tracer uptake suggest improving transplant function on follow-up.

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EDITORIAL

Compensatory Splenic Growth: Role of Functional Indicators

The central nervous system, following partial resection, shows little compensatory growth in terms of either the number or size of the remaining cells. However, "regrowth" and at least partial restoration of function is demonstrated by a number of other organs. The mechanisms involved, however, may be quite varied. Protooncogene expression precedes compensatory growth in the liver, but apparently not in the ovary (*1*). Molecular signals involved in hepatic regeneration are multiple and are unraveled in much detail (*2*). Such information is nearly totally lacking as far as the spleen is concerned. The stimulus for splenic growth is uncertain, following resection of part of the organ; the same can be said for growth of accessory

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or implanted splenic tissue, after removal of the major organ.

The presence of splenic tissues in such situations can usually be detected by a functional indicator, such as uptake of technetium-99m-^{99m}Tc) sulfur colloid, indium-111-oxine-white blood cells, or ^{99m}T-labeled and heat denatured red blood cells (RBCs). Spencer and coworkers reported that, following surgical splenectomy, 2/43 cases showed functional tissue in terms of radiocolloid uptake (*3*). While the principal spleen was still present however, only 2 instances of functional tissue outside of the spleen were noted in 4,426 cases. Thus, after surgical splenectomy, the detection of presumably additional splenic tissue increased nearly 100-fold. Two possible reasons for this were suggested:

1. Removal of the spleen might "unshield" accessory tissue.
2. Accessory or implanted splenic tissue may hypertrophy following extirpation of the major spleen.

These observations were further developed by Pearson and coworkers, who employed an additional functional indicator (*4*). They utilized interference phase-contrast microscopy for examination of RBCs from the peripheral circulation. The spleen normally can repair or prevent red cell surface indentations (referred to as "pits"). Using this technique, the following results were obtained with three groups of children in the table below.

In, the latter grouping, surgical splenectomy because of splenic trauma, two distinct subsets of children could be distinguished:

1. In the first subset, red cells were pitted to the extent found in those who had splenectomy because of hematologic disorders (in which an effort is made to remove both the principal spleen plus any identifiable accessory tissue).
2. The second subset had few red cells pitted, as though some splenic function still remained. In these children with traumatic splenic injury, there may have been the spilling (and implanting) of splenic fragments to intraabdominal sites.

There were two additional functional indicators, which correlated with the reduced number of pitted RBCs:

1. All but one of the patients with few pitted RBCs also had less than one Howell-Jolly body-containing RBC per each 5,000 RBC (the spleen has the ability to "pluck" these intraerythrocytic nuclear inclusions from red cells). By contrast, Howell-Jolly bodies were noted in red cells of children who had splenectomy for hematologic disorders.
2. Technetium-99m-radiocolloid imaging was performed on five children with few pitted RBCs after splenectomy because of trauma. All five of these revealed extrahepatic radiocolloid accumulation in small regions (presumably accessory or "splenotic" splenic tissue).

Pearson and colleagues referred to these regions of uptake as the "born-again spleen" (*4*). We can accept this as representing splenic tissue, because of the multiple functional indicators: RBCs cleared of Howell-Jolly bodies, few pitted RBCs and presence of extrahepatic tissue which concentrated radiocolloid. What was the origin of this tissue? The sites may represent either of two possibilities.

1. About 16% of children have an "accessory" spleen (*5*), which might grow when the principal spleen was removed.
2. "Splenosis" or the seeding and growth of splenic cells, such as following traumatic rupture, has been recognized [and a review of some of the salient literature up to 1978 has been provided (*4*)].

Natasa and coworkers have described part of the natural history of the morphologic and functional growth of implanted splenic cells, by studying patients who had undergone heterotopic splenic autotransplantation because of splenic damage (*6*). In 13 patients who had splenectomy because of trauma to the organ, transplantation of splenic cells was carried out to the region of the greater omentum. The presence of functional tissue was evaluated by means of the uptake of heat-denatured ^{99m}Tc-RBCs. Early imaging (1–7 mo after the procedure) and delayed imaging (3–4.8 yr after surgery) were both performed. Their results are as follows.

1. In 3/13 cases, new foci of activity were seen on the delayed images. This increase in sites in 23% of the

	Percent RBC with "pits"
Normal children ("eusplenic")	Under 1%
Children with elective splenectomy for hematologic disorders	20%
Children with emergency splenectomy because of splenic trauma	A. 9/22 = 20% B. 13/22 = 6% or less.

cases could represent splenosis or the late evolution of small accessory splenic tissue.

2. The surface area of the functional tissue, detected on imaging, increased from an average of 28.2 cm^2 to 44.1 cm^2 on the delayed images. We had demonstrated that based on lateral images of the normal spleen, splenic volume could be approximated as a function of the 3/2 power of the lateral surface area (*7*). If this formulation was valid for the irregularly shaped implanted splenic foci, it suggests that the splenic volume went from 38 g on the early images up to 75 g on the delayed views.

3. The intensity of uptake of heat denatured labeled red cells, by the splenic tissue, increased in each case from the early to the late images. However, this may simply be a concomitant result of the increased volume of tissue.

4. Howell-Jolly intraerythrocytic inclusions were absent from circulating RBCs, on the initial studies, in 2/8 patients. This increased to 5/8 on the delayed views, suggesting that a sufficient quantity of splenic tissue was present to clear these red cell inclusions. In addition to the increase in splenic size with time, at least one functional indicator (the "plucking" of Howell-Jolly bodies) also increased.

5. All of the splenic transplants were successful in terms of demonstrating the ability to accumulate (that is, to clear from the blood stream) intravenously administered labeled and heat-denatured RBCs. However, does this translate into successful immunologic function for the transplanted tissue? This topic has generated much debate in that there is considerable disagreement in the literature. Pearson has stated that the incidence of infection (such as by the encapsulated pneumococcus or meningococcus), after splenectomy for trauma, is low (*4*). This might be due to the presence of splenotic sites. However, the issue is not settled and divergent views have been stated (*8*). The required level of immunologic protection may depend upon a volume of splenic tissue that is considerably greater than that required to clear Howell-Jolly bodies.

The key to further progress is in pursuing splenic functional indicators. A recent review of a wide range of splenic imaging modalities noted that radionuclide studies produced an evaluation of " . . .structural and functional pathology" (*9*). However, no discussion was given of correlating the imaging results with hematologic and immunologic indicators. Such cross comparisons may provide the key to understanding the return of splenic volume and splenic function(s) after the implantation of tissue.

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