

AUTOPLASTIC TRANSPLANTATION OF SPLENIC TISSUE, IN MAN, FOLLOWING TRAUMATIC RUPTURE OF THE SPLEEN

ROBERT A. HAMRICK, M.D.,

BIRMINGHAM, ALA.

AND

JASPER D. BUSH, M.D.

UNIVERSITY, ALA.

FROM DIVISION A, SURGICAL SERVICE, AND DEPARTMENT OF PATHOLOGY, HILLMAN HOSPITAL, BIRMINGHAM, ALA.; AND DEPARTMENT OF PATHOLOGY, UNIVERSITY OF ALABAMA MEDICAL SCHOOL, UNIVERSITY, ALA.

AT THE HILLMAN HOSPITAL, Birmingham, Ala., during a seven-year period, from 1933 through 1939, there were 457 cases with acute abdominal injury, including penetrating wounds, as well as subcutaneous injury, admitted to the hospital. Among these cases, only 17, or 3.7 per cent, of the whole number, were instances of traumatic rupture of the spleen. According to Berger,³ about 51 per cent of individuals who experience acute rupture of the spleen, die of hemorrhage within one hour of the accident. Of those that survive this primary mortality, 15 to 55 per cent will die within a few days, in spite of the best modern surgical treatment for acute traumatic rupture of the spleen. Besides this, there is a huge fatality rate of 90 to 100 per cent, for individuals suffering such an accident, who refuse, or do not receive surgical intervention. Consequently, human survivals of traumatic rupture of the spleen are, indeed, small in number. The chances of a person in this group of survivals, either having an abdominal surgical exploration, or coming to autopsy examination at some future date, would be proportionally much less; which may account for the rare disclosure of the condition which was found upon postmortem examination of the abdomen, in the case to be described. The numerous spleen-like nodules found scattered over the peritoneum, including the surfaces of the omentum, small and large bowel, the diaphragm, and the pelvic cavity, were not accessory spleens, but small splenic implants. These implants grew from viable splenic pulp cells dispersed over the peritoneal cavity, as a result of the intra-abdominal splenic hemorrhage, when this normally vascular organ ruptured. Some of these viable cells, normally situated in the splenic parenchyma, were torn away by the force of the trauma and bleeding, to float with the hemorrhage to a new location, and graft themselves diffusely on living peritoneum. With the passage of time, a fibrous reaction, or capsule, formed about these nests of splenic cells, as they underwent division and growth, in their new beds. Parenchymatous cells of no other abdominal organ are known to exhibit similar characteristics; excepting, possibly, the uterine endometrium.

Case Report.—Hosp. No. 101843: H. M., colored, male, age 9, entered Division A, Surgical Service, Hillman Hospital, September 30, 1935, about five and one-half hours after he had fallen out of a tree, striking his abdomen on the ground. Abdominal pain

AUTOPLASTIC SPLENIC IMPLANTS

was immediately complained of, mainly in the region of the umbilicus. He had not become unconscious, nor had he vomited. There had been no gross hematuria.

Physical Examination.—Temperature, per rectum, 100.6° F.; pulse, 152; blood pressure 90/54. The patient appeared apprehensive; with tense nares; and rapid, shallow respirations. Lungs were negative. The abdomen was moderately distended, and rigid. There was general abdominal tenderness on palpation, which was more marked in the left upper abdominal quadrant, and left flank. An increase in flank dullness was noted, which seemed to shift.

Hemoglobin 50%; R.B.C. 3,010,000; W.B.C. 15,500, with 89% neutrophils, and 11% lymphocytes. Urinalysis: 150 mg. albumin, microscopically, a few granular casts, together with four to six leukocytes, and 50 to 60 red blood cells per high power field. One hour later, the hemoglobin was 49%, R.B.C. 3,000,000. The pulse becoming more rapid. *Clinical Impression:* Ruptured abdominal viscus; exploratory celiotomy advised. Before operation 1,000 cc. of normal saline was administered by hypodermoclysis.

Operation.—R. A. H.: Two and one-half hours after admission: Under ether anesthesia, the abdomen was opened through an upper left rectus incision. A large amount of free blood was found present, and the spleen was found to be ruptured, almost in half, with active bleeding. A splenectomy was rapidly performed. No spleen-like nodules were noted within the abdomen. During operation intravenous gum acacia solution was administered, and this was immediately followed by a blood transfusion.

TABLE I
SERIAL BLOOD COUNTS*

Date	Hemo- globin	Red Blood Cells	Color Index	Leuko- cytes	Neutro- phils	Lympho- cytes	Large Mono- nuclears	Eosino- phils	Baso- pnils	Time Relation to Operation
9/30/35	50%	3,010,000	0.8	15,500	89%	11%				On entrance. Preoperative
9/30/35	49%	3,000,000	0.8							1 hour later
10/ 1/35	45%	2,720,000	0.8	12,950	86%	14%				1st day, P. O. After blood transfusion
10/ 7/35	37%	2,530,000	0.7							P. O. 7th day
10/10/35	40%	2,150,000	0.9							P. O. 10th day
10/14/35	65%	3,560,000	0.9	14,050	82%	12%	3%			P. O. 14th day. After blood transfusion
10/17/35	47%	2,460,000	0.9	6,350	55%	43%		2%		P. O. 17th day

* In the case reported. These were taken during the patient's first stay in the hospital, as a result of the acute traumatic rupture of the spleen.

Except for some abdominal distention during the early postoperative phase, which was combated with a stomach tube, and the presence of a secondary anemia, the convalescence was essentially uneventful. The wound healed per primam; and the dressing was removed 13 days after operation.

Second Admission.—Thirty-nine months later, on January 1, 1939, when the boy was age 13, he was again admitted to the Hillman Hospital, on the Medical Service, Hosp. No. 127278, with a clinical diagnosis of acute tetanus, contracted from an injury of his left little finger by the explosion of a firecracker on December 25, 1938, six days previously. In spite of energetic treatment with tetanus antitoxin, the patient died 20 hours after he entered the hospital. An autopsy (Dr. J. D. Bush) was performed two and one-half hours after death. Only a portion of the complete autopsy report will be included.

Postmortem Examination.—(A-39-2) : The changes of greatest interest were limited to the thoracic and peritoneal cavities. The upper anterior mediastinum was filled by a bilobed thymus gland, which weighed 61 Gm. The tracheobronchial lymph nodes were large and contained black pigment. There were several fibrous adhesions binding the healed splenectomy wound to various loops of bowel and to the omentum. There were numerous adhesions about the splenic bed and one spleen which measured 3 by 4 cm. was firmly adherent to the splenic bed. Scattered over the abdomen were several dozen firm, dark red nodules which measured from 0.5 to 1 cm. in diameter. These were found on the inferior surface of the left dome of the diaphragm, the omentum, the small bowel, the ascending colon, the transverse colon, the descending colon and over the pelvis including the anterior surface of the rectum and the rectovesical pouch. The smaller ones were rounded; the larger ones were flat and measured 0.2 to 0.3 cm. in thickness. All were sessile and covered with serosa. In color and consistency they closely resembled splenic tissue. The surface was red and on section there was a thin, white fibrous capsule enclosing a firm, dark red, spleen-like tissue. The total number of the nodules was approximately 75.

Pathologic Examination.—Microscopic:—Sections of the nodules revealed a structure morphologically similar to adult spleen. Each nodule was surrounded by a capsule composed of fibrocytes and collagenous fibers. The convex surface of the capsule was covered by a layer of flattened endothelial cells continuous with the serosa of the structures to which the implant was attached. In the capsule there were scattered foci of lymphocytes, particles of iron pigment and small blood vessels filled with erythrocytes. Trabeculae extended from the capsule into the pulp, occasionally traversing the entire width of the nodule. These trabeculae possessed a structure similar to the capsule and were accompanied by small blood vessels. There were a number of follicles present, each composed of lymphocytes; in a few an arteriole was also present. No germinal centers were evident. The red pulp was composed of sinuses lined by a single layer of cells with prominent nuclei. The sinuses were filled with erythrocytes, polymorphonuclear, neutrophils and a few endothelial leukocytes. An occasional siderophage was seen in the red pulp.

Discussion.—In medical literature, there apparently have been only ten similar cases described. Two other autopsy examinations were reported, in which spleen-like nodules were so diffusely scattered over the abdominal cavity, as to practically rule out their author's diagnosis of accessory spleens. These two last mentioned autopsy examinations were made on individuals who gave no history of trauma, and had not undergone a splenectomy. However, in both instances the spleen and surrounding area presented gross findings, usually associated with residuals from healed trauma. Consequently, one might well reason that these cases represented splenic implants from traumatic splenic ruptures which had healed, and will be so considered. Table II briefly summarizes the 12 cases described in the literature, as well as our own case. Only three such cases have been reported in American medical literature, and these were published since September, 1939; two of these were by the same author. A detailed review of the earlier reported cases is made in the excellent articles by Shaw and Shafi; Jarcho and Anderson; and Buchbinder and Lipkoff. Buchbinder and Lipkoff recognize Foltin, who described a case in 1911, as being the first to suggest that the spleen-like nodules in question, were splenic implants. These same two authors wished to designate this entity of autoplasmic transplantation of splenic tissue as "splenosis."

AUTOPLASTIC SPLENIC IMPLANTS

FIG. 1.

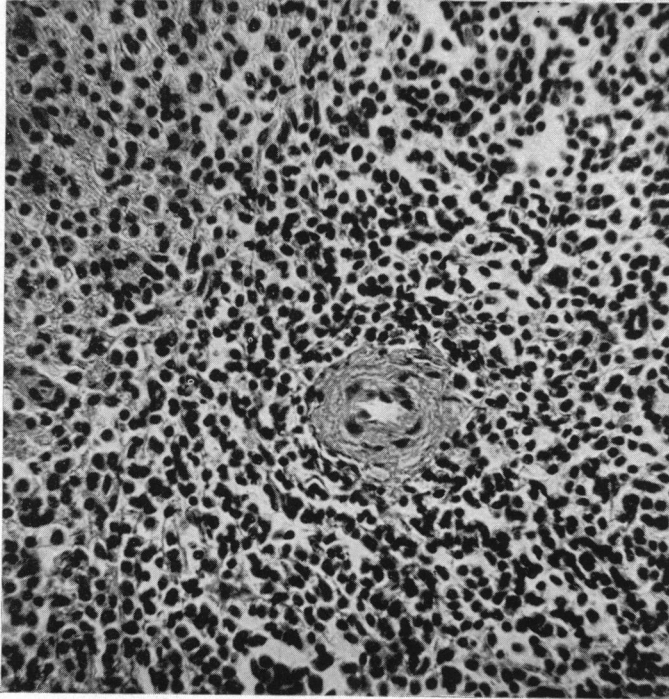
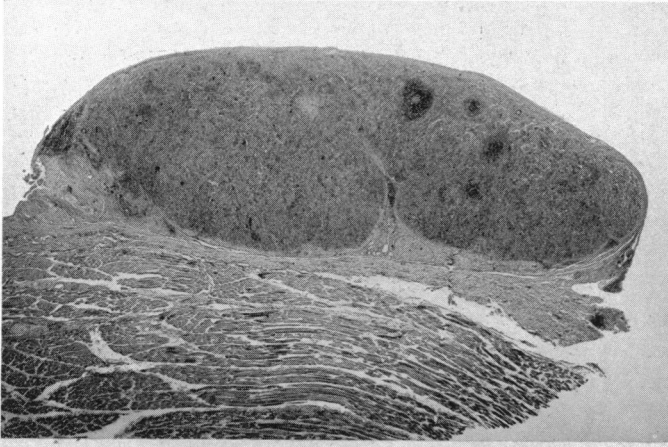


FIG. 2.

FIG. 1.—Photomicrograph of a full-section of autoplasmic splenic transplant, from the case reported, showing capsule, trabeculae, malpighian corpuscles, and pulp. On one surface it is adherent to the diaphragm. (Hematoxylin and eosin). ($\times 10$)

FIG. 2.—Photomicrograph of the same section as shown in Figure 1 showing a central arteriole, surrounded by lymphocytes, and a portion of splenic pulp. (Hematoxylin and eosin). ($\times 176$)

TABLE II
SUMMARY OF REPORTED CASES OF AUTOPLASTIC TRANSPLANTATION OF SPLENIC TISSUE

Author	Date	Sex	Age at Time of Diagnosis	Age at Time of Rupture of Spleen	Reason for Splenectomy	Time after Splenectomy	Location of Nodules	Number	Size of Implants
Albrecht	1896	Male	25	?	Autopsy	No history of trauma or splenectomy	Greater omentum; retrovesical pouch; and both domes of diaphragm.	Numerous	Not stated.
Schilling	1907	Female	47	?	Autopsy	No history of trauma or splenectomy	Greater omentum; peritoneum of anterior abdominal wall; and of pelvis.	42 on great omentum (several more)	Pea to cherry in size.
von Kuttner	1910	Male	?	?	Autopsy	4 years	Scattered throughout the peritoneum.	80 to 100	Not stated.
Foltin	1911	Male	9	3	Chronic appendicitis	6 years	On loops of large and small intestine.	Numerous	Lentil to cherry in size.
von Stubenrauch	1912	Male	?	?	Ileus	10 months	Greater omentum; transverse mesocolon; and small intestine.	Numerous	Hemp seed to pea in size.
Oltman (quoted by von S.)	1919	?	?	?	Not stated	Not stated	Throughout peritoneal cavity.	Multiple	Not stated.
Lee	1923	Male	29	14	Ileus	15 years	Small intestine and mesentery.	Numerous (200-300)	Pin head to 1 1/2 inches.
Kupperman	1936	Male	15	14	Postoperative hernia	6 months	Small and large intestines.	100	Not stated.
Shaw and Shaf	1937	Male	20	?	Autopsy	Not stated	Abdominal wall; pleural cavity; liver; diaphragm; retrovesical pouch; and great omentum.	82	0.2 to 2 cm.
Jarcho and Anderson	1939	Male	8	6	Autopsy (ileus)	18 months	Left dome of diaphragm; liver; stomach; lesser omentum; transverse colon; rt. kidney; rectum; and bladder.	Several dozen	1 to 12 Mm. in diameter.
Jarcho and Anderson	1939	Male	20	12	Autopsy	8 years	Peritoneum; greater omentum; diaphragm; greater curvature stomach.	80	1 Mm. to 3 cm. in diameter.
Buchbinder and Lipkoff	1939	Female	28	8	Pelvic operation	20 years	Parietal peritoneum; great omentum; ileum; sigmoid; and ascending colon.	Numerous	1 Mm. to 2 cm. in diameter.
Authors	1940	Male	13	9	Autopsy (tetanus)	39 months	Parietal peritoneum; pelvic cavity; omentum; serosa of large and small bowel; diaphragm.	Approx. 75	0.5 to 1 cm. in diameter.

The first group of writers who published case reports, which appear to come in this category, diagnosed the nodules as being either accessory spleens, or tissue derived from embryologic spleen-forming rests, contained within the peritoneum. Spleen-forming rests most likely would be found only in tissues or structures closely approximated to the splenic area in embryologic development. Accessory spleens would be the logical outgrowths from these fetal splenic rests, should they take on a growth stimulus. As to the prevalence of accessory spleens, Adami and Nichols found them in 11 per cent of a series of autopsy examinations. These bodies probably are more often observed in young individuals, than in adults. Jolly states that 25 per cent of children, less than seven years of age, had accessory spleens. Sos-suchin observed them in 15 per cent of 153 children, less than ten years of age. Additional mention is made that their diminished occurrence in adult life is possibly due to atrophy. The size of accessory spleens varies from a few millimeters to several centimeters in diameter. Accessory spleens present the same histologic structure, and are subject to the same pathologic alterations, as the main organ. Usually, not more than one to six accessory spleens are present in any one case. These bodies, as mentioned above, are mainly found only in tissues adjacent to the splenic area in fetal development, such as the splenic fossa, gastrosplenic ligament, pancreaticosplenic ligament, pancreas, and the great omentum. The large splenic nodule found within the splenectomy bed, at postmortem examination in our case, no doubt, was a true accessory spleen.

The cases reported in medical literature which show splenic implants reveal that these splenic grafts have been found growing on a portion of almost every area of the peritoneal cavity as well as on the contained viscera. In all the reported cases with splenic implants, there are described numerous spleen-like nodules, surrounded by a fibrous capsule of variable thickness, enclosing tissue much like splenic pulp, which may, or may not, have lymph follicles. Any follicles present may be rudimentary in appearance, consisting of a few lymphoid cells surrounding a central arteriole, or they may be well-developed mature follicles. In some instances definite little blood sinus formations are present. Fibrous septa tend to infiltrate the enclosed cellular mass, from the surrounding capsule. A well-developed hilum is absent. The blood supply is from small arterioles which enter the nodule irregularly, from the surrounding tissue, at various points through the fibrous covering. Enveloping the whole nodule is serosa. Apparently, any function that these transplants might have, would be that of the normal splenic pulp.

Grossly, the splenic implants have been found to be both sessile and pedunculated, and to have a nodular, spherical, or flattened shape. They have varied in size from 1 Mm. to 3 cm. in diameter. In color and consistency, the nodules have the appearance of splenic tissue. Colors described for these transplants are normal spleen color, dark red, purple-red, and greenish-black. In one instance, that reported by Buchbinder and Lipkoff, the sur-

geon first discovered many small purple-red nodules, scattered over the peritoneum and viscera during the course of a female pelvic operation, and mistook their appearance for endometriomata, until microscopic diagnosis of an excised nodule revealed their true nature. The highest numerical estimate for these transplants was 200-300 in one case. In another instance, the base of the left pleural cavity was invaded. Probably this invasion occurred through a small rent in the diaphragm, which happened at the time of the accident, and later healed. No subcutaneous transplants within the operative wound scar have been reported. However, splenic grafts have successfully taken in the subcutaneous tissues of animals, when experimentally transplanted, as demonstrated by Marine and Manley, Perla, and others.

An interesting case is reported by Jarcho and Anderson, in which about 400 cc. of hemorrhagic blood was removed from the peritoneal cavity, at the time of operation for an acute traumatic rupture of the spleen, and immediately citrated, strained through gauze, and reinjected intravenously into the patient. Eight years later, at the age of 20, the patient died from acute perforated appendicitis. On postmortem examination, there were discovered 80 splenic transplants scattered over the peritoneum but no splenic nodules were found in the lungs, or outside the abdominal cavity. Nevertheless, the possibility of viable splenic cells contained in hemorrhagic blood obtained from the abdomen for retransfusion in such patients should be kept in mind.

Kreuter, in 1920, experimentally excised the spleen in monkeys, and then smeared the splenic pulp over the peritoneum. Several weeks, or months, later, the animals were sacrificed, and splenic nodules were found widely dispersed over the peritoneal cavity. Jarcho and Anderson review literature giving instances of dogs who had a history of severe abdominal trauma, and later following death, postmortem examination revealed nodular implants or splenic tissue scattered over the abdominal cavity. These authors also observe that Griffini and Tizzoni, as early as 1883, related that partial splenectomy in dogs was followed by development of spleen-like nodules in the peritoneum.

So far as we were able to ascertain, no cases have been reported in which there were widely disseminated splenic nodules following splenectomy, for nontraumatic diseases of the spleen. Shaw and Shafi express the opinion that the removal of diseased spleens, apparently is rarely, if ever, followed by implants, in spite of occasional tearing, with some associated hemorrhage, during the excision of large splenomegalies.

In the spleens of individuals, past the age of 30, Gross finds that the nuclei of the fibroblasts disappear, and the fibrils become thickened and few. Likewise, the intima and media of the blood vessels within the parenchyma become thickened with connective tissue, and hyaline changes. Wohl calls attention to the gradual collapse of lymph tissue, from birth onward. Because of the changes, mentioned above, he believes there occurs a decrease

in the power of constructive metabolism, which factor contributes to the rather early senescence of the organ.

The average known age at the time of the traumatic rupture of the spleen, among all the reported cases of autoplasmic transplantation of splenic tissue including ours, was nine plus years. It appears to us quite significant that the youngest was age three, and the oldest was 14 years. We believe the likelihood of successful grafting of these cells on a peritoneal surface is proportionate to the youthfulness of normal splenic tissue which has been traumatically ruptured. Pulp cells from the spleen of young individuals, very likely, possess properties of increased viability, or virulence, differing from similar cells in the adult spleen. We are of the opinion that such splenic implants may be found more often after traumatic rupture of the spleen, in young individuals who survive, than is generally recognized, and probably such a response is more the rule than the exception.

As yet, no symptoms have been known to result from these splenic implants. That the opportunity offered to discover such a condition in man, is minimum, was remarked in the early part of this discussion. Jarcho and Anderson, more concretely, emphasize this circumstance in their review of the last 2,000 autopsies at the Babies Hospital in New York, by finding only nine cases who had undergone a previous splenectomy for various reasons, from a few hours to nine years prior to autopsy. The only case in which operation had been performed, because of traumatic rupture of the spleen, was one of their published cases of autoplasmic transplantation of splenic tissue. Then again, out of 2,605 autopsies at the Presbyterian Hospital, in New York, during a ten-year period, these same authors found that splenectomy had been performed in 16 cases, from two weeks to 16 years, prior to autopsy. There were no instances of splenectomy for traumatic rupture of the spleen in this group, and none revealed splenic tissue, other than the finding of an accessory spleen, or so, in the bed from which the spleen had previously been removed. Finally, Shaw and Shafi observe that out of a series of 708 cases of splenectomy, published up until 1908, and 417 cases reported by Mayo in 1926, no pathologic studies of the late results of splenectomy are mentioned.

SUMMARY AND CONCLUSIONS

(1) A human case is reported which developed nodular splenic implants throughout the peritoneal cavity, following traumatic rupture of the spleen. This is the thirteenth case of similar nature, in man, described in medical literature. A chart summarizing these cases is appended.

(2) A detailed discussion of autoplasmic transplantation of splenic tissue, is made.

(3) It is our opinion, that in man relative youthfulness of normal splenic tissue is a very important factor, as regards viability of splenic pulp cells for autoplasmic implantation, and the likelihood of successful grafting of these cells on a peritoneal surface following traumatic rupture of the spleen.

(4) Autoplastic transplantation of splenic tissue may be more the rule than the exception in individuals who have suffered a traumatic rupture of the spleen, in their youth, and have survived the accident.

BIBLIOGRAPHY

- ¹ Adami, J. G., and Nicholls, A. G.: Principles of Pathology. London, 1911. (quoted by Pool and Stillman¹⁷)
- ² Albrecht, H.: Beitr. z. path. Anat., **20**, 513, 1896.
- ³ Berger, E.: Arch. f. klin. Chir., **68**, 865, 1902.
- ⁴ Buchbinder, J. H., and Lipkoff, C. J.: Surgery, **6**, 927-934, December, 1939.
- ⁵ Foltin, R.: Deutsche Ztschr. f. Chir., **110**, 160, 1911.
- ⁶ Griffini, L., and Tizzoni, G.: Arch. ital. d. biol., **4**, 303-306, 1883.
- ⁷ Gross: Jour. Med. Res., **39**, 311, 1918-1919.
- ⁸ Jarcho, S., and Anderson, D. H.: Am. Jour. Path., **15**, 527-545, September, 1939.
- ⁹ Jolly: Bull. Soc. anat. de Par., 1895, p. 745. (quoted by Pool and Stillman¹⁷)
- ¹⁰ Kreuter: Beitr. z. klin. Chir., **118**, 76-94, 1920.
- ¹¹ Kupperman, von William: Zentralbl. f. Chir., **63**, 3061-3062, 1936.
- ¹² von Kuttner, H.: Berl. klin. Wchnschr., **47**, 1520, 1910.
- ¹³ Lee, R. T.: Lancet, **204**, 1312-1313, 1923.
- ¹⁴ Marine, D., and Manley, O. T.: Jour. Exper. Med., **32**, 113-133, 1920.
- ¹⁵ Oltman: Quoted by von Stubenrauch.¹⁹
- ¹⁶ Perla, D.: Am. Jour. Path., **12**, 665-675, September, 1936.
- ¹⁷ Pool, E. H., and Stillman, R. G.: Surgery of the Spleen. D. Appleton & Co., New York, 1923.
- ¹⁸ Shaw, A. F. B., and Shafi, A.: Jour. Path. and Bacteriol., **215**, 215-235, July, 1937.
- ¹⁹ von Stubenrauch: Verhandl. d. deutsch. Gesellsch. f. Chir., **41**, 213, 1912.
- ²⁰ Watkins, V. E.: Med. Rec., **73**, 431, 1908.
- ²¹ Wohl, M. G.: ANNALS OF SURGERY, **82**, 246-249, August, 1925.