to be effective (de Boer, Sumner-Smith and Downie, 1972; Likhite, 1974), or it may be explained by the method of transplantation. Fragmentation of the spleen and maceration are less effective, presumably because of poorer blood supply.

The spleen and wound healing

The authors have examined the role of the spleen in wound healing in rats (Werbin and Bucknall, 1981). One of the groups studied was an auto-transplanted group. After splenectomy, 4 thin slices of the spleen were wrapped by the omentum. When

examined 3 months later, all the transplants showed normal splenic architecture and morphology, with a somewhat thickened capsule and good peripheral vascularization. In the study, Werbin and Bucknall have shown that in long-term asplenia, wound healing is impaired, owing to decreased cellularity and fibroblastic activity in the wound. Transplanted spleens show some haematological and immunological activity and give somewhat improved wound healing.

Splenosis

Auto-transplantation in the peritoneal cavity follows the natural history of ruptured spleen. It has been shown that splenosis is much more frequent than previously suspected (Widman and Laubscher, 1971; Fleming, Dickson and Harrison, 1976) and, in fact, more than 50% of the patients who undergo splenectomy for trauma show, on scintigraphy with ^{99m}Tc sulphur colloid, splenic activity mainly in the area of the splenic bed (Pearson *et al.*, 1978). It is possible that this naturally occurring autotransplantation of spleen is one of the main reasons why OPSI syndrome is less frequent in this group of patients than in those subjected to elective splenectomy for other reasons (Pearson *et al.*, 1978). In several isolated cases (Aigner, Dobroschke and Weber, 1980; Rice and Jones, 1980) fragments of spleen were transplanted to patients, but no conclusions could be drawn.

Conservative approaches to splenic surgery

With the development of new suture materials such as polyglycolic acid, atraumatic needles, new haemostatic agents and laser surgery, experimental and clinical work has been carried out in an effort to conserve the spleen with its blood supply intact (Buntain and Lynn, 1979; Morgenstern and Shapiro, 1979). The use of topical haemostatic agents as an adjunct to control bleeding has been extensively investigated. Morgenstern and Shapiro (1979) review their practice in experimental and clinical work and report using absorbable gelatin sponge (Gelfoam), absorbable oxidized regenerated cellulose (Surgicel) and microfibrillar collagen (Avitene). Strauch (1979) reports several clinical cases where Avitene was used in addition to splenorrhaphy. The recommended use of haemostatic agents in splenic injury is topical application on superficial tears, primarily involving the capsule and not penetrating deep into the pulp. Care must be taken not to pack the spleen for deeper ruptures as this may increase the tear. Hilar injuries involving the splenic vessels should be treated by splenectomy. Orda, Wiznitzer and Goldberg (1974) have reported success with cyanoacrylate adhesives for the control of bleeding in

laboratory animals, but no clinical work has followed.

Repair of spleen (splenorrhaphy) is a fairly new procedure, although isolated reports have appeared as early as 1902 (Berger, 1902; Dretzka, 1930; Foster and Prey, 1940). It was realized that major splenic lacerations may be sutured with morbidity comparable to that seen after splenectomy, the latter being reserved for more severe and irrecoverable situations. However, most surgeons were reluctant to use this method and preferred the safer splenectomy. When the importance of the spleen to the immunological integrity of the organism was understood, renewed efforts to conserve the spleen were made. Ruf *et al.* (1979) and Morgenstern and Shapiro (1979) report on various experimental and clinical techniques of splenorrhaphy and Mishalany *et al.* (1978) and Strauch (1979) add 13 more cases treated by conservative means, such as suturing, partial splenectomy, use of haemostatic agents or even a non-operative approach. The non-operative approach is the most controversial and is advocated in several cases. Mostly in children, when the vital signs are stable and there is no evidence of massive or continued haemorrhage. The patients must be under intensive surveillance and any change in their vital signs warrants an immediate formal laparotomy (Solheim, 1978; Howman-Giles *et al.*, 1978; Strauch, 1979). Mishalany *et al.* (1978) maintained that the vast majority of lacerated spleens could be repaired without noticeable hazards.

Thus, a major part of splenic tissue is conserved, the original blood supply with the filtering effect of the spleen is intact and usually there is no need for additional prophylaxis against OPSI syndrome such as long-term broad spectrum antibiotics (Walker, 1976; Leading Article, 1978), or the polyvalent pneumococcal vaccine (Lennard, 1979) which are commonly advocated for at least 3 years after splenectomy.

Better understanding of splenic vasculature and collateral circulation (Ratner *et al.*, 1977; Tsapogas *et al.*, 1973) has contributed significantly towards a more conservative approach in splenic surgery. Following de-arterialization of the spleen, Tsapogas *et al.* (1973) observed that the spleen, like liver, has a remarkable capability for surviving ischaemia. This observation was soon followed by reports of treatment of splenic trauma by ligation of the splenic artery (Keramides, 1979; Conti, 1980). The 3 patients treated showed initial devascularization followed by the development of collateral circulation and splenic activity as demonstrated by scintigraphy and angiography 20 days later. Conti also suggests that massive mobilization of the spleen should be avoided before ligation as otherwise one would be interrupting the collaterals.

Cooney *et al.* (1979), commenting on the relative merits of partial splenectomy, splenic re-implantation and immunization in rats, have stressed that partial splenectomy is the most appropriate surgical alternative to total splenectomy. It appeared to be associated with a higher antibody titre, better bacterial clearance from the circulation and increased survival rates. At low challenge doses of pneumococci, auto-transplantation and partial resection offered similar protection. When high challenge doses were used (6×10^6), only partial splenectomy increased survival in the examined rats. Immunization impressively increased survival rates in all groups.

Conclusion

Medicine is not an exact science, and nowhere is this observation more appropriate than in the operating room when a surgeon is removing the spleen. What could be more paradoxical about the management of splenic injuries when authors (Dretzka, 1930; Foster and Prey, 1940), having attained success with alternative methods, have yet advocated splenectomy? The controversy over the treatment of splenic trauma continues. It is now well documented that splenic function is important to the immunological integrity of the organism, that splenectomized animals and patients suffer from overwhelming post-splenectomy infection with mortality rates high above the normal population and that there is a need to conserve splenic function, whenever the spleen is injured. Auto-transplantation of splenic tissue is possible with regeneration back to normal splenic architecture and immunological activity but there are conflicting reports as to whether mortality could be lowered by this method.

The need for splenectomy is unquestionable when the spleen is totally disintegrated and completely avulsed from its pedicle, but to accept it routinely for less serious injuries is unjustified. The alternative techniques available certainly require more time than simple splenectomy, and also greater experience and technical expertise. However, if the spleen is to be regarded as essential and, thus, an organ to be preserved, safe and effective techniques should be tried more and more depending upon the clinical situation and the ancillary facilities available.

It is the authors' opinion that a small tear in the splenic capsule occurring during an elective abdominal operation or found to be the cause of haemorrhage after trauma, should be repaired by any of the available techniques, such as suturing or utilization of a haemostatic agent, without sacrificing the spleen. Larger lacerations and injuries of the spleen, mostly in children but also in adults (Dickerman, 1981) can be repaired, using the new surgical armamentarium and monitoring devices.

When repair is not feasible, auto-transplantation of parts of the spleen should be tried and can prove to be useful. The authors do not see the place yet for a non-operative decision, and any doubt of further bleeding should be treated by a formal splenectomy. All the evidence presented indicates that the spleen and splenic function should be preserved whenever possible.

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