Surg Endosc (1995) 9: 172–177

Surgical Endoscopy

Laparoscopic splenectomy

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Received: 19 April 1994/Accepted: 26 August 1994

Abstract. We describe the clinical course of 23 patients considered for laparoscopic splenectomy. One patient was excluded on the basis of preoperative angiography findings, and two (9%) were converted to open surgery. In the remaining 20 patients who successfully underwent laparoscopic splenectomy, no mortality was reported; four postoperative complications (20% morbidity) occurred. Mean operating time was 3 h 35 min (135–300 min). After a mean postoperative stay of 3.9 days (2–9 days), all patients except two were back to normal activities within 2 weeks of hospital discharge. Preoperative splenic artery embolization, begun with the third patient, helped to reduce operative blood loss and made the procedure easier to perform. Laparoscopic splenectomy has become our procedure of choice for elective removal of normal-sized (<11 cm long) or moderately enlarged (11–20 cm long) spleens.

Key words: Splenectomy — Laparoscopy — Embolization — Laparoscopic splenectomy

In late 1991 and early 1992, Delaître in Paris, Carroll in Los Angeles, and our group in Canada published the first reports of laparoscopic splenectomy in patients with hematologic disorders [3, 5, 22]. We present the clinical course of 23 patients considered for laparoscopic splenectomy and discuss the perioperative preparation, technique, and results.

Patients and methods

Between March 1992 and March 1994, 23 consecutive patients were considered for elective laparoscopic splenectomy, including 13 men and 10 women with a mean age of 40 years (13–77 years). Surgery was canceled in one patient on the basis of preoperative angiogram findings, and her case will be discussed separately. Of the remaining 22 patients who underwent elective laparoscopic splenectomy, 11 had immune thrombocytopenia purpura, 10 presented a variety of hematologic disorders, and 1 had sustained an isolated splenic trauma (Table 1).

All patients, except one who underwent partial splenectomy for trauma, received antipneumococcal vaccine in the perioperative period. Thirteen patients were on therapeutic doses of steroids before surgery, and eight were prepared for surgery with intravenous gamma globulins, which brought their platelet count to normal.

Because it is a determinant of difficulty in laparoscopic splenectomy, spleen size (maximum pole length) was measured as the joining line between the two organ poles, as described by Goerg et al., and was divided into three categories: (a) normal spleen (< 11 cm long), (b) moderate splenomegaly (11–20 cm) and, (c) severe splenomegaly (>20 cm) [8]. Spleen size was assessed by ultrasound, and a computed tomography (CT) was obtained when there was doubt about the exactness of the ultrasound measurement, especially at the upper pole and in spleens longer than 16 cm, where ultrasound was inaccurate. The type of splenic blood supply, which also affects the difficulty of the operation, was classified as distributed type or magistral type, as suggested by Michels in his classic essay on the variational anatomy of the spleen and the splenic artery [17]. Complete hematologic evaluation was performed both preoperatively and postoperatively, and operative blood loss was carefully calculated and recorded. Complications and follow-up data were prospectively recorded in a data base.

Preoperative splenic artery embolization

Following blood losses averaging 1,200 ml during the first three operations, we started to use preoperative splenic artery embolization with the intent of reducing operative blood loss and possibly operative time [4, 6, 9]. A 5 French Cobra catheter (Anthron, Toray Medical Co. Ltd, Tokyo, Japan) was inserted in the right groin under local anesthesia. The splenic artery was cannulated up to the hilum, and a digital substraction angiogram was obtained after injection of iohexol 65% (Omnipaque 300, Sterling-Winthrop Inc, Markham, Ontario, Canada) or lothalamate 60% (Conray, Mallinkroft Medical Inc, Pointe-Claire, Québec, Canada) to verify the pattern of splenic blood supply. Ideally, distal embolization of each splenic artery branch

Presented at the annual meeting of the Society of American Gastrointestinal Endoscopic Surgeons (SAGES), Nashville, Tennessee, USA, 18–19 April 1994

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Table 1. Laparoscopic splenectomy pathology

Successful surgery	
Immune thrombocytopenic purpura	11
Spherocytosis	4
Autoimmune hemolytic anemia	2
Thrombotic thrombocytic purpura	1
Chronic lymphocytic leukemia	1
Trauma	1
Converted surgery	
Autoimmune hemolytic anemia	1
Lymphoma	1

was performed taking care to avoid the distal pancreatic branches of the splenic artery. Preferably, 3–5 mm microcoils (Cook, Bloomington, IN, U.S.A.), or gelatin sponge fragments (Gelfoam, The Upjohn Company of Canada, Don Mills, Ontario, Canada) were used. Microspheres were used in four patients and gelatin foam powder in two. The catheter was then pulled 2–4 cm, and one to three microcoils (5–8 mm) were launched in the main trunk of the splenic artery distal to the pancreatica magna artery. This double embolization technique was terminated when the radiologist estimated embolization to involve 80% or more of the splenic parenchyma [10]. Percentage of splenic devascularization was evaluated by intraoperative measurements and by studying video documents. At operation, devascularized segments had a grayish color whereas viable segments retained a pinkish hue; a clear demarcation line separated them.

Operative technique

Surgery was performed through five trocars in the upper abdomen with the patient in a steep Fowler position with left-side elevation. Surgery was started at the lower pole of the spleen by incising the splenocolic, the phrenocolic, and the sustentaculum lienis ligaments [19]. Then each arterial and venous branch of the splenic vessels was ligated individually with clips close to the splenic parenchyma. The plane of dissection was situated between the distal and the proximal embolization sites in cases where preoperative embolization was used. When ligated vessels were sectioned, a small clot was frequently seen, confirming efficient vessel thrombosis. The tail of the pancreas was carefully dissected away from the spleen, taking care to avoid any damage with the cautery or the linear stapler. It must be kept in mind that the tail of the pancreas is in direct contact with the spleen in 30% of patients and lies within 1 cm in 70% [1, 2, 18]. After establishing control of the short gastric vessels and sectioning the phrenocolic ligament at the upper pole, the isolated spleen was inserted in a sterile heavy-duty freezer bag (Ziploc, Dow Brands Canada, Paris, Ontario, Canada). The bag was partially exteriorized until the spleen came to rest against the abdominal wall on the peritoneal side, and a biopsy was made through the 3-cm umbilical incision. The spleen was then finger-fragmented, and the blood was aspirated. The remaining soft stroma was extracted in fragments. In one patient with massive splenomegaly (27 cm long), extraction was made through a 10-cm Pfannenstiel incision after delivery and fracture of the spleen in the pelvis. No drains were used. This technique has not been modified since our early experience [22].

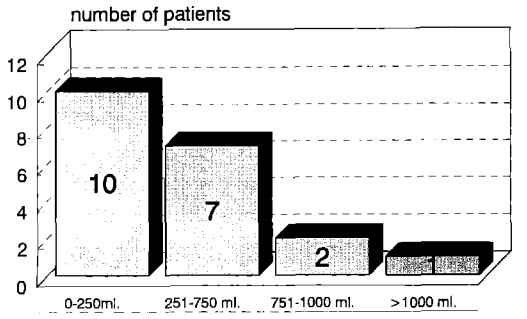

Fig. 1. Intraoperative blood loss: distribution of patients according to blood loss in milliliters during laparoscopic splenectomy.

Results

Preoperative splenic artery embolization

Blood losses during the first three operations were, respectively, 1,200 ml (converted procedure), 1,000 ml, and 1,500 ml. Thereafter, preoperative splenic artery embolization was used as an adjuvant to laparoscopic splenectomy, and helped to reduce intraoperative blood losses [20]. Ten of the subsequent patients lost 250 ml or less, seven lost 251–750 ml, and one lost 900 ml (Fig. 1).

The migration of a coil in a liver segment was the only complication related to the technique of preoperative splenic artery embolization. This occurred in the first patient to undergo the procedure. Computed tomography revealed a 2-cm liver infract that was clinically silent. However, 10 patients experienced enough abdominal pain after embolization to require the administration of narcotics during the night preceding surgery. Pain tended to be more severe (a) when the spleen was completely devascularized, (b) in patients with large spleens, and (c) when gelatin foam powder or microspheres were used.

Clinical experience

One patient with thrombotic thrombocytopenic purpura was excluded after preoperative angiography revealed severely stenotic arteries and evidence of multiple small-vessel thrombosis in the renal, mesenteric, and hepatic territories. Moreover, on venous return, most of the portal flow came from the splenic vein. With restricted arterial flow, splenectomy would have

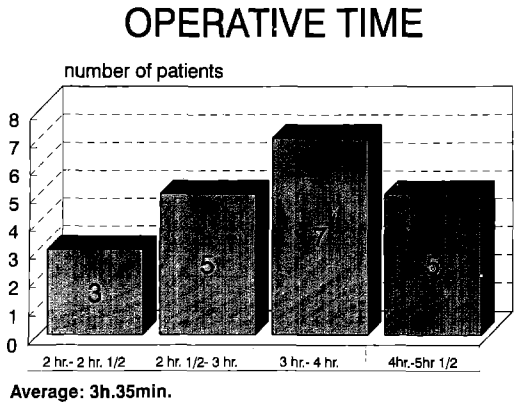

Fig. 2. Operative time: distribution of patients according to time required to perform laparoscopic splenectomy.

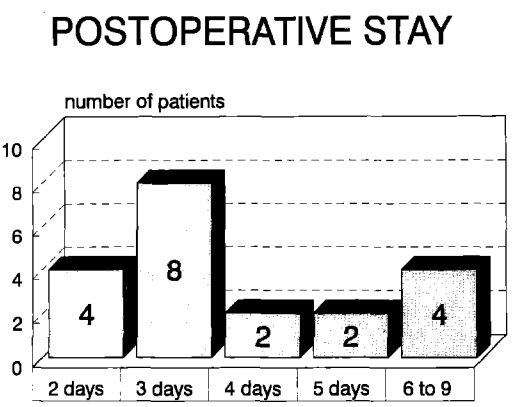

Fig. 3. Postoperative stay: distribution of patients according to length of postoperative stay in days.

deprived the liver of a critical portion of its total blood flow; consequently, surgery was not recommended.

Therefore, 22 patients underwent laparoscopic splenectomy, and the operation was converted to an open procedure in two (9%). The first patient in the series was converted for hemorrhage and the eighth patient for technical difficulties in attempting to dissect a 34-cm spleen. Accessory spleens were found in six patients who successfully underwent laparoscopic splenectomy (30%). Their diameters varied between 5 mm and 4 cm; one patient had two accessory spleens. When possible, accessory spleens were removed during the initial exploration or as soon as they were found because they were more difficult to locate and excise after extraction of the spleen. Mean operative time was 3 h 35 min (135–300 min) (Fig. 2). Two patients received 1 unit of blood during surgery, and one received 2 units in the postoperative period. During surgery, one patient required placement of a left chest tube after a small perforation was made in the diaphragm during dissection of fibrotic adhesions at the superior pole of the spleen. There were no deaths and no hemorrhagic or septic complication requiring surgery in the immediate postoperative period. Four patients (20%) presented postoperative complications: one prolonged ileus and three respiratory complications (atelectasis/pleural effusion) (Table 2). Two of the three patients who suffered pulmonary complications complained of severe pain after the embolization procedure. In all these cases, microspheres or gelatin foam powder had been used. One patient required drainage of a symptomatic pleural effusion and also presented with abdominal pain and fever 4 months after surgery. A 20-ml collection in the splenic fossa was drained with a CT-guided needle aspiration. Another patient, who had left the hospital on the 7th postoperative day, presented abdominal pain and fever of undetermined origin; investigation for sepsis was negative. The low-grade temperature remained for many days at home then disappeared without specific treatment. Gelatin foam powder had been used for her preoperative splenic artery embolization procedure.

The mean postoperative stay was 3.9 days [2–9] (Fig. 3). Fourteen patients had a distributed-type blood supply (63%) and eight a magistral type. Eight spleens measured less than 11 cm long (range: 8–11 cm; average: 9.93 cm), 11 were moderately enlarged (11–20 cm) (range: 11.6–19.5 cm; average: 14.18 cm), and one was massively enlarged (27 cm) (Fig. 4).

Table 2. Laparoscopic splenectomy postoperative morbidity (20%)

Hemorrhage	0
Infections	0
Atelectasis/pleural effusion	3
Ileus	1
Death	0

Discussion

Preoperative splenic artery embolization

We believe that the respiratory complications of two patients may have been caused by the microspheres and gelatin foam powder used during some of the embolization procedures. Like other authors, we think unintended embolization in a territory other than the target organ was responsible for these complications [4, 10]. This can result from backflow during injection; and, in this situation, very small embolic particles, such as microspheres and gelatin foam powder, may be dangerous. Because of their small size, migration to the level of capillaries is possible, and severe tissue necrosis can result in the retroperitoneum or the pancreas. For this reason, we have abandoned the use of gelatin foam powder and microspheres. More recently, the Canadian government banned the use of microspheres for embolization following reports of similar complications.

The learning curve of splenic artery embolization accounts for most of the morbidity of this procedure. At present, we exclusively use coils (3–8 mm) and gelatin foam fragments and proceed to embolization on the morning of the operation to reduce the pain pro-

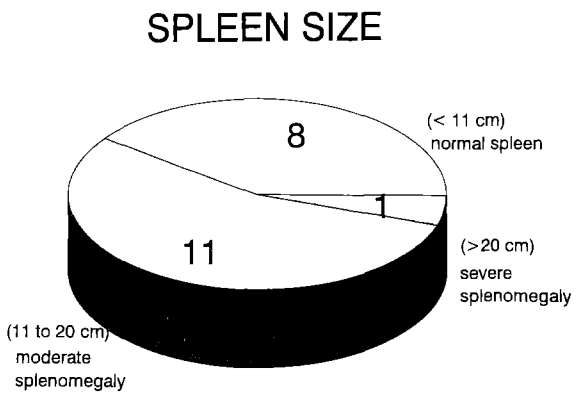

Fig. 4. Spleen size: distribution of patients who successfully underwent laparoscopic splenectomy according to spleen size.

duced by spleen devascularization. We have not experienced complications since we have eliminated the use of microspheres and gelatin foam powder.

In a previous study, we demonstrated a significant linear correlation between the percentage of splenic devascularization observed at surgery after preoperative splenic artery embolization, and blood loss at surgery [20]. Control of hemostasis during laparoscopic splenectomy also improves with experience; however, we still feel that preoperative splenic artery embolization, although optional for patients with a normal-sized spleen, is a useful adjunct to laparoscopic splenectomy and helps to reduce intraoperative blood losses, especially when teaching this procedure to inexperienced surgeons and to residents. Preoperative splenic embolization is also very useful when removing larger spleens [6, 9], and is virtually indispensable for performing partial laparoscopic splenectomy. It also makes the operation less stressful, and has prevented conversion to open surgery in a number of cases in this series.

Clinical experience

Laparoscopic splenectomy is a reproducible procedure that, in this series, had a 9% rate of conversion to open surgery. The first patient was converted because of a hemorrhagic incident after improper application of the linear stapler to hilar vessels; this was due to inexperience. The stapler was closed before it was ascertained that the tip was completely free of tissue. In this situation, closure and firing can result in partial section of a major splenic branch. In the eighth patient, the 34-cm spleen could not be mobilized enough to permit safe dissection of vessels and ligaments. In cases where the spleen was less than 30 cm long, there was only one conversion (1/19) for a rate of 5.2%. There has been no conversion to open surgery since the eighth case, and we believe that the conversion rate will be further reduced with experience. It is noteworthy that accessory spleens were found in 30% of patients, which compares favorably with the 15–30% rate quoted in the literature on open splenectomy [18, 21]. A recent report of eight cases of recurrent hematologic disease after splenectomy successfully treated by removal of accessory spleens serves as a reminder that searching for and excising accessory spleens constitutes an essential step in this procedure whether the access is conventional or laparoscopic [16]. Of our patients, 14 had a distributed-type blood supply and eight a magistral-type. This 64/36 ratio is close to the 70/30 ratio reported by Michels in his classic essay on the vascular anatomy of the spleen [17]. Spleens with a distributed-type blood supply should alert the surgeon that more vessels will need to be ligated, but they will be spread over a wider surface as they enter the splenic parenchyma (75% of the medial surface), and this tends to make the dissection easier. Spleens with a magistral-type blood supply have fewer vessels, but they enter the spleen in a more compact bundle (25–33% of the medial surface), making dissection more difficult [18, 19].

In four recent studies, conventional open splenectomy for similar hematologic disorders is associated with an operative mortality of 1.3–6%, and a morbidity of 19–25% with even higher mortality and morbidity rates being reported for myeloproliferative disorders and massive splenomegaly [11, 13, 14, 23]. Our rates were 0% mortality and 20% morbidity. However, none of our patients had morbid myeloproliferative disorders, and only one had severe splenomegaly ($\geq$1,000 g, $\geq$20 cm); moreover, a larger number of patients is required before definitive judgment can be made regarding the value of laparoscopic splenectomy [7, 15].

The average postoperative stay of 3.9 days would have decreased to 3.4 days by excluding the two patients who stayed 7 and 9 days. These two patients sustained complications probably related to the use of gelatin foam powder and microspheres during their preoperative splenic artery embolization. With these two exceptions, all patients returned to normal activities within 15 days of surgery. Laparoscopic splenectomy seems to demonstrate the advantages ascribed to other laparoscopic procedures [12] and has become our technique of choice for elective removal of normal or moderately enlarged spleens (< 20 cm long). We are presently evaluating the procedure in massive splenomegaly.

References

1. Ballinger WF, Erslev AJ (1965) Splenectomy: indications, technique and complications. Curr Probl Surg Feb: 1–51
2. Baronofsky ID, Walton W, Noble JF (1951) Occult injury to the pancreas following splenectomy. Surgery 29: 852–856
3. Carroll BJ, Phillips EH, Semel CJ, Fallas M, Morgenstern L (1992) Laparoscopic splenectomy. Surg Endosc 6: 183–185
4. Castaneda-Zuniga WR, Hammerschmidt DE, Sanchez R, Amplatz K (1977) Nonsurgical splenectomy. AJR 129: 805–811
5. Delaitre B, Maignen B (1991) Splénectomie par voie laparoscopique, 1 observation. Presse Med 20: 2263
6. Fujitani RM, Johs SM, Cobb SR, Mehrenger CM, White RA, Klein SR (1991) Preoperative splenic artery occlusion as an adjunct for high risk splenectomy. Am Surg 54: 602–608
7. Goldstone J (1978) Splenectomy for massive splenomegaly. Am J Surg 135: 385–388
8. Goerg C, Schwerk WB, Goerg K, Havemann K (1990) Sono-

graphic patterns of the affected spleen in malignant lymphoma. J Clin Ultrasound 18: 569–574
9. Hiatt JR, Gomes AS, Machleder HI (1990) Massive splenomegaly. Superior results with a combined endovascular and operative approach. Arch Surg 125: 1363–1367
10. Hilleren DJ (1991) Embolization of the spleen for the treatment of hypersplenism and in portal hypertension. In: Kadir S (ed) Current practice of interventional radiology, spleen, pp 494–497 Philadelphia, BC Decker
11. Hoeffer RA, Scullin DC, Silver LF, Weakly SD (1991) Splenectomy for hematologic disorders: a 20 year experience. J Ky Med Assoc 89:446–449
12. Litwin DEM, Girotti MJ, Poulin EC, Mamazza J, Nagy AG (1992) Laparoscopic cholecystectomy: trans-Canada experience with 2201 cases. Can J Surg 35: 291–296
13. Ly B, Albrechtson D (1981) Therapeutic splenectomy in hematologic disorders. Effects and complications in 221 adult patients. Acta Med Scand 209:21–29
14. Macrae HM, Yakimets WW, Reynolds T (1992) Perioperative complications of splenectomy for hematologic disease. Can J Surg 35: 432–436
15. Malmaeus J, Akre T, Adami Ho (1986) Early postoperative course following elective splenectomy in hematological disease: a high complication rate in patients with myeloproliferative disorders. Br J Surg 73: 720–723
16. Merlier O, Ribet M, Mensier E, Ronsmans N, Caulier MT (1992) Role of accessory spleen in recurrent hematologic diseases. Chirurgie 118: 229–235
17. Michels NA (1942) The variational anatomy of the spleen and splenic artery. Am J Anat 70: 21–72
18. Perry JF Jr (1984) Anatomy of the spleen, splenectomy and excision of accessory spleens. In Nyhus LM, Baker RJ (eds) Mastery of surgery. Little, Brown and Company, Boston pp 823–829
19. Poulin EC, Thibault C (1993) The anatomical basis for laparoscopic splenectomy. Can J Surg 36: 485–488
20. Poulin E, Thibault C, Mamazza J, Girotti M, Côté G, Renaud A (1993) Laparoscopic splenectomy: clinical experience and the role of preoperative splenic artery embolization. Surg Laparosc Endosc 3: 445–450
21. Sheldon GF, Croom RD, Meyer AA (1991) The Spleen. In: Sabiston DC (ed) Textbook of surgery, 14th ed. WB Saunders Company, Philadelphia, pp 1108–1133
22. Thibault C, Mamazza J, Létourneau R, Poulin E (1992) Laparoscopic splenectomy: operative technique and preliminary report. Surg Laparosc Endosc 2:248–253
23. Ziemski JM, Rudowski WJ, Jaskowiak W (1987) Evaluation of early postsplenectomy complications. Surg Gynecol Obstet 165: 597–614

Discussion

Dr. Cuschiere: (Moderator) This paper is now open for discussion. Perhaps I could start the discussion and ask you about the indications. It is our view that above a certain size the operation becomes difficult, since you don't have exposure and you also have problems with delivery. Our cutoff seems to be 20 centimeters. What is your view?

Dr. Poulin: Our largest sizes were 27 centimeters, and last week we did a spleen of 24 cm which is not included in this paper. We feel that the maximum size would be around 20 to 30 cm. But we do not use the same extraction technique for the larger spleens. We make a 10-centimeter Pfannenstiel's incision, deliver the spleen into the pelvis and fragment it under direct vision in the pelvis. The largest spleen that you can bag is about 24 centimeters, just because of the size of the available bags.

Dr. Phillips: (Los Angeles) You are to be congratulated on some beautiful work. There are a couple of issues that are problematic in this. One is, what instrument do you use to grasp the spleen; and the second is, especially in ITP, what is the incidence of capsular fragmentation and possible contamination of the abdominal cavity?

Dr. Poulin: We try not to grasp the spleen. We make a point in trying to lift it up. So we use a palpator to lift up the lower pole, and once this gets freed, once we start working at the upper pole, the sooner we can lift up the upper pole. That's the technique we're trying to use. Capsular tears were a bit of a problem, as you know. I think you were one of the first to present this operation, to publish on it. There's nuisance bleeding that makes you very humble, but we've almost eliminated that with the preoperative splenic artery embolization. So lifting up the spleen and embolizing the spleen has made a very big difference. We feel it has avoided conversion in many cases.

Dr. Phillips: You were ligating the short gastrics then first?

Dr. Poulin: No, these vessels can be very slender, and they should be taken last.

Dr. Cuschieri: (Moderator) Our technique is slightly different in that we do open the lesser sac early by creating a small window or perhaps ligating one of the short gastrics. And the first step is to ligate in continuity the splenic artery.

Dr. Poulin: No. I don't like that approach. I'll tell you why. A 58-page classic essay in the *American Journal of Anatomy* by Nicholas Michael describes that the splenic artery itself, is divided into four different fragments, and the variation on these is unbelievable. You can have proximal branches to where your point of ligation will be, and you will not have control of the distal parenchyma. Other anatomists, have described transverse anastomoses between the segmental arteries of the spleen, and even if you ligate proximally, you can get blood through the ischemic segment.

Dr. Cuschieri: If you've effectively ligated the splenic artery proximal to the distal branches, the spleen will turn totally black. If you haven't, and there are distal branches due to the abnormalities of the blood supply, then you'll see black spleen with pink areas. But I can tell you, for about nine out of ten you can locate the splenic artery, despite what this monograph says, and the spleen gets black and small.

Dr. Poulin: But the spleen doesn't get black, sir, because you cannot control the short gastrics or the branches of the left gastroepiploic. So you always have the crescent of pink at the top and at the bottom, and the only way you will get those black is from the distal embolization where you get retrograde thrombosis in the upper and lower pole area. I don't think it's a very important point, because once you've devascularized the spleen above 70 percent, it makes

the operation very easy. I don't think you need to get 100 percent devascularization.

Dr. Berman: (Fountain Valley) I congratulate you on a very nice study. But I am a little concerned about the fact that you're taking an operation that with a normal size spleen could be done in about an hour, and exposing the patient to the morbidity of a preoperative angiogram and to the extra expense. Do you have any concerns about the area of cost-cutting?

Dr. Poulin: I think there's a learning curve to this operation. There is also a learning curve in all the vagaries of embolization, but once you've passed through this, it becomes very routine. To us, at this point, it's not a very major problem. So I think it's worth it to the patient. These people—the last kid we did was in school in 12 days.

Dr. Smith: (Cincinnati) We're going to hear a paper tomorrow from another Montreal surgeon about a lateral approach to splenectomy that does not require embolization. Could you, number one, comment on the cost of embolization; and number two, comment about this lateral approach, if you are aware of it?

Dr. Poulin: I'm not very dogmatic about embolization. I don't think it's mandatory, it just makes things easier. If you have a seven centimeter spleen that has an easy blood supply, you will go away with the idea that this is an easy operation. After a while you become able to identify the problem spleens and the complicated vasculatures. I think in these cases, you need all the help you can get. The only thing I'm worried about with the lateral approach is the ability to find accessory spleens. Other than that, I think, there will be many ways of doing this operation.