

## Apparent Fertility of Human Spermatozoa from the Caput Epididymidis

SHERMAN J. SILBER

Fifty-one patients with obstructive azoospermia caused by blockage at the caput epididymidis have been followed for 4 years after undergoing "specific tubule" vasoepididymostomy, bypassing the corpus and cauda. The patency rate was 73%, and the pregnancy rate was 31%. There was no correlation between sperm count and pregnancy rate, but there was a strong correlation with sperm motility. With < 20% motility, only 15% of the patients became pregnant, but with > 20% motility postoperatively, 58% became pregnant. If the wife was over 30 years old, only 21% got pregnant. If the wife was under 30, 67% got pregnant. "Redo" cases were just as likely to succeed as "first-time" attempts. In the "patent" cases, 43% of patients with spermatozoa that never reached or traversed the corpus or cauda epididymidis produced a pregnancy. Spermatozoa from the proximal caput produced a 33% pregnancy rate, whereas spermatozoa from the distal caput produced a 50% pregnancy rate. One-half of the pregnancies occurred more than 2 years postoperatively.

**Key words:** fertility, spermatozoa, caput epididymidis, human, vasoepididymostomy.

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*From St. Luke's Hospital West  
St. John's Mercy Medical Center  
St. Louis, Missouri*

Because of advances in microsurgical techniques, it is now possible to bypass most cases of epididymal obstruction with a high incidence of technical success (Silber, 1978, 1984, 1986). A small percentage of cases of obstructive azoospermia are caused by blockage in the region of the head of the epididymis, and the only therapeutic solution is an anastomosis of the vas to the epididymal tubule in the caput region, thus bypassing the corpus and tail. The issue of whether spermatozoa from the caput epididymidis are capable of either forward motility or fertilization in the human can ideally be studied with this clinical model. In every animal that has been studied, spermatozoa from the caput epididymidis are only capable of weak circular motion at most, and are not able to fertilize (Orgebin-Crist, 1969).

### Methods

#### *Patient Group*

Out of 541 patients undergoing bilateral microsurgical vasoepididymostomy, 51 had bilateral blockage in the head (caput) of the epididymis, and had more than 3 to 4 years

Reprint requests: Sherman J. Silber, St. Luke's Hospital West, 224 S. Woods Mill Road, Suite 730, St. Louis, MO 63017.

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of follow-up. The cause of the blockage at the head of the epididymis was either congenital obstruction, smallpox, chlamydial epididymitis, or secondary blockage caused by pressure buildup after vasectomy discovered at the time of vasectomy reversal. No cases of blockage at the head of the epididymis were due to gonorrheal epididymitis.

The diagnosis of obstructive azoospermia was made by testicular biopsy demonstrating quantitatively normal spermatogenesis, a palpable vas deferens on physical examination, normal semen volume, and azoospermia. No cases of obstructive oligozoospermia are included in this series. The localization of the site of epididymal obstruction was determined at the time of surgery by proximal serial sectioning of the epididymis until normal spermatozoa were found in the fluid coming from the epididymal tubule. Histologic sections obtained in the process of transecting proximally up the epididymis also demonstrated the area of transition from no spermatozoa in the epididymal lumen to an epididymal lumen dilated and packed with spermatozoa.

#### *Factors Related to Pregnancy and "Patency"*

Classical postoperative semen parameters (including numerical count, morphology, percent motility, quality of motility, velocity of motility, and direction of motility) were ascertained at 3-month intervals indefinitely or until the time of pregnancy. Many patients had as many as 10 to 15 semen analyses performed, and the mean of the

semen analyses obtained after a leveling off of the rise after surgery is reported. The area of the head of the epididymis (whether proximal, mid-head, or distal), the degree of dilatation of the epididymal tubule, volume of fluid efflux, and the quality of spermatozoa in the fluid proximal to the obstruction were recorded. These results were then related to the age of the wife and whether normal intrauterine pregnancy occurred, as well as the amount of time until pregnancy occurred. Finally, quantitative evaluation of the preoperative testicular biopsy was compared with postoperative semen results, and the occurrence or nonoccurrence of pregnancy (Silber and Rodriguez-Rigau, 1981).

#### *Surgical Technique*

All vasoepididymostomies were performed with the "specific tubule" technique we have described, which involves an end-to-end anastomosis of the inner lumen of the vas to the epididymal tubule, mucosa-to-mucosa in a leakproof fashion. Virtually all of the earlier literature on vasoepididymostomy involved a longitudinal cut through the epididymal tunic and into the epididymal tubule, which resulted in a random cutting of the epididymal tubule in many of its convolutions. This gave the appearance of many tubules leaking spermatozoa. The vas would then be sutured to that outer epididymal tunic hoping that a fistula would form. Because of the high rate of technical failure with that methodology, it was difficult to obtain accurate data on the potential fertility of spermatozoa directly from the epididymis (Hanley, 1955; Hotchkiss, 1970; Schoysman and Drouart, 1972; Amelar and Dubin, 1975).

A summary of the "specific tubule" technique used in this series is as follows: After the scrotal sac is entered, the vas deferens is first freed up in the usual fashion. The tunica vaginalis is then opened and each testis and epididymis are everted from the hydrocele sac and examined. A dilated epididymal tubule is usually from 0.1 to 0.2 mm in diameter, and the epididymal duct is extraordinarily delicate, with a wall thickness of about 30 microns. If at this point one employed the usual conventional approach and made a deep, longitudinal incision in the epididymis, there might be the illusion of as many as 20 or 30 microscopic-sized tubules leaking spermatozoa, but this is purely an illusion. Under the microscope it is apparent that the blind loop tubules empty out their fluid immediately and only one tubule continues to leak spermatozoa.

In this series, rather than make a microscopic longitudinal slit in a specific loop of the epididymal tubule (which is a perfectly reasonable approach), we freed up the epididymis from the testicular surface and made a transverse section through the distal cauda (Fig. 1). We continued to slice off portions of the epididymis working more and more proximally until we finally reached the point where spermatozoa were found. The desire, thus, is to perform the anastomosis at the distal most possible level, but proximal to the area of obstruction. Since the distal segments of epididymis are being sliced off in the procedure, we can study histologically these sections to determine for certain the presence or absence of blockage.

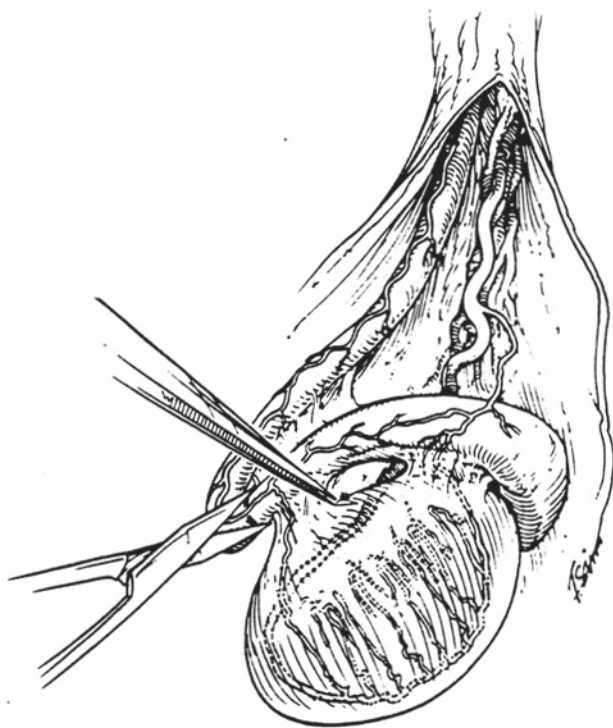


Fig. 1. Freeing up the epididymis.



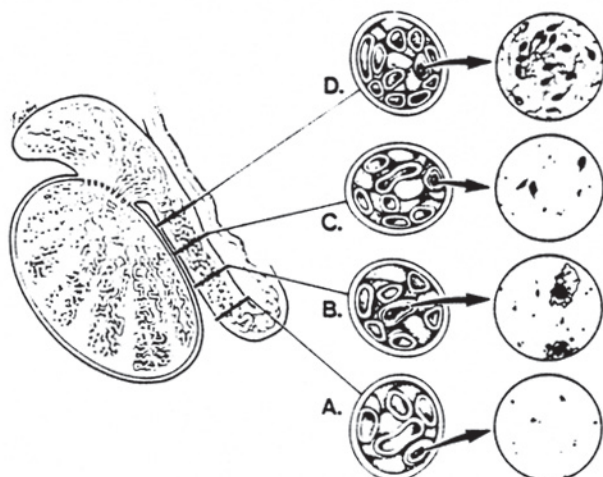


Fig. 2. Transecting proximally the epididymis and checking for spermatozoa.

The critical determinant is when we pass the transition point of no fluid or no spermatozoa in the fluid to the point where there are abundant numbers of spermatozoa in the fluid coming from the epididymal tubule. Under the microscope there may appear to be three or 10 cut tubules visible on the transected surface of the epididymis, but only one of those tubules is leaking spermatozoa, which is the one that is not a blind loop and is continuous with the proximal epididymis. Fluid at every level is examined under a phase contrast microscope in the operating room for the presence and quality of spermatozoa. Once we get proximal to the point of obstruction, the vasoepididymal anastomosis is performed (Fig. 2).

The proximal epididymis is held between the thumb and forefinger facing the microscope in order to see an efflux of fluid and determine which is the correct tubule to anastomose. A 10-0 monofilament nylon suture is first placed from outside to inside the tubule that is leaking the sperm fluid. After the tubule has been thus identified, the epididymis and the vas are fixed in opposite ends of a microsurgical clamp, and the first stitch is then completed with an inside-to-outside stitch in the vas mucosa (Fig. 3). Usually four to five 10-0 nylon interrupted sutures complete the leakproof mucosal anastomosis, and then the outer muscularis of the vas is sutured separately to the outer epididymal tunic with 9-0 nylon interrupted sutures. The caput epididymidis was defined very narrowly as 1 centimeter or less from the funiculus of the efferent ducts.

The patient is allowed to go home a day after surgery, but is restricted from most activity (other than at home) for the first week, and is allowed no heavy exertion or exercise for 4 weeks. Since most patients come from out of town, semen analyses were monitored at long distance through local laboratories at 3-month intervals.

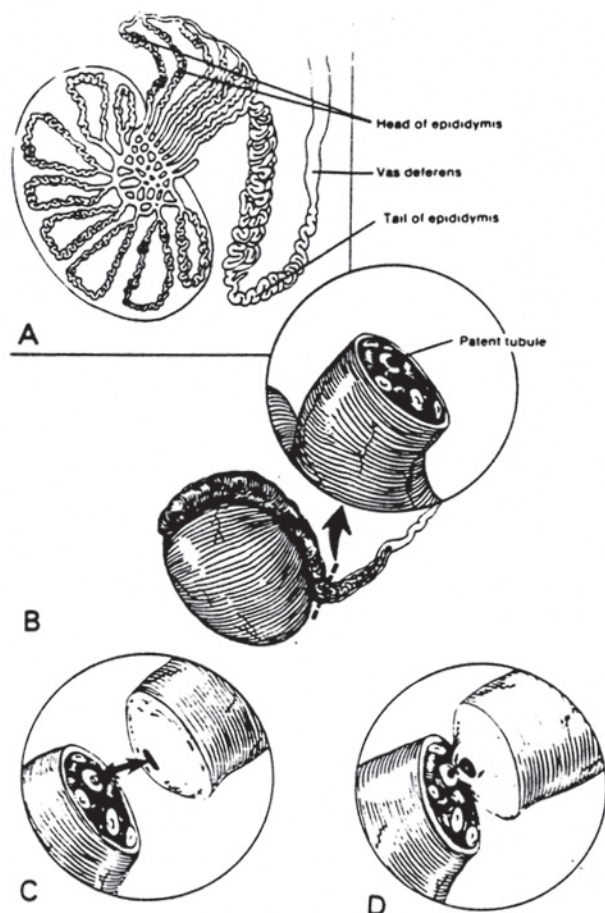


Fig. 3. Diagram of specific tubule anastomosis of the vas deferens to the epididymis.

## Results

Of the 51 patients with 4 years follow-up undergoing vasoepididymostomy to the caput epididymidis, 37 had spermatozoa in the ejaculate postoperatively (73%) (Table 1). Sixteen achieved a successful intrauterine pregnancy with their wife (31%). Therefore, of the 37 patients who had technically "patent" results, 16 (43%) were able to achieve a normal pregnancy. Thus in almost half of the cases pregnancy was achievable with spermatozoa from the head of the epididymis.

Half of the pregnancies occurred after 2 years had elapsed following surgery. The other half occurred within the first 6 months, indicating a bimodal distribution of two groups of patients. There was no correlation between the postoperative numerical sperm count and the pregnancy rate,



TABLE 1. Specific Tubule Microsurgical Vasoepididymostomy to the Head of the Epididymis\*

	Primary Pathological	Secondary to Vasectomy	Total Cases
Total with 4-Year follow-up	20	31	51
Patency	12 (60%)	25 (81%)	37 (73%)
Pregnancy	5 (25%)	11 (35%)	16 (31%)

\*51 cases with 4 years of follow-up.

except to say that no azoospermic patient impregnated his wife. But as long as there was a "patent" result, the numerical count was not significantly predictive of the chances for the wife getting pregnant within 4 years (Table 2). In fact, 31% of the patients who got their wives pregnant had a sperm count of less than  $5 \times 10^6/\text{cc}$ .

There was, however, a close relationship between the occurrence of pregnancy and postoperative sperm motility (Table 3). When less than 20% of the spermatozoa exhibited forward motility, the pregnancy rate was only 15%. However, if there was  $> 20\%$  forward motility, 58% of the men impregnated their wives. Very few patients had greater than 50% progressive motility, and the cutoff in terms of motility having a significant effect on pregnancy was quite clearly at 20%.

Since most of the patients were referred from out of town, it was difficult to obtain reliable studies on the wife's relative fertility. But it is striking how well the wife's age correlated with the pregnancy rate (Table 4). When the wife was under 30, the pregnancy rate in cases with sperm "patency" was 67%. When the wife was over 30 years of age, the pregnancy rate with spermatozoa derived from the caput epididymidis was completely unexpected. The apparent difficulty of the operation did not correlate

TABLE 2. Vasoepididymostomy to the Head of the Epididymis\*

Postoperative Sperm Count/cc	Pregnant No. %	Not Pregnant No. %
Zero	0 (0%)	14 (40%)
$> 0$ to $5 \times 10^6$	5 (31%)	2 (6%)
$> 5 \times 10^6$ to $10 \times 10^6$	3 (19%)	1 (3%)
$> 10 \times 10^6$	8 (50%)	18 (51%)
Total	16 (100%)	35 (100%)

\*Lack of relation of sperm count to pregnancy rate.

TABLE 3. Relation of Pregnancy to Sperm Motility in 37 Cases with Patency

% Sperm Motility	Pregnancy Rate	Pregnant	Not Pregnant
0—20%	15%	2 (13%)	11 (52%)
$> 20\%$	58%	14 (87%)	10 (48%)
Total	43%	16 (100%)	21 (100%)

well with the pregnancy rate. In patients who had a previous failure at vasoepididymostomy and who were referred here for a second attempt, the pregnancy rate was 38%, whereas with cases who had not undergone any previous attempt at vasoepididymostomy, the pregnancy rate was 29% (Table 5).

The numerical sperm count was related to how far proximal in the head of the epididymis the blockage was found. In cases of distal caput blockage, the numerical sperm count postoperatively was higher than in cases of proximal caput blockage. Furthermore, azoospermia following attempt at vasoepididymostomy was much more likely in cases of proximal caput blockage than in distal caput blockage (Table 6). Table 7 will clarify this in a different way. Without reference to the numerical sperm count, just dividing patients into those who were "patent" after vasoepididymostomy to the head of the epididymis and those who were azoospermic after vasoepididymostomy, it is apparent that with a distal caput anastomosis only 11% of the patients were azoospermic after vasoepididymostomy, indicating an 89% technical success rate. However, at the proximal caput epididymidis, 47% were azoospermic after surgery, for a 53% technical success rate. Therefore, technical success was much more readily obtainable with distal caput anastomosis.

Among those patients with "patent" results, the

TABLE 4. Relation of Age of Wife to Pregnancy Rate in Cases with Patency

Age of Wife	Pregnancy Rate	Pregnant	Not Pregnant
25—30	67%	12 (75%)	6 (29%)
$> 30$	21%	4 (25%)	15 (71%)
Total	43%	16 (100%)	21 (100%)



TABLE 5. Vasoepididymostomy to the Caput Epididymidis\*

	Pregnant	Not Pregnant
Re-do after previous failure	6 (38%)	10
Virgin case	10 (29%)	25

\*Lack of relation of successful vasoepididymostomy to previous failure.

pregnancy rate was progressively greater the more distal the anastomosis. With anastomosis to the proximal caput epididymidis, the pregnancy rate amongst those with "patent" results was 33%. At the distal caput epididymidis, the pregnancy rate among those with "patent" results was 50% (Table 8).

The testicular biopsies consistently showed mature spermatid counts per tubule that correlated with postoperative sperm counts in patients who impregnated their wives (Table 9). The mature spermatid count also correlated with sperm count postoperatively in most "patent" cases without pregnancy. The ratio of pachytene spermatocytes to mature spermatids (P/S) was consistently around 1 (0.95 to 1.21) (Fig. 4), which is the same as is seen in a normal population (Silber and Rodriguez-Rigau, 1981; Silber and Cohen, unpublished data). The cases with azoospermia or severe oligozoospermia postoperatively usually had adequate mature spermatid counts on testicular biopsy, indicating that the major problem in these cases was not testicular, but rather residual, obstruction.

### Discussion

Since less than 10% of our patients with epididymal obstruction have their blockage at the level of the caput epididymidis, these findings are more important for what they tell us about the

TABLE 7. Relation of Postoperative Patency to Area of Anastomosis at the Head of the Epididymis

	Proximal Caput	Mid Caput Or Mixed	Distal Caput
Patent	9 (53%)	10 (71%)	17 (89%)
Nonpatent (Azoospermia)	8 (47%)	4 (29%)	2 (11%)
Total	17 (100%)	14 (100%)	19 (100%)

physiology of sperm maturation than perhaps for their clinical impact. The fact that when technically successful anastomosis to the caput epididymidis is achieved, almost 50% of the wives get pregnant within 4 years, clarifies the issue that spermatozoa do not necessarily have to traverse the corpus or cauda epididymis in the human to achieve fertilizing capacity. Yet there can be no doubt from looking at the semen parameters that these are not altogether normally fertile men. Only a few patients have motility of greater than 50%. Yet as long as there is greater than 20% forward motility, 58% of the patients could eventually impregnate their wives. But half of the patients who impregnated their wives required over 2 years to do so. The other half impregnated them fairly promptly within 6 months. So although 43% of patients with "patent" results at the head of the epididymis ultimately impregnated their wives, only 22% can be reasonably assumed not to have had some fertility defect. Or perhaps it would be more correct to suggest that late pregnancies are not the result of any improvement in the fertilizing capacity of the spermatozoa, but simply a statistical delay that one can expect to take place when semen parameters show a diminished pattern of motility. This is likely because after 1 year there was no continuing appreciable improvement in sperm motility.

Although we could not evaluate the interaction between male factor and female factor in these

TABLE 6. Vasoepididymostomy to the Caput Epididymis\*

Postoperative Sperm Count/cc	Proximal Caput	Mid Or Mixed Caput	Distal Caput
Zero	8 (47%)	4 (29%)	2 (11%)
> 0 to $5 \times 10^6$	1 (6%)	3 (21%)	2 (11%)
> $5 \times 10^6$ to $10 \times 10^6$	10 (0%)	2 (14%)	2 (11%)
> $10 \times 10^6$	8 (47%)	5 (36%)	13 (67%)
Total	17 (100%)	14 (100%)	19 (100%)

\*Relation of sperm count to area of blockage in the head of the epididymis.

TABLE 8. Relation of Pregnancy (With Patent Results) to Area of Blockage in the Head of the Epididymis

Location of Blockage	Pregnancy Rate	Pregnant	Not Pregnant
Proximal Caput	33%	3 (19%)	6 (29%)
Mid or Mixed Caput	38%	3 (19%)	5 (24%)
Distal Caput	50%	10 (62%)	10 (48%)
Total		16 (100%)	21 (100%)



TABLE 9. Example of Quantitative Testicular Biopsy Results in Patient with Anastomosis of the Caput Epididymidis

Postop Sperm Count:  $50 \times 10^6/\text{cc}$ 

75% Motility

 $S_{C+D} = 35.7$   $10.0$   $P = 35.14$   $9.8$  $S_A + B = 34.0$   $12.1$   $P/S = 0.98$ Expected Sperm Count:  $52 \times 10^6/\text{cc}$ 

patients, it is striking to see the impact of the age of the wife on the pregnancy rate. We would have to speculate that even though there may be reduced fertility in most of these patients, in a younger (perhaps more fertile) wife, this reduction in fertility of caput spermatozoa is not sufficient to preclude pregnancy.

It is remarkable that among those patients who had a technically successful anastomosis with "patency," 43% got their wives pregnant. Technical "patency" was much more likely with distal caput anastomoses than proximal caput anastomoses. When the blockage was in the distal caput, almost 90% of the patients had a technically successful result, and when the blockage was in the proximal caput, only 53% had a technically successful result. Thus one of the major reasons why pregnancy rates were lower from the proximal caput was the lower technical success rate. Among those patients who were "patent," the pregnancy rate from the proximal caput (33%) was somewhat lower than from the distal caput (50%), but this difference was not statistically significant. Since the technical success of the procedure is so critical, it is instructive to note that the success rate after redoing a previously failed vasoepididymostomy was just as good as that achieved in "virgin" cases. Therefore after a failure to achieve "patency," it is absolutely reasonable to operate a second time on such patients.

In 1969, Orgebin-Crist asked the key question of whether the factors governing the maturation process of spermatozoa are intrinsic to the spermatozoa, or whether they reside in the epididymis. Many experiments were performed to ligate various regions of the epididymis to see if aging alone matures the spermatozoa or if spermatozoa need to pass through specific regions of the epididymis to mature. These epididymal ligation experiments all caused dilatation and epithelial disruption that could hurt the maturation of the retained caput spermatozoa. These experiments did not allow for the deleterious effects of the ligation experiment

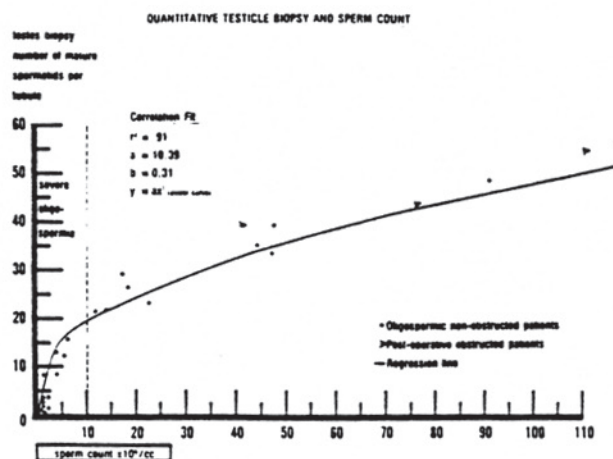


Fig. 4. Quantitative testicle biopsy and sperm count.

on the activity of the duct epithelium (Gaddum and Glover, 1965; Orgebin-Crist, 1967, 1969; Paufler and Foote, 1968; Glover, 1969).

In all species studied, spermatozoa obtained from the seminiferous tubule exhibit only weak tail vibration, and spermatozoa from the head of the epididymis are either immotile, or have only a nondirectional, circular swimming motion. It is not until the spermatozoa reach the corpus epididymidis that there is a gradually increasing velocity of sperm forward progression (Bedford, 1966b; Gaddum, 1969). When the epididymis is ligated, spermatozoa in the caput begin to develop motility by aging alone, but by 3 weeks all spermatozoa are again nonmotile, and pregnancies were not achieved with spermatozoa from these regions (Bedford, 1966a; Orgebin-Crist, 1967, 1969). There remained the possibility that spermatozoa could mature in the vas deferens without the need of traversing the full length of the epididymis. A vasoepididymostomy model, in which spermatozoa had never traversed the corpus, might possibly allow the spermatozoa to mature on their own in the vas deferens.

Bedford later speculated "Although the potential of the vas deferens for sperm maturation is unknown, clinical results (and experimental evidence in animals) strongly suggest that the influence of the corpus and cauda regions of the epididymis is not mandatory for maturation of human spermatozoa" (Bedford, 1966b). The fact that in 43% of "patent" cases spermatozoa that could not have travelled through the corpus or cauda epididymidis



(traversing only the proximal caput or distal caput epididymidis) were capable of fertilization indicates that a full journey through the epididymis is not required for sperm maturation sufficient to allow pregnancy. However, it is apparent that these spermatozoa do have limited fertilizing capacity since the pregnancy rate is considerably lower than with vasovasostomy or with vasoepididymostomy to the corpus epididymidis (Silber, 1984, 1986; Silber and Cohen, unpublished data; Schoysman and Bedford, 1986).

It should be emphasized that none of these patients underwent any special treatments such as *in vitro* fertilization or GIFT, and these pregnancies all occurred simply with natural intercourse. In the next several years we may find out whether more than 43% of these patients will or will not be able to achieve fertilization with spermatozoa from the caput epididymidis using *in vitro* techniques. In the meantime, at least we know that spermatozoa that have gone through even a small portion of the proximal caput epididymidis can mature sufficiently while being stored in the vas deferens to fertilize ova.

### References

- Amelar RD, Dubin L. Commentary on epididymal vasostomy, vasovasostomy, and testicular biopsy. Current operative urology. New York: Harper and Row, 1975;1181-1185.
- Bedford JM. Development of the fertilizing ability of spermatozoa in the epididymis of the rabbit. J Exp Zool 1966a;163:311-318.
- Bedford JM. Development of the fertilizing ability of spermatozoa in the epididymis of the rabbit. J Exp Zool 1966b;163:319-330.
- Gaddum P, Glover TD. Some reactions of rabbit spermatozoa to ligation of the epididymis. J Reprod Fertil 1965;9:119-130.
- Gaddum P. Sperm maturation in the male reproductive tract: development of motility. Anat Rec 1969;161:471-482.
- Glover TD. Some aspects of function in the epididymis: experimental occlusion of the epididymis in the rabbit. Int J Fertil 1969;14:216-221.
- Hanley HG. The surgery of male subfertility. Ann R Coll Surg 1955;17:159-183.
- Hotchkiss RS. Surgical treatment of infertility in the male. In: Campbell NF, Harrison HH, eds. Urology. 3rd edition. Philadelphia: WB Saunders, 1970;669-682.
- Orgebin-Crist MC. Sperm maturation in rabbit epididymis. Nature 1967;216:816-818.
- Orgebin-Crist MC. Studies of the function of the epididymis. Biol Reprod 1969;1:155-175.
- Paufler SK, Foote RH. Morphology, motility and fertility in spermatozoa recovered from different areas of ligated rabbit epididymis. J Reprod Fertil 1968;17:125-137.
- Schoysman R, Drouart JM. Progres recents dans la chirurgie de a sterilite masculine et feminine. Acta Chir Belg 1972;71:261-280.
- Schoysman R, Bedford JM. The role of the human epididymis in sperm maturation and sperm storage as reflected in the consequences of epididymovasostomy. Fertil Steril 1986;46:293-299.
- Silber SJ. Microscopic vasoepididymostomy, specific anastomosis to the epididymal tubule. Fertil Steril 1978;30:565-571.
- Silber SJ, Rodriguez-Rigau LJ. Quantitative analysis of testicle biopsy: determination of partial obstruction in prediction of sperm count after surgery for obstruction. Fertil Steril 1981;36:480-465.
- Silber SJ. Microsurgery for vasectomy reversal and vasoepididymostomy. Urology 1984;23:505-524.
- Silber SJ. Diagnosis and treatment of obstructive azoospermia, male reproductive dysfunction. In: Santen RJ, Swerdloff RS, eds. Male Reproductive Dysfunction. Diagnosis and Management of Hypogonadism, Infertility, and Impotence. New York: Marcel Dekker, 1986;479-517.

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