

# Testicular Transplantation and Autotransplantation

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## TESTICULAR AUTOTRANSPLANTATION FOR THE HIGH UNDESCENDED TESTICLE

There has been considerable discussion recently of how best to localize a nonpalpable cryptorchid testis (spermatic venography, EMI scan, or spermatic arteriography).<sup>23, 49</sup> Furthermore, there has been much debate over proper surgical management when the testis is high and intraperitoneal.<sup>12, 16, 17, 23</sup>

In our hands, laparoscopy has been the simplest, safest, and most reliable method of localizing high intra-abdominal testes.<sup>13</sup> For surgical management, the spermatic vessels must be divided in order for the testicle to be brought into the scrotum (Fig. 22-1). Ischemic damage is not obvious in many cases because of the collateral blood supply via the deferential artery<sup>16</sup> (Fig. 22-2). However, in many cases there is a great risk of testicular atrophy.

We have recently seen five patients with bilateral intra-abdominal testes who underwent division of the spermatic vessels with microsurgical reanastomosis to the inferior epigastric vessels on one side, and on the other side simple division without reanastomosis.<sup>35, 43</sup> On the side where revascularization of the spermatic vessels was performed, the testis retained its normal size and texture. On the side where the vessels

were simply divided without reanastomosis, partial or complete testicular atrophy occurred. Martin has made similar observations.<sup>24</sup>

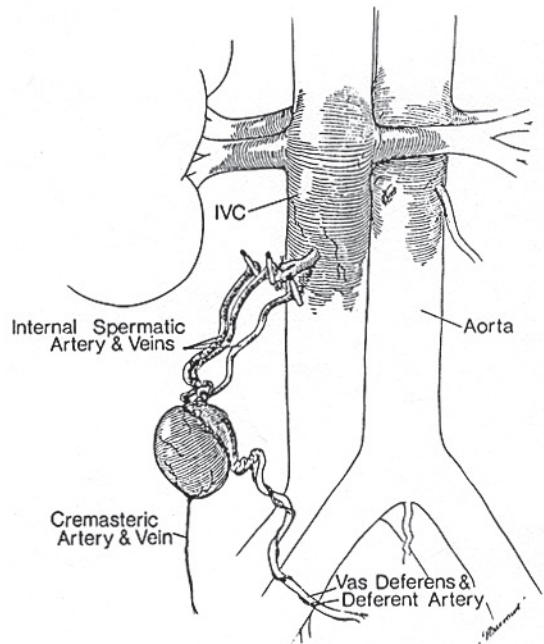


Figure 22-1 The spermatic vessels must be divided to bring the high testis into the scrotum. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.

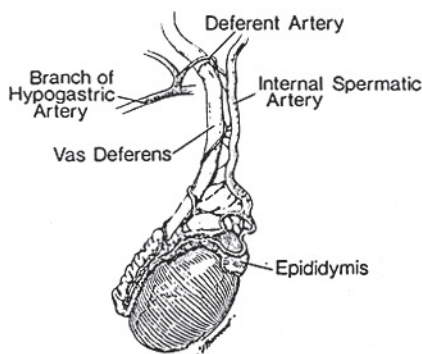


Figure 22-2. Illustration of collateral circulation to the testes. In more than half the cases this collateral circulation is meager. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.

### Rationale

The controversies that surround the problem of the intra-abdominal testes fall into two major categories. First, does it make any sense to try to treat these intraperitoneal testes surgically? Second, if there is a rationale for such treatment, what is the safest surgical approach?

The danger of unrecognized cancer in the intra-abdominal testicle has already been dealt with in detail, and certainly provides one motive for placing such a testicle in the scrotum or possibly removing it.<sup>11, 26</sup> Furthermore, the intra-abdominal testis is easily subject to possible torsion, which could present as a severe acute abdomen.<sup>33</sup>

It had been generally assumed in previous years that the cryptorchid testicle suffered only a loss of spermatogenic function; hormonal function was supposedly unaltered. However, recent studies have demonstrated that the abdominal environment also affects the endocrine function of the testis, and will result in premature loss of testosterone production. Cryptorchid patients have impaired intratesticular androgen production. An adult with untreated bilateral cryptorchidism will have an elevated luteinizing hormone (LH) level, and will have premature loss of testosterone secretion.<sup>3, 8, 15</sup> Experimental studies in the rat<sup>1</sup> have demonstrated that when scrotal testes are transferred to the abdomen, there is an immediate and dramatic elevation of follicle-stimulating hormone (FSH) corresponding to a rapid deterioration of spermatogenesis. However, over a longer period of time the LH level begins to gradu-

ally go up also, indicating later loss of endocrine function of the cryptorchid testes. The intra-abdominal environment is detrimental not only to spermatogenesis, but also to hormone production. It simply takes longer for this aspect of testicular function to deteriorate.

The major unanswered question is whether transplantation of these testes to the scrotum in a child will enhance the ultimate development of fertility when the child grows up. There is overwhelming experimental evidence that making a testicle cryptorchid diminishes spermatogenesis and then replacing that cryptorchid testicle in the proper scrotal environment allows spermatogenesis to recover.<sup>19, 21, 29, 32, 45</sup>

More dramatic are the few but well-documented case reports of azoospermic adults (16 to 25 years of age) with bilateral cryptorchidism who after orchidopexy developed normal spermatogenesis and reasonable sperm counts. These are unusual cases, but they dramatically demonstrate the potential for fertility in cryptorchid patients.<sup>10, 14</sup>

The second question in this controversy is: What is the safest method for transferring the high intraperitoneal testis into the scrotum? The concept of simply dividing the internal spermatic vessels is not new. Bevan<sup>7</sup> first recommended this approach in 1903. Both he and Moschowitz<sup>31</sup> reported good results. However, Mixter,<sup>30</sup> in 1924, and Wangenstein,<sup>48</sup> in 1927, as well as MacCollum,<sup>27</sup> in 1935, reported uniformly poor results with the Bevan operation.

It was Fowler and Stephens<sup>16</sup> who first demonstrated, in 1963, that by dividing the internal spermatic vessels high up and not dissecting their attachment to the cord, it was possible to preserve collateral circulation via the deferential artery. The spermatic vessels could be clamped first and the testicle biopsied to determine the adequacy of collateral blood flow. Even in their hands, almost half of the patients underwent some testicular atrophy, and a third underwent rather severe atrophy. Furthermore, the original diagrams of Fowler and Stephens demonstrate that their technique was most valuable in management of the so-called "long-looped vas," where the testis is really located at the level of the internal inguinal ring and the vas deferens loops down in the canal toward the external ring and then comes back to the testis at the internal ring. By avoiding dissection in the inguinal canal



the collateral circulation can be preserved. Most of the cases Fowler and Stephens described did not involve severely high intra-abdominal testes. Brendler,<sup>9</sup> Clatworthy et al.,<sup>12</sup> and Gibbons et al.<sup>17</sup> have all resorted to the Fowler-Stephens procedure for high intraperitoneal testes. Variable instances of atrophy have been reported by all groups utilizing this approach.

To our knowledge, three groups have used revascularization of the divided spermatic vessels in treating such cases.<sup>43</sup> We reported the first such case in 1976. Martin discussed his cases in 1977.<sup>25</sup> Romas reported his series in 1978.<sup>28, 34, 47</sup> It is with the very high intraperitoneal testicle that atrophy is encountered. Harrison,<sup>20</sup> in 1949, demonstrated in fresh autopsy dissections that the sum of the diameters of the deferential and cremasteric arteries was equal to the diameter of the testicular artery in only a third of cases, indicating that adequate functional collateral circulation to the testis is by no means universal.<sup>41</sup> Furthermore, observations in patients who have undergone ligation of the spermatic artery at the time of varicocelectomy or inadvertently at the time of childhood inguinal herniorrhaphy have demonstrated to us that collateral circulation to the testes is by no means secure, and in most cases it will be inadequate to nourish the testes adequately after spermatic vessel ligation.

Referral of patients to our center has been based upon reasonable suspicion ahead of time that these patients would suffer testicular atrophy if revascularization were not accomplished. In all cases there was some tension on the vas deferens with proper scrotal placement. Possibly this tension could have compromised the collateral blood supply afforded by the deferential artery. In any event we observed that after division of the spermatic vessels, back-bleeding was usually present but was meager. In such cases, when revascularization was not performed some testicular atrophy was highly likely. However, when revascularization was performed no atrophy, functional or anatomic, was observed.

### Report of Five Cases

Five patients discovered to have very high intraperitoneal testes were referred to us

specifically because of anticipation that in their particular cases division of the spermatic vessels without reanastomosis might be hazardous. Two of the patients (both 5 years old) had had previous division of the spermatic vessels on one side only, using the Fowler-Stephens technique to bring the high testes into the scrotum, but this had resulted in complete atrophy. These two patients were thus referred to us with only one remaining testicle each, and a history suggesting that simple division of the spermatic vessels without microsurgical reanastomosis might result in the loss of their only remaining testicles. In a third case the patient had undergone no previous attempt at orchidopexy, but since he was 21 years of age and postpubertal development had been normal, and he had heavy abdominal musculature, it was feared that there would be tension on the vas deferens and deferential artery. The fourth patient was a 5-year-old boy, with very high testes, who had not previously undergone any attempt at orchidopexy. The fifth patient, an 11-year-old boy, had undergone an attempt at orchidopexy on one side without division of the spermatic vessels, and the testicle could not be brought beyond the internal ring.

*Case 1.* A 5-year-old boy with nonpalpable undescended testes was referred from out of state. A year earlier he had undergone bilateral inguinal explorations and no testes had been found in the inguinal canal. An intraperitoneal extension of the incision on each side had demonstrated high intraperitoneal testes. On the right side the internal spermatic vessels had been clamped and a small incision made in the testis to check for adequacy of the collateral circulation. Bleeding had been observed but had not been brisk. The Fowler-Stephens test was thus felt to be equivocal on the right side, but the vessels had been divided and the testicle then placed in the scrotum. The Fowler-Stephens test on the left was also equivocal, but on this side the vessels had not been divided, and the procedure had been abandoned. Postoperatively over the next three months the right testicle atrophied totally. The patient was then referred to us for autotransplantation of the remaining left testicle.

Laparoscopy showed that the left testicle was intraperitoneal, and it appeared to be tacked down in the area of the internal ring. The internal spermatic vessels were under tension. The vas deferens was not under tension. The abdomen was opened through a midline intraperitoneal incision. The spermatic vessels were clamped proximally and a microvascular clamp was placed on the vessels distally. The epigastric



vessels were freed up inferior to the area of the previous left groin incision. The spermatic artery was spatulated and then anastomosed to the inferior epigastric artery by the technique previously described.<sup>13, 38</sup> Ischemia time was 40 minutes. The testicle was placed in the left scrotal sac with the vas deferens coming just over the pubic symphysis, the shortest possible route. There was no tension on the microvascular anastomosis, but there was a fair degree of tension on the vas deferens and the deferential vessels, which seemed unavoidable.

Postoperatively the patient's course was unremarkable. He was discharged six days later, and on follow-up examination eight months later, the testicle was of normal size and consistency, with no sign of atrophy. The human chorionic gonadotropin (HCG) stimulation test showed a normal testosterone response, similar to that found preoperatively.

Case 2. A 5-year-old child with prune belly syndrome had undergone left-sided orchidopexy at another institution with the Fowler-Stephens procedure, dividing the spermatic vessels and allowing the testicle to be supplied by the artery of the vas deferens. The vascular pedicle had been divided high and the testis brought down on a long strip of peritoneum which was attached to the vas deferens and its blood supply. The surgeon had noted that there was still some tension on the vas deferens and collateral vasculature supplying the testes, but that it finally had been anchored satisfactorily in the scrotal pouch in the left scrotum.

Postoperatively the testis was found actually to be located just above the pubic symphysis in the subcutaneous fatty tissue, and not truly in the scrotum. There was partial atrophy as well. It was therefore decided to perform the orchidopexy on the opposite side using microvascular technique.

Laparoscopy demonstrated an intraperitoneal testicle essentially undisturbed. Autotransplantation was accomplished by division of the spermatic vessels with reanastomosis to the inferior epigastric vessels. Postoperatively the testes were in a good position, with no atrophy. There was some tension on the vas deferens, but this did not compromise the blood supply coming from the reanastomosed internal spermatic vessels. Postoperatively the HCG stimulation test demonstrated a normal testosterone response, as it had preoperatively.

Case 3. A 6-year-old boy had no palpable testes. A positive HCG stimulation test had an EMI scan that revealed the testes to be located very high intraperitoneally. The abdomen was opened through a midline intraperitoneal incision, and two normal-sized testes were found intraperitoneally, rather high up. The Fowler-Stephens maneuver was performed on each side, and free bleeding was noted. The spermatic vessels were then divided and the testes mobilized

out of the abdomen with no interference with its collateral blood supply through the deferential artery. However, it was noted that on each side there would be tension on the vas deferens if the testes were brought into the scrotal sac.

On the left side reanastomosis of the vessels was not performed, and the testicle was allowed to remain in the left scrotal sac under some tension, relying on collateral circulation via the deferential artery and vein. On the right side, however, the inferior epigastric artery and veins were anastomosed directly to the divided spermatic vessels by use of microsurgery.

Six months postoperatively, the left testicle had atrophied almost completely and the right testicle was normal in size and consistency. The postoperative HCG stimulation test showed a normal testosterone response.

Case 4. A 21-year-old man who was about to be married was concerned that he had never notice testicles in his scrotal sac. He had been turned down by the army for this reason, and was seeking consultation. He had undergone normal post-pubertal development. Testosterone levels averaged 315 ng/dl. Follicle-stimulating hormone was essentially at castrate levels (more than 100 mIU/ml), and LH was markedly elevated, in the range of 45 to 55 mIU/ml (upper limit of normal less than 30 mIU/ml). The EMI scan demonstrated two normal-sized testicles intraperitoneally at about the level of the pelvic brim. Semen analysis demonstrated azoospermia with a normal semen volume and normal fructose.

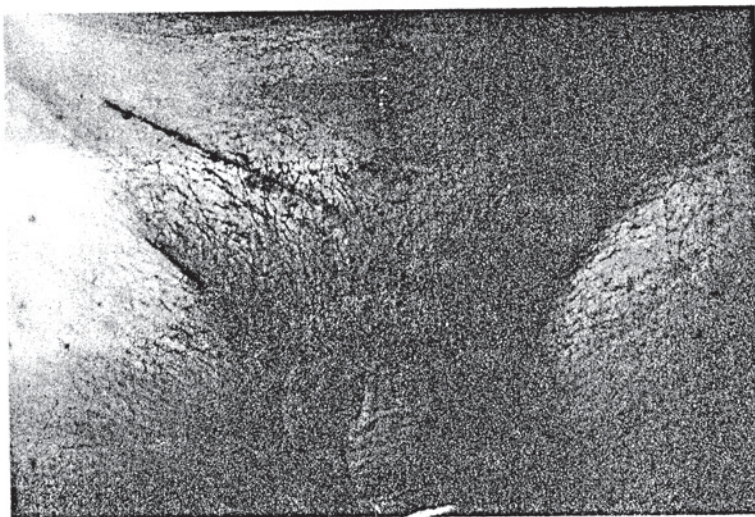
Because the patient was concerned about possible development of an intra-abdominal testicular malignancy, as well as the possibility of premature loss of endocrine function of the testicles, he underwent laparotomy.

Two normal-sized testes were located at the pelvic brim, as predicted by EMI scan. The intraperitoneal appearance was similar to that of two normal ovaries in a young woman. On each side the Fowler-Stephens maneuver was performed, and bleeding from the cut tunica albuginea of the testicle was present but equivocal in briskness. On the right side division of the spermatic vessels with microvascular reanastomosis to the inferior epigastric vessels was performed. On the left side, however, the spermatic vessels were merely divided and the testicle was brought into the scrotal sac, relying on collateral circulation via the deferential artery and veins, which were properly preserved. There was a great deal of tension on the vas deferens despite the fact that the shortest possible route was used to get the testicle into the scrotum.

Three months postoperatively the left testicle was completely atrophied and the right testicle was of normal size and consistency (Fig. 22-3). Postoperative hormonal values were unchanged from preoperative values. Follow-up on this patient extended to six months without any sign of deterioration of the right testicle. Shortly after the



**Figure 22-3** Testicular auto-transplantation in a 21-year-old man with high testes. The right side was revascularized after division of the spermatic vessels, and the left side was not. The left side atrophied and the right side did not. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.



last follow-up visit he was killed in an automobile accident.

**Case 5.** An 11-year-old boy who had bilaterally nonpalpable testes underwent left groin exploration with extension of the incision in an attempt to free up and bring down a high intraperitoneal testis on that side. The spermatic vessels were not divided, and the testicle could not be brought below the internal ring. He was then referred to us. Laparoscopy revealed a very high intraperitoneal right testis. The left testis was atrophied and fixed by adhesions at the internal ring. Microvascular autotransplantation was performed on the right. Postoperatively there was no atrophy, and the right testicle was properly located in the scrotum. Right testicular blood flow had been poor after division of the spermatic vessels, but became brisk after revascularization.

### Microsurgical Technique

Microvascular Scoville-Lewis, Schwartz, or Heifetz neurosurgical clips are placed on the deep inferior epigastric artery and both superficial and deep inferior epigastric veins inferiorly. These vessels are then tied off superiorly. Although blood flow through the epigastric vessels is adequate in either direction, one can rely on better arterial pressure and better venous drainage inferiorly, since these vessels are direct branches of the external iliac artery. The inferior epigastric vessels are each divided and the lumens examined. The spermatic vessels are then brought into the area for anastomosis.

There will usually be one or two spermatic veins and one spermatic artery. The one spermatic artery is about a third the size of

the spermatic vein and is generally too small to be anastomosed to the deep inferior epigastric artery unless it is spatulated. This is no problem, however. The spermatic artery is spatulated dorsally to create a triangular opening that will allow its diameter to match the diameter of the deep inferior epigastric artery. The arterial anastomosis is performed first.

For this anastomosis, 9-0 or 10-0 nylon on a BV-6, BV-2, or GS-16 needle is ideal. The first suture is placed in the apex of the spatulation on the spermatic artery from outside to inside and then is carried through to the anterior 12 o'clock position of the deep inferior epigastric artery from inside to outside. The suture is tied down and one end is left 2 cm long as a stay suture for manipulation. The next suture is placed at one or the other of the corners of the spatulated spermatic artery and carried through to a position 120 degrees from the first suture in the inferior epigastric artery. This is also tied. Several sutures are then placed between these two initial stay sutures. This represents an anastomosis of a third of the vessel's diameter (Fig. 22-4).

Next, the stay sutures are used to rotate the vessels so that the unsutured portion of the anastomosis is now in the anterior position. The next stay suture is placed at the corner of the other spatulated edge of the spermatic artery, outside to inside, and then from inside to outside in the inferior epigastric artery, again 120 degrees away from the original anterior suture. This stay suture similarly is left 2 cm long for easy manipula-



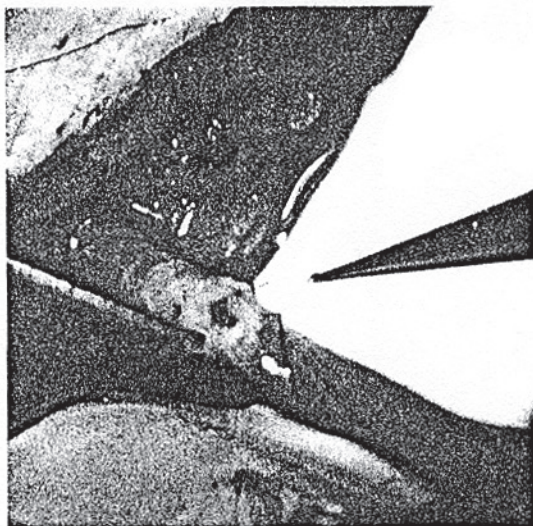


Figure 22-4 Arterial anastomosis of the spermatic vein to the inferior epigastric vein. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.

tion, and several sutures are placed between it and the original anterior suture. Now two thirds of the arterial anastomosis has been completed. The two lateral-most stay sutures are then used to completely rotate the vessel 180 degrees, exposing the remaining 120 degrees of unsutured vessel wall. Usually two or three more sutures are adequate to complete the anastomosis in this portion. When the anastomosis is complete, all stay sutures can be divided. Strict adherence to a methodical pattern such as this is important, or otherwise one will fairly soon find oneself confused as to what portion of the donor artery goes to what portion of the recipient artery.

Interrupted sutures are absolutely critical. Continuous suturing will result in a purse-stringing effect, bunching, and at best, a confusing, and at worst, an obstructed, anastomosis. The interrupted sutures should be tied down and cut as one goes, rather than leaving them to be tied down at the end. If one does the latter, one will have an impossible puppet show, in which the spider-web-thin sutures will become entangled with each other before even half of them have been placed. No attempt should be made to perform the arterial anastomosis until the spatulation has been performed as described because the discrepancy between the lumens is otherwise too great.

Contrary to the procedure usually used in

other sorts of transplantations, the arterial microclamp may be taken off prior to any venous anastomosis and the testicle allowed to become perfused. There may be a tiny amount of arterial suture line bleeding at first, but patient application of a sponge for a few minutes should control it. One should be very cautious about placing an extra stitch in a bleeding area of the anastomosis, as is commonly done in macrovascular surgery. Usually any bleeding will stop with application of a sponge for a few minutes, and any suture placed in haste in such a delicate anastomosis will often result in obstruction. The arterial clamp can be removed before any venous anastomosis is performed because even in a testicle with an excellent blood supply, the flow is slight enough that blood loss via the venous outflow will not seriously affect the patient's condition. In the meantime, the ischemic period is considerably reduced by such a maneuver. The two spermatic veins have freely anastomotic circulation, and therefore one of these veins can be clamped with a microvascular clamp in preparation for anastomosis to the deep inferior epigastric vein while the other spermatic vein is allowed to bleed freely. After the first venous anastomosis to the deep inferior epigastric vein is performed, the microvascular clamps can be removed from both the spermatic vein and the deep inferior epigastric vein and a clamp placed on the extra spermatic vein, which has been bleeding all this time, to prepare it for anastomosis to the superficial inferior epigastric vein. Now there is one adequate venous channel, so we still do not have to worry about congestion of the testis from venous occlusion during either of these venous anastomoses.

The technique for the venous anastomosis is somewhat simpler. Since the vessel sizes here will generally match up very nicely, spatulation is not necessary. A standard anastomosis can be performed by placing two anterior stitches 120 degrees apart (Fig. 22-5). Several sutures can be placed between these two initial stay sutures, and the entire vessel is then rotated 180 degrees so that the posterior 240 degrees that have not been sutured yet are facing anteriorly (Fig. 22-6). Another stay suture is placed halfway, dividing this into two 120-degree segments, each of which will require several sutures in between to complete the anastomosis. Patency of the arterial anastomosis is generally checked by observing excellent venous out-



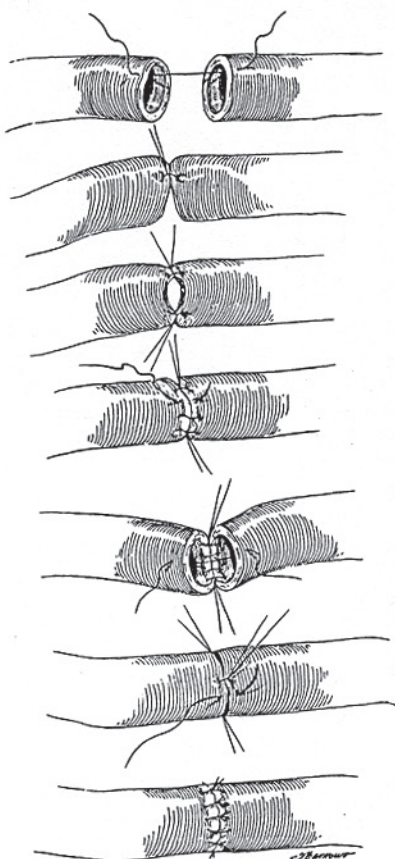


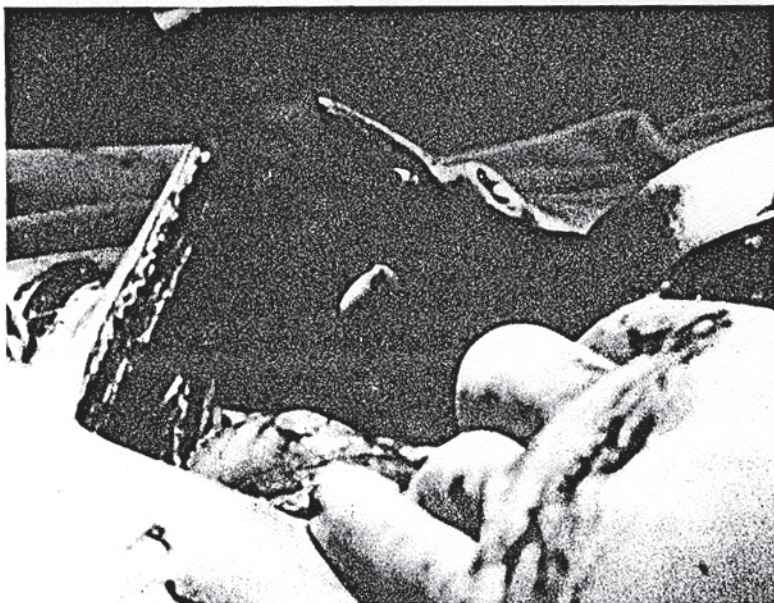
Figure 22-5 Diagram of venous anastomosis. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.



Figure 22-6 Venous anastomosis after arterial anastomosis is completed. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.

flow, and also can usually be observed under the microscope directly. Patency of the venous anastomosis can be ascertained by a prompt filling of the clamped venous segment across the anastomosis when the clamp on the spermatic vein is removed. Following this, the clamp on the inferior epigastric vein is removed. The testicle has now been completely revascularized; it can be placed into

Figure 22-7 Typical intra-peritoneal appearance of a high intra-abdominal testis in an otherwise normal 5-year-old (without prune belly syndrome). Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.





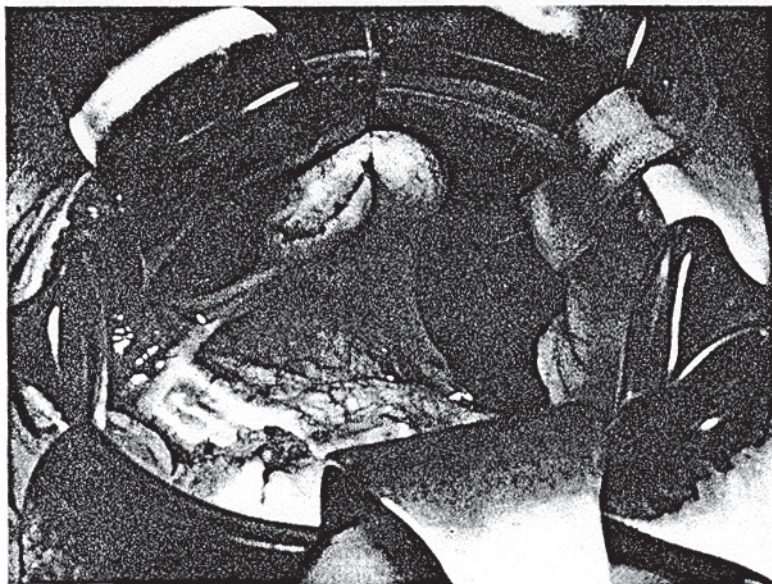


Figure 22-8 A normal-sized intra-abdominal testis in a 9-year-old boy with prune belly syndrome. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979. The Williams and Wilkins Company, Baltimore, Maryland.

the scrotal sac without any tension (Figs. 22-7, 22-8, and 22-9). Adequacy of blood flow to the testis both intraoperatively and postoperatively is monitored with a Doppler probe.

In bilateral cases where we have reanastomosed the divided spermatic vessels on one side but relied on collateral circulation via the vas deferens on the other side, we have always wished that we had simply revascularized both sides.

#### TESTICULAR HOMOTRANSPLANTATION FOR ANORCHIA

Bilateral anorchia occurs in only one in 50,000 patients. At present, we do not rou-

tinely recommend testicular homotransplantation for these patients because of concern about the risks of rejection therapy for treating a nonfatal condition. However, we have employed it successfully in each of two patients whose donors were identical twin brothers.<sup>40</sup> We have learned a great deal about testicular physiology from these cases.

A 30-year-old man had been born with no testes, while his identical twin brother had been born with two normal testes in the scrotum. They requested a testicular transplant so that the anorchic twin would no longer have to take testosterone injections, and also so that he might possibly be able to father children. The twin with testes had gone through normal puberty at 13 years of age, and by the age of 30 he had fathered

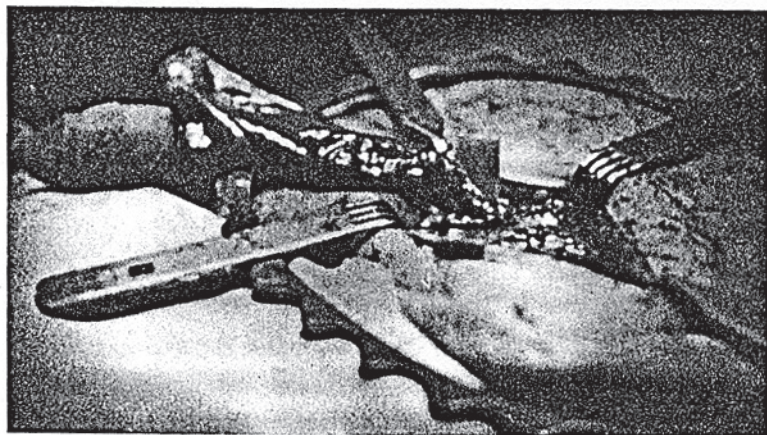


Figure 22-9 The high intra-abdominal testis can now reach the scrotum after division of the spermatic vessels and reanastomosis to the inferior epigastric vessels. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.



three healthy children. The twin without testes had not gone through puberty, and at the age of 14 had undergone a lengthy course of chorionic gonadotropin injections. When no response to chorionic gonadotropin occurred, he had undergone an extensive surgical exploration, and no testes had been discovered. He was found to have a vas deferens in the scrotum on the right side, which ended in what was assumed to be an atrophic testicular remnant.

The patient continued to retain a eunuroid appearance, with no pubertal changes, until the age of 18, when therapy with varying doses of depo-testosterone was begun. This regimen induced normal puberty, and secondary sex characteristics developed. The patient underwent a rapid growth spurt at this time, so that by the age of 20, he was 5 feet, 11 inches tall, whereas his brother with testes had stopped growing much earlier, at 5 feet, 7 inches tall.

The anorchic brother was then able to have an active sex life, but noticed lability in his mood and drive when relying on monthly testosterone injections. With weekly injections he had a more stable mood pattern. Shortly before the transplantation, he relied on weekly intramuscular injections of depo-testosterone, 200 mg. For the preceding five years he had been actively searching for medical authorities who would consider a testicular transplant.

tion was found to be normal in all respects. Serum FSH was 11 mIU/ml (normal male range, 3 to 20 mIU/ml) and LH was 14 mIU/ml (normal male range, 6 to 30 mIU/ml). Serum testosterone was 626 ng/dl (normal male range, 300 to 1200 ng/dl). The sperm count, performed twice, was 44 million sperm/ml, with 85 per cent motility and 90 per cent normal forms, a volume of 3.5 ml, and pH 8.0 the first time; on the second occasion, it was 76 million sperm/ml with 85 per cent motility and almost all normal forms, a volume of 3 ml, and pH 8.0. A radiogram of the chest, complete blood count, and SMA-12 chemical profile disclosed no abnormality. An intravenous pyelogram was normal, and a scrotal scan showed normal activity bilaterally.

**Recipient.** The patient was 5 feet, 11½ inches tall and weighed 150 pounds. Physical examination showed no abnormality except a well-healed lower abdominal surgical scar, complete absence of testes in the scrotum, and a palpable vas deferens on the right. The patient had normal secondary sex characteristics.

The patient's weekly testosterone injections had been discontinued a month prior to the scheduled operation. At that time serum FSH had been 96 mIU/ml and serum LH, 110 mIU/ml. Serum testosterone was 76 ng/dl (lower limit of normal in the male is 300 ng/dl). A semen analysis revealed no spermatozoa, a volume of 3.0 ml, pH 8.0, and a positive fructose test. A radiogram of the chest, complete blood count, and SMA-12 chemical profile showed no abnormality. An intravenous pyelogram was normal bilaterally, and a scrotal scan revealed no radioactivity in either scrotum.

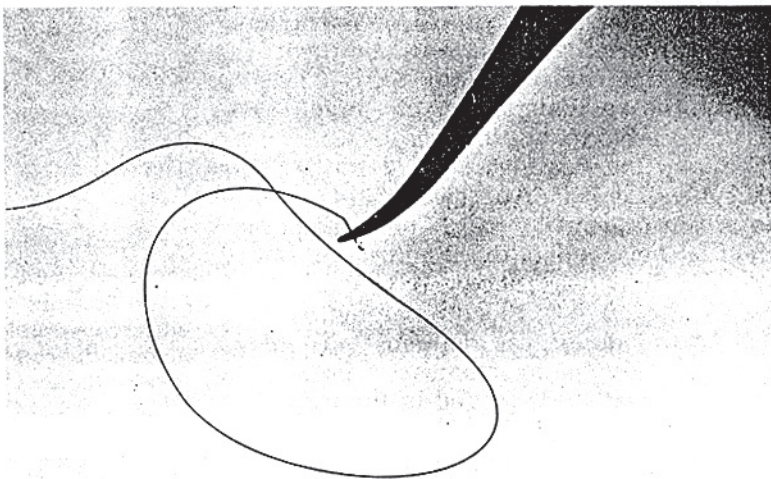
### Preoperative Studies

**Donor.** The donor was 5 feet, 7 inches tall, weighed 147 pounds, and on physical examina-

### Operative Technique

The microvascular technique for testicular homotransplantation is very similar to that

**Figure 22-10** 9-10 nylon on a microscopic needle is used for the anastomoses. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.





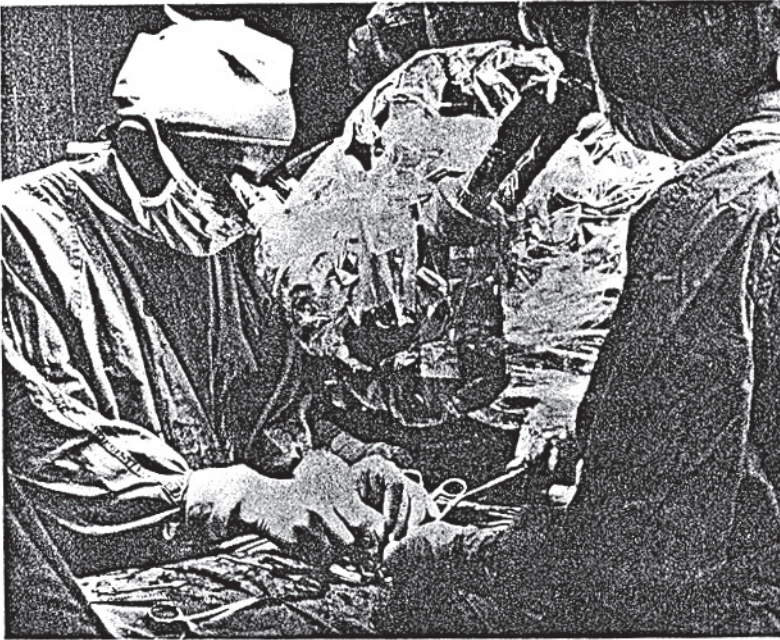


Figure 22-11 All anastomoses must be performed under the operating microscope. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.

for autotransplantation.<sup>39, 43</sup> The donor testis was removed through a right inguinal incision at the level of the internal inguinal ring, where there were one testicular artery (0.5 mm in diameter) and two testicular veins (1.5 mm in diameter). The vas deferens (inner diameter 0.3 mm, outer diameter 2.0 mm) was also divided at this level. A similar right inguinal incision was made in the recipient, and the testicular artery of the donor was anastomosed to the deep inferior epigastric artery (1.5 mm in diameter) of the recipient after spatulation of the donor testicular artery. The two spermatic veins of the donor were then anastomosed to the superficial and deep inferior epigastric veins of the recipient. Interrupted sutures of 9-0 nylon were used for all anastomoses, and the cold ischemia time was 1.5 hours (Fig. 22-10). Finally, the vas deferens of the donor was anastomosed to that of the recipient, using a technique that has also been described in great detail.<sup>36, 37, 42</sup> All anastomoses were performed under 16× to 25× magnification under a Zeiss operating microscope, and excellent flow was observed through the vessels (Fig. 22-11). Bleeding along the cut edge of the donor vas deferens was then noticed. When the anastomoses were completed, the testis was placed in the scrotum in its proper anatomic position, and the incision was closed. Doppler readings taken

in the cord area just above the testis at regular intervals demonstrated good flow.

### Postoperative Studies

**Donor.** The donor's postoperative sperm count and hormonal values are summarized in Table 22-1. Testosterone remained in the normal range. There was a subtle elevation in FSH during the first three days postoperatively, but FSH returned to preoperative levels by 90 days. These changes were minimal, however, and the donor suffered no abnormality from unilateral orchiectomy.

**Recipient.** The excised end of the vas deferens was histologically unremarkable. A right testicular arteriogram performed via the right iliac artery seven days postoperatively revealed a normal, patent anastomosis between the deep inferior epigastric artery of the recipient and the internal spermatic artery of the donor testis (Fig. 22-12).

The recipient's postoperative sperm count and hormonal values are summarized in Table 22-2. The sperm count obtained seven days postoperatively was 3.5 million sperm/ml, with 35 per cent motility, a volume of 3.0 ml, and pH 8.0. The sperm count on the following day was 2.5 million sperm/ml, with 25 per cent motility. The sperm count obtained a month postoperatively showed only a very rare, nonmotile sperm. In subsequent months the count began to increase slowly to its present normal range of 15 million sperm/ml, with more than 50 per cent motility and 90 per cent normal morphology.

Blood samples for hormonal determinations



TABLE 22-1 Hormonal Values\* and Sperm Counts of the Testicle Donor

	Days Postoperatively											
	-1	(2 hr) 0	1	2	3	4	5	6	7	90	240	
Serum testosterone (ng/dl)	943 626	385	392	353	414					550	450	
Serum luteinizing hormone (mIU/ml)	27 14	17	16	18	21					19	11	
Serum follicle-stimulating hormone (mIU/ml)	12 11	11	11	19	23					17.9	15	
Sperm count	$44 \times 10^6$					$47 \times 10^6$				$53 \times 10^6$		
Density	85%											
Motility	$76 \times 10^6$											
	85%					85%				50%		

\*Laboratory normal ranges: testosterone, 300–1,200 ng/dl; luteinizing hormone, 6–30 mIU/ml; follicle-stimulating hormone, 3–20 mIU/ml.

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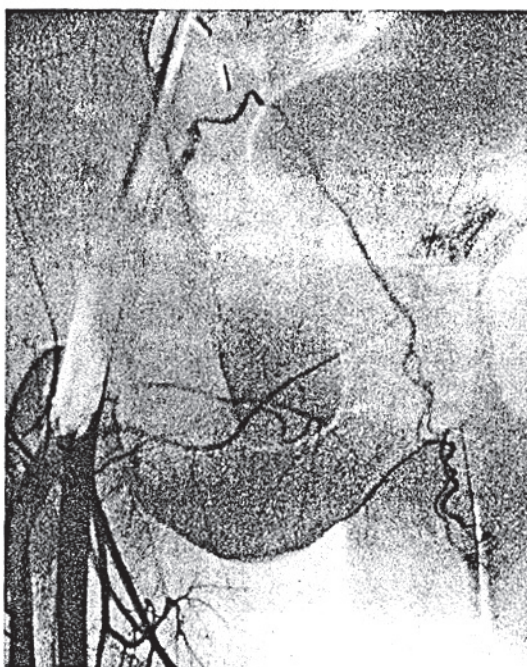


Figure 22-12 Arteriogram seven days postoperatively, demonstrating good testicular blood flow and a patent anastomosis of the 1.5-mm inferior epigastric artery of the recipient to the 0.5-mm spermatic artery of the donor testicle. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.



TABLE 22-2    Hormonal Values\* and Sperm Counts of the Testicle Recipient  
Days Postoperatively

	-1	(2 hr) 0	1	2	3	4	5	6	9	30	60	90	150	230
Serum testosterone (ng/dl)	81 76	348	311	378	551		569	630	528	740	—	470	830	—
Serum luteinizing hormone (mIU/ml)	102 110	145	76	70	81		105	67	39	39	20	—	15	—
Serum follicle-stimulating hormone (mIU/ml)	94 96	115	115	82	66		52	50	35	17.4	—	—	14.8	—
Sperm Count									3,400,000					
Density	0	0	—	—	—	—	—	—	35% 2,400,000	Rare	83,000	1,000,000	9,500,000	18,000,000
Motility	0	0							25%	0%	1%	20%	10%	50%

\*Laboratory normal ranges: testosterone, 300–1,200 ng/dl; luteinizing hormone, 6–30 mIU/ml; stimulating hormone, 3–20 mIU/ml. Reprinted from Silber, S. J.: Transplantation of human testis for anorchia. *Fertil. Steril.*, 30:181, 1978.

were obtained two hours after the microvascular clamps were removed and perfusion to the transplanted testis was re-established. The serum testosterone level jumped almost instantly to the normal range, and then continued to increase slowly to higher levels over the next 40 days. Serum FSH and LH levels came down more slowly, and did not really reach the normal range

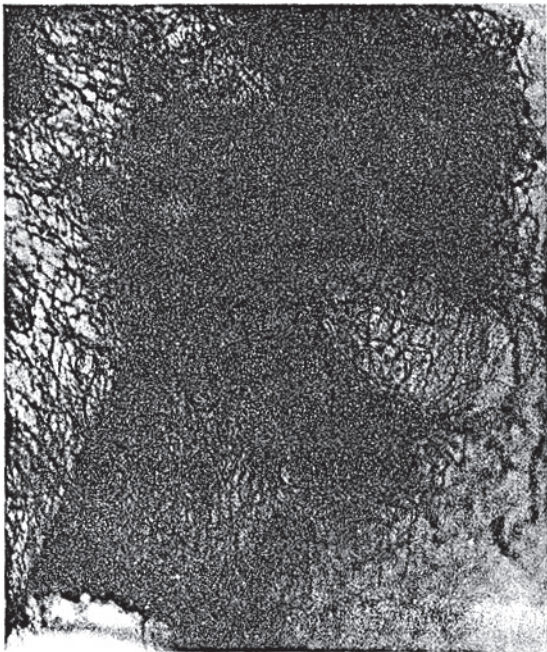


Figure 22-13 Testis of the anorchic patient who had received a testicular transplant on the right side from his twin brother six months earlier. Reproduced with permission of the author and publisher from Silber.<sup>38</sup> Copyright 1979, The Williams and Wilkins Company, Baltimore, Maryland.

until 30 to 60 days postoperatively. However, the decline of FSH and LH from castrate levels to normal had begun by the second postoperative day. The recipient continues to have normal hormonal levels and normal sexual drive and activity, despite receiving no medication since a month before operation. His incision is well healed and his new testis looks just as though it were his (Fig. 22-13).

Two years following the transplant, the patient's wife became pregnant after her ovulatory dysfunction had been successfully treated. Their child is now 6 months old and healthy.

Discussion

Attaran et al.<sup>4</sup> described testicular transplants in dogs utilizing a nonmicroscopic technique that necessitated excising a cuff of the anterior aortic wall along with the spermatic artery in order to have a segment large enough for anastomosis to a recipient vessel. The autotransplants appeared to survive, but the homotransplants were rejected. Their technique would not be applicable to human cases, since it would involve extensive intra-abdominal exposure and vascular risk, which neither the donor nor the recipient would be likely to agree to.

Lee et al.,<sup>22</sup> Altwein et al.,<sup>2</sup> and Gittes et al.<sup>18</sup> studied testicular transplantation in syngeneic rats and compared the results of simple testicular implantation with those obtained after vascularized transplantation. It was very clear from their studies that simple implantations of testicular tissue did



not result in an endocrinologically viable testis. Syngeneic rats that had undergone bilateral orchiectomy with vascular transplantation of a new testis maintained normal FSH and LH levels. However, rats given simple testicular implants after bilateral orchiectomy developed extremely high FSH and LH levels.

Human testicular transplantation has been made possible by sophisticated microsurgical techniques that allow both donor and recipient to be operated on through a simple inguinal incision, without intraperitoneal exploration. Vessels 0.5 mm in diameter can be anastomosed with very good assurance of continued patency. The transplanted testis of our patient is obviously functioning as a normal endocrine gland, as evidenced by the return of FSH, LH, and testosterone levels to normal values. It is interesting that the testosterone level became normal so rapidly despite a much slower decline in gonadotropin levels.

Sperm seen in the recipient's ejaculate seven and eight days postoperatively clearly had been produced while the testis was in the donor. The decline in the sperm count thereafter would imply a temporary interruption of spermatogenesis related to the ischemia time. However, the possibility of a defect in conduction of peristalsis along the denervated vas deferens cannot be ruled out. The subsequent improvement of the sperm count could have been due to recovery from the transient episode of ischemia or to reinnervation of the vas deferens.

Animal studies by Smith<sup>44</sup> and by Steinberger and Tjioe<sup>46</sup> indicate that the testis may tolerate as much as two to four hours of ischemia without severe damage. It is clear that beyond that interval testicular recovery is poor. We feel now that with some technical innovations, the ischemia time for future such operations can be reduced to 30 minutes. If so, this might help to answer the question posed by the temporary decrease in sperm count in this case.

Anorchia is acquired in utero.<sup>6</sup> Since there are a fair number of individuals with anorchia who are dependent upon testosterone injections, the question of transplantation in nonidentical individuals naturally comes up. Patients receiving immunosuppressive therapy for renal transplants (prednisone, 5 mg to 30 mg/day, and azathioprine, 1 mg to 2 mg/kg/day) are known to have fathered children and to have normal sperm counts.<sup>5</sup>

However, the application of this surgical procedure to nonidentical individuals awaits the development of still safer methods of specific immunosuppression.

At the present time the greatest use for this technique is in transplanting the high cryptorchid testicle to the scrotum, without atrophy, and with the best chance of preserving spermatogenesis.

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