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VASOEPIDIDYMOSTOMY TO THE HEAD OF THE EPIDIDYMIS: RECOVERY OF NORMAL SPERMATOZOAL MOTILITY*

SHERMAN J. SILBER, M.D.†

St. Lukes West Hospital, St. Louis, Missouri 63112

We previously reported a microsurgical technique for bypassing epididymal obstruction by performing a specific microanastomosis to the epididymal tubule. When obstruction was near the head of the epididymis, spermatozoal motility was always poor (0 to 1%) even though the numerical count was high.

There are now over 1½ years of follow-up on the first five patients who had a vasoepididymostomy performed in the proximal region (head) of the epididymis. None of these patients had more than 0 to 1% spermatozoal motility postoperatively despite counts of more than 50 million sperm/ml. However, within 1½ to 2 years the spermatozoa of these patients eventually developed normal motility.

This study verifies that in humans spermatozoa derived from the head of the epididymis are at first not capable of motility. However, after 1 or 2 years, these spermatozoa eventually recover normal motility. This unexpected finding sheds new light on epididymal physiology and offers some hope for men with proximal epididymal obstruction. Fertil Steril 34:149, 1980

It has been well known for over a decade that spermatozoa derived from the head of the epididymis have very poor motility and are incapable of fertilization.[1-6] Spermatozoa arriving from the ductuli efferentes into the head of the epididymis acquire the ability to become motile only gradually during their 11-day course through the epididymis. For this reason it has been felt that vasoepididymostomy should be performed as distally as possible to allow for maximal spermatozoal motility. Vasoepididymostomy to proximal regions of the epididymis theoretically would not result in fertility even if the operation were technically successful.

We have reported a technically reliable method for bypassing epididymal occlusion by anastomosing the vas deferens directly to the epididymal tubule.[7] However, occasionally azoospermia is caused by obstruction so high in the epididymis that the only surgical alternative is to bypass the entire corpus and tail and to anastomose the vas directly to the head of the epididymis. We originally doubted that such patients requiring anastomosis to the proximal epididymis would ever become fertile because spermatozoa from this region are known to be immotile.

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†Reprint requests: Sherman J. Silber, M.D., 456 North New Ballas Road, Suite 108, St. Louis, Missouri 63141.

METHODS

A total of 158 bilateral vasoepididymostomies have been performed by us in the past 3 years. Ten of these involved anastomosis to the caput region. Five of these patients have had a minimum of 1½ years' follow-up. Of the five patients with less than 1½ years follow-up, one is azoospermic. The other nine have normal patency as demonstrated by numerical sperm counts of over 20 million/ml. In all patients except two, anastomosis to the epididymal tubule was made within 1 cm of the vasa

efferentia; in the other two, it was within 1.5 cm. The surgical technique involved a specific bypass microanastomosis of the vas to the epididymal tube just proximal to the point of obstruction.[7-9]

RESULTS

Patients with Over 1½ Years' Follow-up

Case 1. A 45-year-old man had undergone a bilateral vasectomy in April 1958 after having fathered four children. He presently wished to have more children. We performed a scrotal exploration in January 1978 and found that there were no spermatozoa in the vas fluid on the testicular side of the vasectomy site. Further exploration revealed obstruction in the head of the epididymis. Serial transections of the epididymis were performed, and at each level no spermatozoa were noted in the fluid until the head of the epididymis was reached. An anastomosis of the inner lumen of the vas deferens directly to the epididymal tubule in this region was then accomplished on each side. For the first 4 months postoperatively there were very few spermatozoa in the ejaculate. By 8 months postoperatively the semen contained 19.6 million sperm/ml but only 1% weak motility. By 10 months postoperatively there were 26 million sperm/ml and no motility. By 1½ years postoperatively there were 21 million sperm/ml with 47% motility. The majority of the spermatozoa exhibited straightforward progression with high velocity. Several months later the count was 39.8 million sperm/ml with 58% motility, and again the majority of the spermatozoa exhibited high-velocity, straightforward, normal progression.

Case 2. A 40-year-old man had undergone a bilateral vasectomy in the fall of 1963 after having fathered three children. He was later remarried to a 29-year-old woman and desired another family. He underwent an accurate microsurgical vasovasostomy in December 1976. No spermatozoa had been noted in the vas fluid, and the patient remained azoospermic postoperatively. We reoperated in February 1978 and explored the epididymis. On the right side, despite serial sectioning along the entire length of the epididymis up to the rete testes, no spermatozoa were found in the fluid. On the left side the epididymis was noted to be obstructed in the caput region. Serial transections from the midcorpus all the way up to the head of the epididymis showed no spermatozoa in the epididymal fluid until the head of the epididymis was reached. At this level there were abundant intact spermatozoa with no motility. A vasoepididymostomy to the specific epididymal tubule leaking the sperm fluid was performed at this level according to the technique previously described.[7] Postoperatively the patient had a moderate-sized hematoma on the left side which resolved over the next month. A sperm count by 7 months postoperatively revealed 46.2 million sperm/ml with only 1% motility. At 1 year postoperatively the count was 58.6 million sperm/ml with again only 1% motility. At 1 year and 4 months postoperatively the count was 90.6 million sperm/ml, but motility had risen to 35%. By 1½ years postoperatively the count was 107.5 million sperm/ml with 65% motility. Most of these spermatozoa exhibited grade III straightforward progression.

Case 3. A 49-year-old doctor had undergone a bilateral vasectomy 10 years previously after having fathered five children. He now wished to have more children. On March 24, 1977 a scrotal exploration was performed, and no spermatozoa were noted in the vas fluid on the testicular side of the vasectomy site. Epididymal exploration on each side revealed obstruction at the junction of the corpus and the head of the epididymis. A vasoepididymostomy to the caput region was performed according to the technique previously described.[7] Postoperatively no spermatozoa were noted in the patient's semen during the 1st month. By 3 months postoperatively he had 19.4 million sperm/ml with no motility. By 6 months postoperatively the count suddenly rose to 120 million sperm/ml with 60% motility. Most of the spermatozoa exhibited grade III purposeful forward progression. Two years passed but the wife had not become pregnant. Reevaluation of her revealed ovulatory dysfunction. She was treated with clomiphene citrate and became pregnant in the second treatment cycle.

Case 4. A 30-year-old man from Iran was noted to have azoospermia during a fertility work-up. A vasoepididymostomy had been attempted in Iran, but the patient remained azoospermic. He then came to the United States, and we performed a scrotal exploration on July 10, 1978. The epididymis on each side was serially transected from the tail region distally to the head proximally, and spermatozoa were sought in the vas fluid at each level. No spermatozoa were found on either side until the head of the epididymis was reached. The patient then underwent a specific anastomosis of the inner lumen of the vas directly to the epididymal tubule in this region. Postoperatively for the

first 10 months the patient had fewer than 2 million sperm/ml with poor motility. By 1 year postoperatively he had 12 million sperm/ml with 70% forward progressive motility.

Case 5. A 38-year-old man had undergone a vasectomy in February 1965 after having fathered four children. In October 1972 he underwent a vasovasostomy but remained azoospermic postoperatively. His follicle-stimulating hormone, luteinizing hormone, and testosterone levels were within the normal range, and his testicular biopsy showed normal spermatogenesis. He was referred to us and underwent epididymal exploration on June 17, 1977. No spermatozoa were noted in the vas deferens fluid. The epididymis was explored and found to be obstructed at the caput region bilaterally. Fluid in the midcorpus region of the epididymis showed no spermatozoa. Serial transections were performed proximally until fluid harboring many intact spermatozoa was finally reached in the head of the epididymis. An anastomosis of the inner lumen of the vas deferens to the specific epididymal tubule leaking the sperm fluid was achieved with the technique previously described.[7] By 3 months postoperatively the sperm count was 56 million sperm/ml with no motility. By 1½ years postoperatively the patient's semen contained 85.2 million sperm/ml with only 1% motility, but even the few motile spermatozoa were sluggish and just vibrated in place. By 2 years postoperatively there was 4% motility with rapid forward progression.

Patients with 1 Month to 1 Year of Follow-up

Because of the long period required by many of these patients to recover normal spermatozoal motility, this group deserves only brief mention. One of these men remains azoospermic at 13 months. One of them at 15 months has a sperm count of 70 million/ml with no motility. Of the other three, one has 21 million/ml with 55% normal motility, one has 28 million/ml with 33% normal motility, and one at 1 month already has 10% normal motility. In all of these five patients, the vasoepididymostomy was performed within 1 cm of the vasa efferentia.

DISCUSSION

After a microscopic vasoepididymostomy to the midcorpus or distal corpus region, over 80% of patients recover a normal sperm count.[7] Spermatozoal motility then reaches normal levels within the first 5 months postoperatively. In cases where the corpus epididymidis was not bypassed there has been no discrepancy between numerical count and motility. However, in nine of ten cases in which the anastomosis had to be performed at the level of the head of the epididymis, there were high numerical sperm counts with dramatically poor motility. At first we had little hope for these patients. We predicted that, although they might have high numerical sperm counts, spermatozoal motility and maturity would most likely be inadequate for fertilization because the spermatozoa did not have enough epididymal length through which to travel.

However, with long-term follow-up (more than 1½ years), the spermatozoa of four of five such patients now have normal motility and all have normal morphology. One patient has finally impregnated his wife. Of the five patients with less than 1½ years of follow-up, two already have normal motility, one is likely to reach normal motility early, one still has no motility, and in one the anastomosis was a technical failure. There was no correlation between the variability of recovery of spermatozoal motility and the level of anastomosis, but all anastomoses were clearly at the caput level. It is apparent that some sort of compensatory mechanism eventually allows spermatozoa from the caput to exhibit normal motility.

Numerous experiments in animals have demonstrated the role of the epididymis in conferring motility to spermatozoa.[1-6] In the rabbit, Gaddum[1] sampled spermatozoa from the seminiferous tubules, the ductuli efferentes, and various levels of the epididymis to determine their intrinsic motility and fertilizing capability. Spermatozoa from the seminiferous tubules and ductuli efferentes showed only weak vibratory movements with no forward progress. Spermatozoa in the proximal head of the epididymis showed very irregular, erratic motility with no forward progression. Traversing the corpus epididymidis, however, increasing numbers of spermatozoa began to show forward movement with proper longitudinal rotation as they progressed distally toward the tail of the epididymis.

To determine whether this progressive increase in spermatozoal maturity was merely a function of time required for passage of spermatozoa or whether it was dependent upon the function of specific areas of the epididymis, Glover[4] ligated various portions of the epididymis in rabbits and

examined samples of spermatozoa from each portion. After interruption of sperm flow, epididymal spermatozoa which had been poorly motile in the caput region showed increased motility initially, but this was short-lived. By 3 weeks, all of the spermatozoa from the head of the epididymis were again nonmotile. Glover[4] and Gaddum and Glover[5] believed that it was possible for spermatozoa to mature at any level of the epididymal duct, but their experimental approach created such an abnormal environment that this hypothesis could not be studied. Obstruction to the flow of spermatozoa within the epididymis has been shown clearly to result in stagnation of epididymal spermatozoa, so that the increased time allowed for maturation in that experiment was counterbalanced by the abnormal obstructed environment.[6] Orgebin-Crist[10] made similar experimental observations.

Thus purely technical problems stood in the way of determining whether spermatozoa could mature in proximal regions of the epididymis. Our microsurgical approach to a large population of patients with obstructive azoospermia allowed us to study this question in humans, and without the previously experienced technical problems.

We were surprised when in long-term follow-up these patients eventually recovered good motility, usually within approximately 1½ years postoperatively. Not only did the percentage of motility in these patients come up to normal levels, but the quality of sperm movement was also completely normal, with straightforward rapid progression. The morphology was unremarkable and could not be differentiated from that of fertile men. Although one of the five patients has successfully impregnated his wife, we cannot yet draw conclusions about fertility in these patients, as they have only recently attained normal motility. However, motility is certainly the single most obvious aspect of posttesticular spermatozoal maturation.[11]

This finding may be of considerable clinical importance because patients with obstructive azoospermia frequently have multiple levels of epididymal occlusion, and occasionally the obstruction is located very proximally. However, even more intriguing is the physiologic conclusion that, after a prolonged period of time, the remaining segment of a vastly shortened epididymis can in some compensatory fashion restore motility to spermatozoa in a region where under normal circumstances they would never be motile.

It is now important to determine the possible mechanisms of this phenomenon. Androgen-binding protein produced in the testis is present in very high concentration in the proximal caput epididymidis, but not in the corpus or tail. There is also high androgen-binding capacity in the cytosol of the caput epididymidis. The proximal caput epididymidis is very dependent on the flow of androgen-binding protein from the testis, but the distal caput corpus and tail of the epididymis are completely independent of it.[12] Exogenous testosterone can completely support the corpus and tail, but the proximal caput atrophies without the flow of androgen-binding protein from the testis. Thus the *proximal caput* is the most metabolically active site in the epididymis and may possibly be the only area of the epididymis with an active role in initiating the sperm maturation process.

We are planning to collaborate with basic scientists in a study of enzyme markers associated with spermatozoal motility (such as protein carboxylmethylase and lipid peroxidase) and ultrastructural details of the obstructed human epididymis.[13, 14]

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