Vasectomy Reversibility
—A Status Report—

SUMMARY

As vasectomy increases in popularity throughout the world, the need for reversal of the operation, although rare, is growing at a somewhat slower pace. Demand for restoration of fertility, still low in most countries, is, for example, about 1 request per 1,000 vasectomies in Korea (88), India (106), and the United Kingdom (42).

Reasons for requesting reversal are similar from country to country. Those cited most frequently are:

• remarriage after divorce or death of wife (12, 71, 72, 77, 93, 111, 117);
• death of one or more children (72, 77, 93, 111, 117);
• improved economic situation (72, 77, 111);
• psychological desire to overcome supposed ill effects of vasectomy (72, 77, 93, 117).

Although the importance of reversibility in the acceptance of vasectomy has not yet been definitely determined, it may have considerable influence in some situations. Pardanani of G.S. Medical College in Bombay believes reversibility would enhance the popularity and acceptability of vasectomy (109). Reversibility may help to eliminate some of the religious and cultural objections to vasectomy. For example, at the Rabat Conference on Islam and Planned Parenthood in 1971, consensus was negative toward permanent sterilization but positive toward reversible sterilization, which was viewed as temporary contraception (105).

Three approaches to reversibility are considered in this report. They are:

• vas anastomosis (surgical reversal of vasectomy);
• frozen semen storage (fertility insurance without the necessity for surgical or mechanical reversal);
• vas occlusive devices (mechanical reversal of vasectomy).

To date, there are neither standard techniques nor criteria by which to assess the success of vas anastomosis. Success is dependent, to a large extent, on the vasectomy technique used as well as on the anastomosis technique. If the vasectomy has been done in the convoluted part of the vas and if a large segment of the vas was removed, chances of successful anastomosis decrease. The experience of the surgeon performing the operation is also a factor. (See Fig. 1.)

There is a substantial difference between the rate of anatomical success (40-90 percent) as determined by reappearance of sperm and that of functional success (18-60 percent) as determined by pregnancy rate.

CONTENTS

History .................................. D-42
Problems in Vasectomy Reversal .......... D-46
Vas Anastomosis Procedure .............. D-48
Frozen Semen Storage .................... D-51
Experimental Vas Occlusive Devices ...... D-52
Research Priorities ...................... D-57
Bibliography ............................ D-57

D-41
The team of Martin, Carnett, Valentine, and Pennington intervention to restore fertility was first reported in 1902.

Before the 20th century vasectomy was not practiced; causing loss of the propulsive force of vas, low prevasectomy spermatic granulomas, obstructions, misalignment of the vas ends, and choice of vasectomy technique. Functional development improved anastomosis techniques and vas occlusion of the mate. Another cause of functional failure anastomosis procedures require surgery and take about two hours to perform, and most procedures require general anesthesia. However, requests for such procedures are sufficiently rare that performing them would not work hardship on a country where medical resources are scarce.

Most vas occlusive devices are experimental and are not readily available. However, preliminary results with several devices appear promising. Vas occlusive devices have the potential of making a simple, reversible, safe, and effective method of contraception available for men, but the development and testing of these devices are necessarily long-term processes.

Frozen semen storage, a type of fertility insurance which does not involve surgery or use of mechanical devices, is another approach to reversible male sterilization. At present, it remains in the experimental stage due to its high cost, limited availability, and uncertain results.

Priority needs to be given to research on male reproductive physiology and suitable animal models for testing to develop improved anastomosis techniques and vas occlusive devices.

HISTORY

Before the 20th century vasectomy was not practiced; hence, little attention was devoted to reversibility. Surgical intervention to restore fertility was first reported in 1902. The team of Martin, Carnett, Valentine, and Pennington noted the absence of sperm following epididymitis (inflammation of the epididymis), apparently caused by an obstruction in the epididymis. The investigators observed that sperm were present in the epididymis on the testicular side of the obstruction site and that the vas was usually unobstructed from the block in the epididymis to the urethra. Based on these observations, Martin attempted a vaso-epididymal anastomosis in which the vas is joined to the epididymis. His technique involved implanting the vas, where a 0.6 cm longitudinal cut to the lumen had been made, into an opening in the head of the epididymis. The anastomosis was accomplished with four fine, silver wire sutures, placed from the outside of the vas to its lumen and through the fibrous tunica of the epididymis. Nineteen days after the anastomosis, there were motile, apparently healthy sperm in the patient’s semen (90). The first reported vas deferens anastomosis happened by chance in 1907 when Parlovociello accidentally severed and then rejoined the vas during a herniorrhaphy (32, 89).

Nearly three decades passed before Martin’s technique was tested. In 1931 Hagner reported on 31 operations, with success rates of 60 percent as determined by reappearance of motile sperm and approximately 40 percent as determined by pregnancy. Hagner noted that reappearance of sperm took anywhere from one month to nearly a year (60).

In 1937 Strode reported two cases of unilateral vas deferens anastomosis on patients who had undergone vasectomies in 1930. One was judged successful as determined by the appearance of mature, motile sperm two months after the anastomosis (145).

Twyman and Nelson in 1938 reported a successful vas deferens anastomosis performed in 1928 on a patient who had undergone vasectomy four years previously. Success was determined by pregnancy and subsequent birth 18 months after the anastomosis. The patient had a positive sperm check in a 1938 follow-up (147).

In 1939 Freiberg and Lepsky reported a unilateral side-to-side anastomosis on a man who had a vasectomy seven years before. After making a longitudinal incision in the vas, they inserted a silkworm gut splint 1.25 cm into each vas with the aid of a large-sized intravenous needle. The needle holding the splint was then pierced through the vas walls and removed, leaving the splint ends which emerged through the skin incision and were loosely tied. The side-to-side anastomosis was accomplished with three black silk sutures. Patient follow-up over a two-year period showed a normal count of motile sperm and normal morphology. Success was attributed to side-to-side rather than end-to-end technique and to the use of silk instead of catgut sutures (51).

A successful bilateral vas anastomosis case was reported in 1941 by each of two investigators—Nelson and Barker. Nelson used Strode’s procedure (see Table 1) with a catgut splint in 1937. Six months later sperm had not appeared in the patient’s ejaculate so Nelson repeated the procedure, using a dermal rather than a catgut splint. This attempt resulted in a pregnancy and live birth in 1940 (98). Barker, using Twyman’s and Nelson’s technique, performed an anastomosis on a man who had a vasectomy four years earlier. After six months a normal sperm count was observed; after 14 months a live birth occurred (18).
Cameron reported a successful bilateral vas anastomosis in 1945 utilizing a splint different from the solid dermal or calgit types used previously. End-to-end anastomosis was performed over a 5-9 mm long hollow steel tube made from an ordinary 21-gauge hypodermic syringe needle. The tube was held in place by fine black silk tied around the outside of the vas over grooves previously cut in the tube. The procedure's success was verified by the presence of 2.5 million sperm/cc in the ejaculate (32).

Until the mid-1940s, vas anastomosis attracted very little attention. However, in 1948, O'Conor reported not only his own 14 vas anastomosis cases, but also the results of a questionnaire on the subject distributed to 1,240 recognized specialists in urological surgery. Of the 750 who replied, only 135 (18 percent) had ever attempted the procedure one or more times. Among the 430 procedures reported, there were 160 successes, 239 failures, and 31 undetermined (representing patients who were not examined postoperatively but later reported a partner's pregnancy). Success in this study was determined by presence of spermatozoa in the semen (100).

In addition, O'Conor reported nine successes (54 percent) in cases he attempted to reverse. All of these were bilateral reunions in which end-to-end anastomosis was done, using a strand of silkworm gut introduced 2.5 cm into each lumen as a splint. The splint was brought outside the skin through the scrotal incision and removed in 6-10 days (100).

In 1949 Massey and Nation reported four anastomoses in which no new techniques were used. In one case the vasectomy was done in the convoluted portion of the vas, making it impossible to pass the splint the usual distance into the proximal vas. In this case only a few sperm reappeared. In the other three cases, normal sperm counts of 50-158 million sperm/cc with 50-70 percent motility and 88-90 percent normal morphology were found at 3-5 months following anastomosis. One pregnancy was reported. Massey and Nation pointed out that the sperm count might continue to improve for at least a year (91).

During the 1950s separate studies done by Dorsey, Humphreys, O'Conor, Mauritzien, and Rosenbloom added significantly to the small number of anastomosis cases reported previously. In 1952 Mauritzien (Denmark) reported one case in which success was determined by the appearance nine months after the anastomosis of 48 million sperm/cc, showing healthy appearance and 61 percent motility (92). In 1953 Dorsey reported six cases with sperm reappearing in five, and pregnancies occurring in three (44); and in 1957 he reported 14 more cases in which sperm reappeared ranging in count from 7-100 million/cc in 13 patients. The partners of two of these patients became pregnant (45). In 1953 O'Conor reported 24 cases, 10 of which were successful as determined by a minimum count of 20 million/cc motile sperm of normal morphology (102). The same year Humphreys reported on three cases, all of which showed normal sperm counts, and two pregnancies occurred (66).

In 1956 Rosenbloom reported on 11 cases, 8 of which he followed up. Three were successful as measured by appearance of live sperm in the ejaculate; one was successful as determined by pregnancy. Rosenbloom suggested the value of using a magnifying loupe (magnifying lens) in preparing and anastomosing the vas ends (122).

There are two vasa deferentia. Each is a tube measuring 35-45 cm in length and a component of the spermatic cord, along with nerves, blood vessels, muscles, and lymph vessel (104).

The epididymis is an intricately coiled tube about 5 cm long which, if stretched to full length, measures about 6 meters. The walls of the tube consist of smooth muscle cells and mucous membranes.

The epididymides:
- act as a passageway for sperm between the testicles and vasa deferentia;
- are the primary storage place for sperm;
- secrete a substance which aids the development and maturation of sperm;
- absorb the testicular fluid which has carried sperm into the epididymal body (104).

The testicles, the primary male reproductive organ, produce male hormones and conduct spermatogenesis. After vasectomy the testicles are thought to continue to produce sperm at the normal rate (117). Because the vas is obstructed, the epididymides and proximal vas become distended with sperm until a balance is reached between sperm production and absorption. The lumen of the proximal vas remains somewhat dilated, even after the balance is reached. Therefore, at the time of vasovasostomy, the lumen of the proximal vas may be 75 percent greater than the diameter of the lumen of the distal vas (129).
## Table 1—Vasovasostomy Techniques Used in Selected Studies, 1937–1976

<table>
<thead>
<tr>
<th>Author</th>
<th>Ref. No.</th>
<th>Scrotal Incision Size &amp; Location</th>
<th>Action on Vas Ends</th>
<th>Patenty Test</th>
<th>Splinting Procedure</th>
<th>Suture Procedure</th>
<th>Closure of Skin Incision</th>
<th>Postoperative Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsey 1973</td>
<td>46</td>
<td>unspecified</td>
<td>fibrosed ends mobilized with minimal dissection</td>
<td>fluid delivered by gentle compression of epididymis</td>
<td>introduction of 1-0 monofilament dermalon</td>
<td>straight, blunt 1 3/4 inch 20 gauge hypodermic needle with obturator plunged wall of proximal lumen 1 cm from anastomosis site, then through to scrotal surface; obturator removed; 1-0 monofilament dermalon introduced; needle removed, leaving splint; other end introduced 12-14 cm into distal vas</td>
<td>sutured with 3-0 chromic; split threaded through lead shot, passed through scrotal skin on curved cutting needle, and threaded through 2nd lead shot; lead shot then capped</td>
<td>splint removed 12-14 days</td>
</tr>
<tr>
<td>Humphreys 1966</td>
<td>67</td>
<td>two incisions 8 cm in length</td>
<td>fibrosed ends separated with minimal trauma; fibrosed ends are cut transversely and removed</td>
<td>presence of cloudy spermatic fluid</td>
<td>introduction of thin wire, a piece of dermalon catgut, or a fine blunt probe</td>
<td>needle hugging No. 1 plain catgut inserted 2 cm into distal lumen, passed through wall of vas, then knot tied in catgut; needle threaded on lower end of catgut, passed 2 cm into proximal vas, then passed through wall, pulled taut, and tied</td>
<td>no sutures in vas</td>
<td>unspecified</td>
</tr>
<tr>
<td>Lee 1966</td>
<td>82</td>
<td>two incisions</td>
<td>fibrosed ends identified with minimal mobilization from cord or fibrous mass; vas incised transversely to lumen just proximal and distal to fibrous mass; 24 gauge needle passed 3 mm into each end and brought out wall; fine pointed knife engaged in beaver of needle incises wall longitudinally as needle is withdrawn</td>
<td>presence of milky fluid oozes</td>
<td>injection of 2-3 ml normal saline</td>
<td>purple nylon split introduced with syringe needle into vas before anterior stitches; end of split brought out through scrotal skin</td>
<td>needle rethreaded with split and passed out scrotal wall; anchored with another bit of scrotal skin sutures: 2-3 silk sutures in neighboring fascia</td>
<td>antibiotics and lidocaine prescribed; bed rest 3 days; scrotal support 2 weeks; splint removed 10th day; intercourse after 3 weeks</td>
</tr>
<tr>
<td>Mehta 1970</td>
<td>93</td>
<td>two upper scrotal incisions 2 inches in length</td>
<td>ends identified with minimal mobilization from cord or fibrous mass; vas incised transversely to lumen just proximal and distal to fibrous mass; 24 gauge needle passed 3 mm into each end and brought out wall; fine pointed knife engaged in beaver of needle incises wall longitudinally as needle is withdrawn</td>
<td>injection of 2-3 ml normal saline</td>
<td>injection of 2-3 ml normal saline</td>
<td>purple nylon split introduced with syringe needle into vas before anterior stitches; end of split brought out through scrotal skin</td>
<td>side-to-side anastomosis using 2 to 3 posterior and 2 to 3 anterior 6-0 nylon interrupted stitches, passed through wall, not entering lumen; 1 or 2 stay stitches through soft tissues around vas</td>
<td>closed in layers</td>
</tr>
<tr>
<td>O’Conor 1948</td>
<td>100</td>
<td>unspecified</td>
<td>free embedded ends 1 to 2 cm; cut away scarred ends</td>
<td>injection of epididymal fluid to verify sperm present</td>
<td>probe with strand of silkworm gut; or, inject methylene blue and recover with uroblin</td>
<td>introduction of silkworm gut 2.5 cm into each vas end, the proximal strand brought out wall and through skin incision</td>
<td>closed in layers; bed rest 7 days; nylon split and skin stitches removed 7th day; broad spectrum antibiotics and anti-inflammatory agents indomethacin or oxphenbutazone administered; 30 mg Prednisolone given orally daily for 1 week after wound heals; semen analysis after 3 weeks, repeated as necessary</td>
<td>splint removed 6 to 10 days</td>
</tr>
<tr>
<td>Pardanani 1974</td>
<td>110</td>
<td>two anterior vertical incisions</td>
<td>severed ends defined with minimal vascular disruption; fibrous ends excised with sharp knife</td>
<td>injection of 0.01 inch nylon thread; presence of whitish fluid</td>
<td>introduction of 0.01 inch nylon thread; introduction of 0.01 inch nylon thread; injection of saline</td>
<td>large diameter (0.025–0.0027) silastic tubing with round bodied needles attached to both ends introduced 1.5 to 2.0 cm into proximal and distal lumens; pierced through walls</td>
<td>closed in layers; bed rest 7 days; splint removed 7th day</td>
<td>closed in layers; bed rest 7 days; splint removed 7th day</td>
</tr>
<tr>
<td>Name</td>
<td>Year</td>
<td>Technique</td>
<td>Outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phadke</td>
<td>1967</td>
<td>Two incisions; 3 inches in length; vas segments and some surrounding soft tissues dissected free; fibrous ends sectioned at junction between fibrotic and normal parts</td>
<td>Coze of milky fluid; injection of normal saline; needle introduced 1 inch into proximal lumen, then pierced through wall; fine nylon thread passed through needle; needle removed; nylon thread inserted 4-6 inches in distal lumen; ends approximated with 1 stitch through soft tissues; 3 equidistant 6-0 arterial silk sutures on an atrumatic needle, taking care not to encroach on lumen</td>
<td>Sutured in layers; scrotal support with adhesive strips; bed rest 7 days; broad spectrum antibiotics prescribed; splint removed in 8 days; scrotal suspensory for 1 month advised; intercourse as early as possible; semen examined after 1, 2, and 3 months, then every 3rd month for a year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roland</td>
<td>1961</td>
<td>Two incisions 3 cm in length; obstructed ends located; scarred tissue transected and discarded</td>
<td>Introduction of No. 28 stainless steel wire; wire pushed 2-4 cm into each vas and pushed through wall; end-to-end anastomosis using 3-0 atrumatic silk sutures through adventitial walls of vas; wire splint then removed; 4-0 plain catgut to loosely approximate fascia</td>
<td>Closed with 4-0 catgut; scrotal suspensory advised day and night for 14 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schmidt</td>
<td>1975</td>
<td>Two incisions in scrotum; using loupé 2.5x magnification; fascia spread; vas grasped with Allis clamps above and below obstruction; longitudinal incisions in sheath down to, but not into vas; ends freshened with transverse cuts; resected only if spermatic granuloma is present; underlying fascia freed from each end 2-3 mm</td>
<td>Presence of clear or milky spermatic fluid; injection of normal saline with blunted 23 gauge hypodermic needle; if obstructed, 2-0 nylon suture probe will locate obstruction; end-to-end anastomosis using 3-0 atrumatic silk sutures through adventitial walls of vas; wire splint then removed; 4-0 plain catgut to loosely approximate fascia</td>
<td>Unspecified outpatient procedure under light general anesthesia; sterile dressing; scrotal support advised day and night for 14 days; bathing after 48 hours; intercourse after 10 days; sperm test after 1 month</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silber</td>
<td>1976</td>
<td>Two incisions; 1.5-2 inches in length; vas and testicles fully exposed; scarred tissue ends cut and removed; ends pulled together with modified aneurysm clamps; distal lumen dilated</td>
<td>Visual; visual; no splints used; end-to-end, two-layer anastomosis using operating microscope; 4 to 6-0 monofilament nylon sutures through mucosa and some muscularis, placed outside-in at distal and inside-out at proximal; 10-0 sutures in outer muscularis to insure proper peristalsis</td>
<td>Unspecified hospitalized overnight; intercourse after 14 days; semen count after 1 month, periodically until pregnancy occurs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strode</td>
<td>1937</td>
<td>Ends mobilized and cut back to open lumen</td>
<td>Unspecified; strand of plain catgut threaded into each lumen, passed through wall, tied; two stitches to hold ends together and keep splint in place</td>
<td>Unspecified unspecified</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winer</td>
<td>1972</td>
<td>Ends dissected out, then transected</td>
<td>Presence of milky secretion; injected with dye; nylon splint in lumen</td>
<td>Ends approximated under operating microscope; 3 or 4 sutures through muscularis and adventitia, without touching mucosal layer; 2 to 3 supporting sutures of 4-0 nylon or 1/2-3 silk to remove tension</td>
<td>Skin sutured with 3-0 or 4-0 plain catgut or 4-0 nylon; elastic support used as pressure dressing; tissues packed with gauze; 4 days relative inactivity; splint removed and home from hospital 4th day; skin sutures removed in 7 days</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
To pinpoint causes of failure, Schmidt performed a series of vas anastomoses on dogs in the 1950s. Spermatic granuloma, resulting from inadequate approximation of the vas ends or puncture of the vasal lumen, was cited as the primary cause of failure. Infection and misalignment were also noted as causes of failure (124). During this period Schmidt experimented with a variety of splinting materials and in 1956 concluded that nylon was best due to its elasticity and the lack of tissue reaction to the material. He also determined that to allow time for proper healing at the anastomosis point, the splint should be left in place for 10 days (123).

PROBLEMS IN VASECTOMY REVERSAL

Presently, there is no standard for evaluating successful vas anastomosis. Board-certified urologists, surveyed by Dr. Paul Getzoff of the University of California at Irvine, use several different measures of success (1) as follows:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Number of Urologists</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance of normal sperm in semen analysis</td>
<td>63</td>
<td>42</td>
</tr>
<tr>
<td>Pregnancy ending in a live birth</td>
<td>45</td>
<td>30</td>
</tr>
<tr>
<td>Evidence of any pregnancy</td>
<td>28</td>
<td>19</td>
</tr>
<tr>
<td>Appearance of &quot;some&quot; sperm in the ejaculate</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>100</td>
</tr>
</tbody>
</table>

These criteria for success fall into two categories: anatomical success, determined by reappearance of sperm in the ejaculate; and functional success, determined by pregnancy rate. Anatomical success occurs in 40–90 percent of anastomosis cases and functional success in 18–60 percent.

Variations in rates stem from different causes. For example, surgical or anatomical success depends to a large extent on the technique used in the vasal segment as well as on the technique used for anastomosis. On the other hand, functional success depends on such factors as prevasectomy fertility and fertility of the patient's partner.

Reasons for Anatomical Failure

Physicians over the past 25 years have noted a number of reasons for anatomical failure of vasovasostomy. Among the primary causes of failure cited are:

- spermatic granuloma (71, 84, 95, 124, 144);
- obstruction in proximal vas or epididymides (24, 85, 93, 131, 139);
- misalignment of the proximal and distal vas lumens (84, 117, 124, 139, 144);
- vasectomy done in the convoluted rather than straight portion of vas (84, 95, 111, 117, 121, 126);
- too large a segment of vas removed at the time of vasectomy (25, 62, 65, 84, 95, 111, 117, 131);
- obstruction. Granulomas are associated directly with another major problem in vas anastomosis—obstruction of the vas. Inflammation and scarring accompany granulomas and may obstruct the vas at the anastomosis site (128). On numerous occasions, Schmidt found an obstruction located where a split was removed. As a result he abandoned the use of splints (8).

Absence of sperm in the proximal vas (end of vas near the testicle) at the time of anastomosis and the absence of fluid containing sperm after gentle compression of the vas may indicate the presence of an epididymal obstruction. Such obstructions may appear with attempts to milk the epididymis at the time of anastomosis (65), or after vasectomy. Epididymal obstructions are found on one or both sides in 15–20 percent of anastomosis patients (130). After vasectomy, the epididymis is whitish pink in color, filled with spermatic fluid, and the epididymal tubules are visible to the naked eye. The obstructed empty epididymis looks dark pink, and its tubules can only be seen with magnification. The head of the epididymia may appear full and its tail empty, or it may appear entirely empty (126).

MISALIGNMENT. The diameter of the vas lumen (opening within the vas) is quite small, averaging approximately 1.05 mm (26). After vasectomy, the lumen of the distal vas (end of vas nearest to the urethra) remains the same, but the proximal lumen dilates by approximately 75 percent to 1.73 mm in diameter, even though the external diameter of the vas remains unchanged (132). Because of the differences in luminal diameter, misalignment of the vas ends sometimes occurs, thus causing failure to reestablish a pathway for sperm (79, 140).

VASECTOMY IN CONVOLUTED VAS. Anastomosis is technically more difficult to perform when vasectomy has been done in error either high in the inguinal area or lower in the convoluted vas near the testicle. Use of the mucosa-to-mucosa anastomosis technique lessens the difficulty, however. In the convoluted portion of the vas, the tight windings make identification of the lumen difficult. Also, it is difficult to cut the vas at right angles (128). If the vasectomy is done midway between the upper pole of the testicle and the external inguinal ring in the straight portion of the vas, the likelihood of successful anastomosis is greatest (110, 117). When the vasectomy is done too near the testicle and only a short proximal stump is left, a vasal-epididymal anastomosis rather than a vas anastomosis can be done. This procedure is more complicated and has a lower success rate (72, 117).
LARGEST VAS SEGMENT REMOVED. The amount of vas removed influences the success of failure of anastomosis. The longer the segment removed, the more traction and pressure there will be on the anastomosed proximal and distal ends of the vas, resulting in a greater likelihood of separation and failure (51, 65, 131). For example, techniques such as multiple ligations in one vas (126) or removal of 3-4 cm of vas followed by folding back and double ligation (65) result in considerable scarring. When these scarred ends are removed during vasovasostomy, the anastomosed vas is pulled tightly, thereby increasing tension. As a result, the likelihood of anatomical failure increases.

Possible Reasons for Functional Failure

The causes of functional failure most frequently reported are:

- Epididymal and testicular changes (10, 48, 54, 63, 71, 129, 137, 139);
- Injury to sympathetic nervous system (10, 37, 65, 71, 95, 149);
- Low prevasectomy semen quality (12, 65, 95, 117, 140);
- Low fertility of partner (1, 65, 95, 117);
- Poor follow-up (65, 95, 129);
- Sperm agglutinating and immobilizing antibodies (10, 13, 14, 15, 16, 55, 116, 117, 129, 135, 142).

Epididymal and Testicular Changes. Epididymal and testicular changes, which may be either temporary or irreversible, probably account for lowered sperm counts in postanastomosis studies involving human and animal subjects. The postanastomosis sperm count in humans probably never returns to prevasectomy level. For example, based on experience with 178 patients, Lee reports a 33 percent reduction (77). Alexander of the Oregon Regional Primate Research Center found a similar drop in sperm count in rhesus monkeys having vasectomy follow ed by vas anastomoses; however, in the monkeys, the count returned to prevasectomy level in eight weeks (9).

Hagedoorn and Davis studied the morphological effects of vasectomy on seminiferous tubules (where spermatogenesis occurs). Their findings showed the blood supply to the tubules to be intact, the lumens to be patent, and the Sertoli and germinal epithelial cells to be present. Normal stages of spermatogenesis were observed, indicating that sperm formation was uninhibited. Spermatozoa did not appear in their typical location near the lumen, however, but were located instead near the "basement membrane" of the tubule. The authors suggest that this atypical location might presage the phagocytosis (ingestion of foreign cells by other cells) of the spermatozoa (59).

In another study Phadke and Phadke also reported that sperm production continues unabated after vasectomy. Then sperm pass on to the epididymis where they are stored. Consequently, the epididymis and proximal vas become dilated and filled with large numbers of both live and dead sperm. Subsequently, phagocytosis begins, with the sperm being resorbed (117). Studies using bulls have shown a slowing of spermatogenesis (54) which Alexander suggests may also occur in rhesus monkeys, since epididymal engorgement (excessive fullness of the epididymis) is only temporary (9). Schmidt terms this imbalance between sperm production and absorption, which leads to an engorged epididymis following vasectomy, congestive epididymitis. He reports that the condition disappears within a week or so (126). Pardanani and associates have also documented a postvasectomy disparity in the rates of sperm production and sperm reabsorption (113).

Homan of Norwalk, Ct., Hospital (USA) conducted animal studies to resolve conflicting data regarding testicular and epididymal alterations following vasectomy. He observed that dilatation and rupture of the epididymis may cause permanent damage to the sensitive mechanisms affecting sperm maturation and transport. Therefore, sperm which reach the anastomosed vas may be too senile to fertilize (63).

Schmidt suggests a similar phenomenon on which he calls an "adynamic" epididymis (127). As the tubules of the epididymis dilate after vasectomy, their thin walls become even thinner. Eventually, changes in the walls prevent them from regaining their original size or muscle tone. This condition may affect their peristaltic ability so that after vas anastomosis is performed, the sperm move through the epididymis tubules so slowly that many die on the way (127).

Sympathetic Nervous System Injury. Three important studies support the theory that intact sympathetic nerve endings are probably vital to sperm transport (65). If the nerve endings are temporarily disrupted or permanently destroyed during the vasectomy or vasovasostomy, this could interfere with or prohibit the powerful contractions needed to move the 60-70 percent of sperm in the proximal vas and epididymis to the urethra during seminal emission and ejaculation.

Freund and Davis of New York Medical College demonstrated that approximately 60-70 percent of the sperm in a normal ejaculate come from the vas proximal to the site of vasectomy and from the epididymides (53). They based this conclusion on the fact that first specimen ejaculates in vasectomized men contained 30-40 percent the amount of sperm found in their preoperative specimen. Later, these investigators joined with Ventura and Pannuti in an in vitro study of the mechanisms controlling vas motility, the results of which were used to formulate hypotheses regarding control of sperm transport. They reported spontaneous motility of the human vas, a "rhythmicity gradient" along the vas (the frequency with which contractions increase from that part of the vas nearest the epididymis distally toward the urethra), and powerful contractions in the vas upon administration of norepinephrine—a chemical substance considered capable of activating and regulating vas motility. As a result of these findings, they suggested:

- the intrinsic rhythmicity of the human vas is dependent upon the local concentration of norepinephrine while the powerful and coordinated series of contractions that propel the sperm from the epididymis to the urethra during ejaculation are initiated and controlled by the release of substantial amounts of norepinephrine from the sympathetic nerve endings (149).

In addition, Bedford of Columbia University, New York City, observed that nerve regeneration may be affected by scar tissue present after vasectomy. Division of the inferior
SPERM ANTIBODIES

Whether or not sperm antibodies in determining fertility if they undergo vas anastomoses has yet to be established (16). In 1964 Phadke and Padukone of the Family Welfare Bureau, Bombay, detected sperm agglutinating antibodies in 32 percent of vasectomized men they studied, but concluded that the presence of sperm agglutinating antibodies in the blood serum was neither responsible for nor indicative of infertility (116).

In the early 1970s various studies prompted researchers to consider the possibility of developing immunological infertility in vasectomized men (13, 135). Studies conducted in three different laboratories by Ansbacher, and Shulman, and Coombs, Rumke, and Edwards determined that sperm antibodies occur in from 50-62 percent of vasectomized men (14, 137).

Gupta and associates found a positive correlation between the titres of anti-sperm antibodies and autoagglutination of spermatozoa in ejaculates of normospermic men who had vasectomies and then vasovasostomies. They suggest this might be an important cause of low fertility rates in anatomically successful vasovasostomy cases (56).

Recent studies with the rhesus monkey indicate a high correlation between spermatic granulomas and sperm agglutinating antibodies (12). Schmidt suggests that prevention of sperm autoimmunity is related to prevention of sperm spillage and granuloma formation (129), but additional clinical investigation is required. Recently, Schmidt and Alexander have observed immobilizing antibodies in only 6 of 13 granuloma patients. Additional research is needed to determine why they are present in some granuloma cases and not in others (130).

FERTILITY OF PARTNER

Obviously, the partner's fertility is important in establishing success as determined by the patient's normal sperm count before the vasectomy is unknown (65). Because vasectomy is still considered a permanent procedure, semen analysis prior to surgery is rarely done (117). Also, semen quality varies greatly, so it is likely that some men who had vasectomies may not have had good quality semen to begin with. Semen quality after vasectomy can only be as good as it was before vasectomy.

SPERM ANTIBODIES

Whether or not sperm antibodies in men who have had vasectomies are detrimental to their fertility if they undergo vas anastomoses has yet to be determined (16).

Two types of sperm antibodies, sperm agglutinating and sperm immobilizing, have been studied to determine their relationship to infertility. When sperm agglutinating antibodies are present, sperm appear motile. They cling or clump together and do not separate or move normally. When sperm immobilizing antibodies are present, sperm do not exhibit motility and appear dead (12).

Although sperm antibodies occur in 1 percent of proven fertile men (14) and 2 percent of normally fertile men (13), they are more common among infertile men and those who have had vasectomies. In the 1950s Wilson and Rumke confirmed in independent studies the presence of sperm agglutinating antibodies in infertile men (137). In 1964 Phadke and Padukone of the Family Welfare Bureau, Bombay, detected sperm agglutinating antibodies in the blood serum of infertile men (116). In the early 1970s various studies prompted researchers to consider the possibility of developing immunological infertility in vasectomized men (13, 135). Studies conducted in three different laboratories by Ansbacher, and Shulman, and Coombs, Rumke, and Edwards determined that sperm antibodies occur in from 50-62 percent of vasectomized men (14, 137).

FOLLOW-UP

There is surprisingly poor follow-up among vas anastomosis patients—as low as 50 percent in some studies (65). Evaluation, therefore, is difficult. Schmidt suggests that insufficient follow-up may reflect indifference on the part of the patient who may have felt pressure from a partner to restore his fertility, and who feels he has done his part by undergoing the anastomosis (129, 131).

VAS ANASTOMOSIS PROCEDURE

To date, vas anastomosis, sometimes called vasovasostomy, appears to be the only method which has progressed beyond the experimental stage and offers the chance of regaining fertility. (See Table 2.) Vasovasostomy involves surgical reconstruction of the severed ends of the vas deferens to restore fertility in men who have undergone vasectomy or who are azoospermic for some other reason.

Because vas anastomosis is a lengthy and painstaking procedure involving delicate handling of tissues and precise hemostasis, most physicians perform the procedure in a hospital operating room under general or spinal anesthesia. On the other hand, Schmidt of the University of California at San Francisco (USA) now uses only local anesthesia with preoperative sedation and reports excellent results in 30-40 cases (130). Cerruti and colleagues of the University of California at Irvine (USA) report encouraging preliminary results with an outpatient procedure using local anesthesia (34).

A vas anastomosis operation may take from 75 minutes (93) to two or three hours (3, 117, 140). Some physicians hospitalize their patients. A hospital stay of four days is average (3, 120). Lee of Seoul National University (Korea) hospitalizes some patients only two days but prefers a stay of seven days (77, 86). Schmidt thinks hospitalization unnecessary since present-day anesthetics allow the patient to be released as soon as he is fully awake (131). Full aseptic practices are followed for the procedure.

Scrotal Incision, Identification and Action on Vas Ends

The scrotum is examined carefully. The cut ends of the vas can be palpated as nodules, scarring, defects, or hardening of the vas deferens (82, 107, 131). Usually only the scrotal hair is shaved; the pubic hair and penis are fixed with an adhesive plaster to the suprapubic abdominal wall. The scrotum and suprapubic area are cleansed with soap and water and an antiseptic solution and then draped (82). Merthiolate or a mercurial antiseptic solution are not recommended as they sometimes cause dermatitis with exfoliation (130). A 4-8 cm incision is made. Then, either a
<table>
<thead>
<tr>
<th>Author &amp; Date</th>
<th>Ref. No.</th>
<th>Years Performed</th>
<th>Total Cases</th>
<th>Technique Preferred</th>
<th>Interval between Vasectomy and Vasovasostomy</th>
<th>Criteria for Success</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cases with Sperm Reappearance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Belt 1960</td>
<td>24</td>
<td>NR</td>
<td>24</td>
<td>using operating microscope, end-to-end anastomosis with dermalon splint</td>
<td>NR</td>
<td>22</td>
</tr>
<tr>
<td>Derrick 1973</td>
<td>41</td>
<td>NR</td>
<td>1630a</td>
<td>all techniques</td>
<td>NR</td>
<td>620</td>
</tr>
<tr>
<td>Dorsey 1972</td>
<td>46</td>
<td>1946–1972</td>
<td>129</td>
<td>using magnifying loupe, end-to-end anastomosis with dermalon splint</td>
<td>3 mos.–19 yrs.</td>
<td>114</td>
</tr>
<tr>
<td>Hanley 1972</td>
<td>61</td>
<td>NR</td>
<td>35</td>
<td>NR</td>
<td>NR</td>
<td>27</td>
</tr>
<tr>
<td>Kaneko NR</td>
<td>77</td>
<td>NR</td>
<td>73</td>
<td>NR</td>
<td>NR</td>
<td>53</td>
</tr>
<tr>
<td>Lee 1975</td>
<td>77</td>
<td>1964–1974</td>
<td>185 (178)d</td>
<td>end-to-end or side-to-side anastomosis with nylon splint</td>
<td>1–28 yrs.</td>
<td>144</td>
</tr>
<tr>
<td>Mehta &amp; Ramani 1970</td>
<td>93</td>
<td>NR</td>
<td>31 (22)</td>
<td>side-to-side anastomosis with nylon splint</td>
<td>3 mos.–4 yrs.</td>
<td>20</td>
</tr>
<tr>
<td>O'Connor 1948</td>
<td>100</td>
<td>NR</td>
<td>430e</td>
<td>all techniques</td>
<td>NR</td>
<td>191</td>
</tr>
<tr>
<td>Pai 1973</td>
<td>107</td>
<td>1961–1971</td>
<td>30</td>
<td>end-to-end anastomosis with nylon splint</td>
<td>6 mos.–10 yrs.</td>
<td>21</td>
</tr>
<tr>
<td>Pardanani 1974</td>
<td>110</td>
<td>NR</td>
<td>50 (35)</td>
<td>end-to-end anastomosis with nylon splint</td>
<td>6 mos.–10 yrs.</td>
<td>1</td>
</tr>
<tr>
<td>Phadke &amp; Phadke 1967</td>
<td>117</td>
<td>1954–1966 (73)</td>
<td>76</td>
<td>end-to-end anastomosis with silastic splint</td>
<td>NR</td>
<td>63</td>
</tr>
<tr>
<td>Silber &amp; Owen 1976</td>
<td>140</td>
<td>1974–1975</td>
<td>26</td>
<td>using operating microscope, end-to-end, mucosa-to-mucosa anastomosis</td>
<td>NR</td>
<td>26</td>
</tr>
</tbody>
</table>

NR - Not Reported
aReported in survey of 2,775 board-certified urologists
bThree cases fewer than 20
cIncludes one abortion
dFigures in parentheses denote patients followed up
eReported in survey of 1,240 urologists
fIncludes 31 patients never examined who reported partner's pregnancy
gIn most successful cases
single incision is made in the midline of the scrotum (44, 85) or two incisions—one over each vas in the area where the vasectomy was done (67, 82, 93, 109, 117, 131, 140, 144). The incision is deepened by incising (117) or spreading apart (129) the fascia. The cord is delivered (93) and the fibroed ends of the vas identified and dissected free (117). Minimal mobilization and dissection of the vas from the cord and fibrous mass are usually undertaken to avoid vascular injury (46, 93, 109). Schmidt recommends freeing 2-3 mm of underlying fascia from the ends to prevent its intervention in the anastomosis (129).

At this point procedure varies somewhat depending on whether the technique used is end-to-end or side-to-side anastomosis, whether it is done in the straight or convoluted portion of the vas, or whether a vas-to-vas or vas-to-epididymis union is sought. (See Fig. 2.)

In end-to-end anastomosis in the straight or convoluted portions of the vas, the fibroed ends of the vas are delivered and cut transversely between the scarred and healthy tissue until a healthy lumen can be seen at both ends (45, 84, 91, 107, 111, 117, 121, 131). Most physicians remove the ends (45, 91, 111, 117, 121, 131). Schmidt feels it is unnecessary to remove the ends unless they form a granuloma, in which case he removes them (129).

If the procedure is a side-to-side anastomosis, the normal-looking vas just proximal and distal to the fibrous mass is cut transversely only until the lumen is entered. Care is taken not to transect the vas completely. A 24-gauge hypodermic needle is passed into the lumen for about 3 cm from this transverse cut and then through the vas wall. A fine-pointed knife engaged in the bevel of the needle longitudinally incises the wall toward the transverse cut as the needle is withdrawn (93).

If the vasectomy has been done in error very near the epididymis in the convoluted vas, sometimes a vas-epididymal anastomosis is done. To accomplish this, a 1 cm longitudinal incision is made as far down in the epididymis as possible. A portion of the distal vas suitable for approximation to the epididymal incision is cut transversely just deep enough to incise its anterior half. A needle is then inserted into the lumen and through its wall. A No. 11 Bard-Parker knife is engaged with its tip in the bevel of the needle and swiftly withdrawn to split the vas deferens longitudinally (73).

At this juncture in either procedure the patency of the vas is tested. Patency of the proximal vas can be inferred if milky spermatic fluid oozes from the cut end. If fluid is present and flows into the surrounding area, it should be sponged or irrigated as it can cause spermatic granuloma or inflammation (93, 128). When this fluid is absent the vas may be compressed gently to express it (131), or a 2-0 or 3-0 nylon thread (82), or Nos. 28, 30, 32 steel wire (121) passed into its lumen to check for any obstruction. Patency of the distal vas is tested by the introduction of a 1-0 to 3-0 nylon thread (46, 83), or a fine blunt probe (44) along it; or it may be tested by the injection of normal saline with a blunted 23-gauge needle (93, 117, 131), or with a blunted needle filled with indigo carmine solution which will appear in the bladder if the vas is patent (71, 144).

Various types of splinting materials have been tried. Among them are solid splints, such as silkworm, catgut, or nylon thread (44, 67, 71, 82, 93, 117, 131), or a small polyethylene catheter with a fine wire inside it (144); and open splints, such as a hollow stainless steel tube (32), or silastic or polyethylene tubing (131). Solid splints are introduced into the lumens from 1.0 to 3.0 cm into the proximal vas through the shaft of a 20-25 gauge hypodermic needle which is pierced through the vas wall (44, 46, 82, 117, 131, 144). The other end of the splint is introduced into the distal lumen either for a distance of 1.5 to 4 cm with the aid of a needle and pierced through the vas wall (67, 82, 110, 121) or for a distance of 8 to 14 cm and left in the lumen (44, 46, 93, 117, 131, 144) and the ends brought outside and tied together (67, 110). Solid splints are removed sometime between the fourth and 14th day following the anastomosis (44, 46, 71, 82, 93, 117, 131, 144). Open splints are placed at least 1 cm into the distal vas and 1.5 to 2 cm into the proximal vas. They are not secured and are permanent (131).

Schmidt, who has tried most kinds of splints over the years, abandoned their use altogether due to leakage and obstruction problems (8). However, Nuwayser and associates reported promising preliminary results from animal experiments using an absorbable splint, which might eliminate these problems (99).

For an end-to-end anastomosis, the ends are approximated with a single suture of 4-0 nylon through the fascia (129) by the use of modified aneurysm clamps (140), or with a single suture through the soft tissues (117).

Most physicians suture the adventitial and muscularis tissues only with interrupted stitches, taking care not to penetrate the mucosal lining of the lumen (46, 71, 85, 93, 110, 117, 144). Recently, some physicians are changing to and advocating mucosal sutures to insure the closest approximation possible (129, 138) and a water- and

Fig. 2. Five steps followed during an end-to-end, mucosa-to-mucosa vas anastomosis procedure are shown here: 1) scarred vas ends are cut and removed to reveal patent lumen; 2) a probe is inserted into the distal lumen to test for patency; 3) sutures are carefully placed to approximate the ends insuring lumen-to-lumen anastomosis; 4) with anastomosis of vas ends completed, sutures are tied; 5) closure is completed.
sperm-tight closure (140). Some use as few as one or two sutures (44, 107) while others use as many as six (140). Most physicians use from three to five sutures to anastomose the vas itself (46, 71, 82, 110, 117, 121, 131, 144). The most commonly used materials are 5-0 or 6-0 monofilament nylon or arterial silk sutures (44, 57, 82, 93, 111, 117, 144). Use of 7-0 monofilament polypropylene (130) and of 9-0 nylon is also reported (138). After the vas is anastomosed, many physicians place from two to five supporting sutures in the adjoining fascia to prevent tension and stress (44, 71, 110, 121, 144). Silber of the Veterans Administration Hospital in San Francisco, California (USA) places 10 sutures in the muscularis, which he believes are critical in re-establishing the peristaltic ability of the testes (93).

Optical aids are used by many to assist in accurate approximation of the ends and for precise suturing. Lee and Dorsey reported the use of magnifying loupes (46, 77) while a number of others use operating microscopes at magnifications from 10 to 40 times (24, 71, 128, 138).

In a side-to-side anastomosis four to six interrupted stitches of 5-0 nylon are used to join the anterior vas walls, taking care that the sutures do not enter the lumen. One or two stay stitches are placed through the soft tissues surrounding the vas (93).

In a vaso-epididymal anastomosis, three anchoring stitches are taken between the epididymis and vas below the anastomosis site. Six 5-0 Anacap silk sutures are usually sufficient to anastomose the two layers of the vas and epididymis, with a portion of epididymal tubules included in each stitch (73). Schoysman and Schmidt use 6-0 or 7-0 monofilament polypropylene to suture (130). The scrotal incision is closed in layers using 3-0 or 4-0 plain catgut or nylon (46, 71, 117, 121). Phadke reported application of an adhesive strip scrotal support (117), and Winer reported use of an elastic support as a pressure dressing and gauze packing of the testes (71).

Postoperative Care

Postoperative care procedures vary greatly among physicians. Postoperative care includes: the use of a scrotal suspensory for 7-14 days in most cases (82, 121, 131); bed rest for seven days recommended by some (82, 93, 111, 117); no sexual intercourse for at least 10-14 days (129, 144); and semen analyses after three weeks to one month (77, 93, 117, 128) and periodically up to one year (117) or until pregnancy in the partner is confirmed (140). Broad spectrum antibiotics are sometimes prescribed (82, 93, 117, 144) and the administration of Liothyronine, a thyroid replacement agent (82), and Prednisolone, a corticosteroid (93), are reported.

Effectiveness

Vas anastomosis is:
- the only method in wide clinical use;
- safe, with only minor complications reported.

From a summary of 1937-1974 study results, Lee concluded that there is anatomical success in 64 percent of the 1,267 cases studied and functional success in 33 percent (77). After evaluating 53 recent cases, Schmidt reported 82 percent success in restoring sperm to the ejaculate, and 38 percent success in pregnancy in the patient’s partner (130). Reported pregnancy rates rarely exceed 40 percent and quite often are as low as 10-17 percent. However, in 1967 Phadke and Phadke reported that sperm reappeared in 83 percent of 76 cases, and pregnancy occurred in 55 percent (117). In 1969 Belt reported the reappearance of sperm in 92 percent of cases studied and pregnancy in 46 percent (24).

In known studies there appears to be no relationship between success rates and the techniques used. Most recently, however, higher success rates have been reported by physicians using microsurgical techniques, although the number of cases is too few to be conclusive. (See Fig. 3.) Silber and Owen report a 69 percent pregnancy rate among 26 patients who were followed up for at least six months (140).

Any family planning program which makes vasectomy widely available would do well to include an anastomosis component in their program. Such a service should take into account the fact that:
- surgery, usually under general anesthesia, is required;
- considerable skill and training are needed;
- the procedure is time-consuming, taking from 75 minutes to three hours;
- one surgical team can meet the needs of a very large area, maybe even an entire country or a group of small countries, because there are few requests.

While the service should be offered, the operation results are not sufficiently predictable that the possibility of reversal should be a factor in the man's initial decision-making. Vasectomy, at this time, should only be represented as irreversible.

FROZEN SEMEN STORAGE

The freezing and storing of semen in semen banks prior to vasectomy is one possible approach to vasectomy reversal. Potentially the process is simple, prior to vasectomy, a man would provide a number of semen specimens which...
would be frozen and stored in a semen bank. After the operation, if he wishes to father a child, a specimen of his semen would be removed from the bank, thawed, and introduced into his partner by artificial insemination.

However, storing human frozen semen still is somewhat experimental even though it was first suggested as a possibility in 1866 by Montegazzio. Almost a century passed before glycerol was found to be a successful cryoprotective agent (one which protects sperm at the very low temperatures used for frozen storage) in 1949. Later, in the 1950s, a simple, efficient, clinically approved technique for freezing was developed and further increased the feasibility of semen storage (133).

At an International Conference in Andrology in April 1975, the following conclusion was drawn regarding frozen semen storage:

The capacity for freezing human semen varies among individuals and must be tested before semen is banked. Variations in the freezability of semen are not related to concentration, motility, viability and morphology of spermatozoa. In order to predict good freezability a repeated freeze-thawing procedure is applied (58).

Liquid nitrogen, the best refrigerant for low temperature freezing, is usually used for the freezing and storing of semen (31, 143, 148). The procedure involves adding glycerol in concentrations of 5–10 percent (133) to the semen; initial freezing in ampules or pellets at a temperature ranging from -45°C (22) to -99°C (148); and transfer for storage to a canister in a liquid nitrogen tank where a temperature of about -196°C is maintained (133). The semen is stored until needed, at which time it is removed from the tank and thawed at room temperature (22).

In 1973, Sherman reported that clinical use of frozen and stored semen resulted in 564 normal births, 7 (1 percent) abnormal births, and 50 (9 percent) spontaneous abortions. These rates are similar to those for a normal population; so although the series is small, use of frozen, stored semen would not seem to increase the risk of abnormal births or spontaneous abortions (133).

Fertilizing capacity of sperm that have been frozen appears to be 12–15 percent lower than that of fresh sperm (133, 143). Summarizing their experience with donor inseminations over a ten-year period, Steinberger and Smith of the Houston Texas Medical Center (USA) reported that pregnancy rates were 12 percent higher in their 48 attempts with fresh semen than in their 59 attempts with frozen semen (148).

Sperm that have been frozen then thawed show a significant loss of motility (decrease in the number of sperm showing independent movement). Beck and Silverstein reported a motility loss ranging from 34 to 49 percent in a study of 48 men (22); and Steinberger and Smith, a motility loss of approximately 50 percent with semen from 533 ejaculates of 207 donors (141). Nevertheless, there seems to be no correlation between motility loss and such factors as paternity history, prefreeze microscopic appearance of sperm, initial sperm count, and technique and speed of freezing process (22).

Freund has successfully frozen and stored sperm for as long as four years without motility loss (52), but the fertilizing capacity of the sperm after thawing was not determined. The number of inseminations performed with sperm stored for five years or more is too small to draw reliable conclusions about long-term fertility. Although Sherman reports one birth resulting from impregnation with semen stored for ten years (133), most investigators report births from semen stored less than one year (141, 143). Tyler, reporting on experience with 196 donor insemination patients, cautions that there is no "guarantee" of long-term usefulness of frozen semen (148).

At present the high cost of sophisticated equipment and techniques preclude the use of frozen semen storage in other than large medical centers and large cities, primarily in developed countries. Barkay, Zuckerman, and Heiman of the Central Emek Hospital (Afula, Israel) and "Or" Artificial Insemination Coop (Safed, Israel) recently developed a sperm cryofreezer* they believe will make frozen semen storage practical and feasible even in small centers, private offices, and perhaps in developing countries. The sperm cryofreezer is small, economical to purchase and inexpensive to use, quick, easy to operate, and capable of either rapid or slow freezing (17).

Freund has suggested the importance of developing dilution techniques which would allow many samples of sperm to be prepared from a single human ejaculate. Dilution would facilitate controlled quantitative and more critical studies (52).

Investigators studying frozen semen storage agree that more research and a considerably larger series of clinical use data are necessary before valid statistical compilations can be made (22, 133, 143). Meanwhile, the following questions are among those currently under consideration:

- Why does freezing reduce fertility?
- What guidelines should be used to evaluate the fertilizing capacity of frozen sperm?
- What changes should be made in the freezing technique?
- How can cryoprotection be improved (23)?

The medico-legal and sociological problems of sperm storage have not yet been explored. Many problems also exist concerning commercial sperm banks. Not only is there a lack of knowledge about sperm physiology and freezability for these banks to contend with, but also a lack of standards and guidelines for their operation.

**EXPERIMENTAL VAS OCCLUSIVE DEVICES**

Experiments with various types of reversible vas occlusive devices in dogs, rabbits, rhesus monkeys, and humans have been underway since the 1960s in search of what Hulka and Davis call "the standard for efficient reversibility." Ideally this standard would include:

- Some type of simple operation with the insertion of a device in the vas which would cause little tissue reaction or loss of function and which would allow for the return to normal function of the vas and the ejaculation of healthy sperm. (85)

As yet, however, all devices remain experimental and none has been proven effective enough for wide clinical use.

* patent pending
An effective vas occlusive device would:
- completely block the vas, thus producing azoosperma (29, 48, 97, 109);
- be easily and completely reversible to allow normal sperm passage (29, 48, 97, 108);
- be safe and involve a minor surgical procedure, causing minimal disturbance to blood, nerve, lymph, and muscle continuity and minimal tissue reaction (29, 48, 57, 97);
- provide effective tissue ingrowth with the device (29, 48);
- be simple and economical to produce and install, thus making it suitable for mass application at low cost (29, 48, 97);
- have a consistency similar to that of the tissue into which it is placed (140).

Four approaches to surgical vas occlusion have been tested—plugs, intravas devices, clips, and vas valves. Valves hold the most promise, according to the conclusions reached during a 1971 workshop on male sterilization held at the Battelle Population Study Center in Seattle, Washington (USA) (71).

**Plugs**

In the 1960s experiments were undertaken to insert Silastic™ and other nonreactive synthetic materials into the vas which would plug the vas from within (25, 64, 72, 76). To do this effectively, the substance must be fixed in place and must adhere to the vas walls well enough to prevent the formation of a channel around itself (142). Azoosperma was achieved in dogs by silicone injection (64) and by polyethylene tubing held in place by surgical clips on the exterior of the vas (97). In both these studies, sperm reappeared in the ejaculate after the silicone or tubing was removed. The experimental periods were short, however. Moon and Bunge concluded that longer periods of observation were needed to evaluate tissue reaction, semen quality, and improved material for the plug (97).

In experiments with rats, guinea pigs, and rabbits, Laurence of The Rockefeller University, New York (USA), concluded that it is possible to occlude the vas without impairing it, but to be successful, this must be done with a method that prevents even the slightest movement of the device (76).

Derrick and Frenselli studied the use of the Brodie R-IVD in thirteen volunteers. Although the device was handled with ease, reversibility was not obtained in any of the subjects. They believed the results to be due to tissue damage probably caused by the large size of the device (40). [The Brodie R-IVD is discussed in "Vasectomy—Old and New Techniques," Population Reports, D-1, December 1973.]

**Clips**

Another approach, hypothetically attractive because it appears to offer potential for easy application and reversal, involves the use of removable occlusive clips placed on the exterior of the vas deferens. A study by Jhaver and associates using dogs was not encouraging, however. Removal of the clips was more difficult than anticipated; and sperm did not reappear in the ejaculate in two of the three dogs tested. Because less scar tissue developed with the clips than with standard vasectomy techniques, the authors suggest that clips might provide a better condition for anastomosis than standard vasectomy techniques (70).

Pardanani recently tested the use of Weck's medium size tantalum Hemoclips™ (Vasoclips) for reversible vas occlusion in animals and then in six human volunteers. Results were discouraging (108). Frick is experimenting with the use of removable tantalum clips. So far he has observed successful vas occlusion and subsequent vas patency after removing the clips, but his method needs further improvement and evaluation (55). Clips such as the Falope Ring™ (also known as the Yoon band) which has been tested clinically in women may be used in males if altered in size.

**Intravas Devices**

Lee's experiments with the intravasal thread (IVT) are considered in "Vasectomy—Old and New Techniques," Population Reports D-1, December 1973. At that time Lee reported that sperm reappeared in the ejaculate of 83 percent of men who had their IVT removed. Lee reports no new information on the IVT since then (89). (See Fig. 4.)

In 1967, Kothari and Pardanani reported on two cases in which the intravas contraceptive device (IVCD) was used. The IVCD is made of thick nylon thread, approximately the size of No. 1 chronic catgut. In one case a single strand was used; and in the other, two strands. In both cases the sperm count was reduced below fertile levels after the device was inserted (75). Later, in 28 patients, Pardanani reported using silastic tubing by Dow Corning with an outer diameter of approximately 1.25 cm. In all 28 cases, sperm remained in the ejaculate; and in 10 cases, pregnancies occurred during the two-year follow-up period. In this study, the method was considered a failure and the study abandoned (108).

---

**INTRAVASAL THREAD**

![Image](https://via.placeholder.com/150)

**EXTRA LARGE**

**ORDINARY**

**EXTRA SMALL**

---

Fig. 4. Three sizes of intravasal thread (IVT)—extra large, ordinary, extra small—are pictured above. The IVT is one of several intravas devices investigators have studied in recent years. (Courtesy of Dr. H. Y. Lee, Seoul National University, Korea.)
SURGICAL REVERSAL

- 1 to 2 hour surgical procedure under general or spinal anesthesia
- 40-90 percent likelihood of reappearance of sperm in ejaculate
- 16-60 percent likelihood of pregnancy in partner

MECHANIC

- Vas occlusive devices not yet available

STEP 1

HISTORY OF PATIENT AND PARTNER

- Record of semen quality, including sperm count, motility, and morphology
- Paternity history
- Record of fertility of female partner

STEP 2

VASECTOMY PROCEDURE

- Incision or incisions high in scrotum to expose straight vas
- Each vas end ligated: to prevent recanalization, ends can be folded back on themselves and ligated a second time, or crossed and ligated together, or one end can be placed within the fascia to separate the ends

STEP 3

VAS-TO-VAS ANASTOMOSIS PROCEDURE

- Location of vasa ends, palpated as nodules, scarring, or defects
- Midline incision or two incisions over palpated vasa ends
- Scarred ends of vasa cut back until healthy lumen is seen
- Patency of distal vas ascertained by introduction of nylon thread along its passage
- Ends approximated using modified aneurysm clamps or by single sutures through the fascia
- Suture of muscularis surrounding vas with 4-10 stitches, to prevent tension and stress at the anastomosis site and to reestablish the peristaltic ability of muscularis

STEP 4

POSTOPERATIVE CARE

- Use of scrotal support for 10 days
- Intercourse not resumed for 10 days
- Semen analysis, the first 3 weeks following anastomosis, and every 3 weeks thereafter until there is a pregnancy, or up to 1 year (if normal sperm count not reached after 1 year, procedure should be considered a failure. A second anastomosis may be successful.)
REVERSAL

FROZEN SEMEN STORAGE (INSURANCE OF FUTURE FERTILITY)

- 12-15 percent lower pregnancy rate in artificial insemination with frozen semen than with fresh semen
- Significant (up to 50 percent) motility loss in frozen sperm, resulting in lowered fertilization probability
- Long-term effects of freezing and storage on sperm preservation not yet determined

STEP 1

HISTORY OF PATIENT AND PARTNER

- Record of semen quality, including sperm count, motility, and morphology
- Paternity history
- Record of fertility of female partner

STEP 2

SEMEN STORAGE PROCEDURE

- Men collects and deposits in commercial semen bank minimum of 36 vials (2 to 5 ejaculates depending on semen volume and sperm count) of semen
- Semen stored at -196°C in special freezers until wanted for artificial insemination
- Collection and deposit costs approximately $100 (US); annual storage costs approximately $25 (US)

STEP 3

VASECTOMY PROCEDURE

- Incision or incisions high in scrotum to expose straight vas
- Vas transected in straight portion of vas
- Each vas end ligated or fulgurated approximately 2-4 mm, withdrawing needle as soon as electrical current is turned on so that only mucosa and underlying cells and not muscle or surface blood vessels are affected
- Proximal vasa closed within muscle sheath to avoid recanalization

STEP 4

ARTIFICIAL INSEMINATION

- Semen sample removed from freezer and thawed
- 1 to 4 inseminations per menstrual cycle, either daily or every other day at time ovulation is presumed to occur and when cervical mucus appears receptive to sperm survival and transport, until pregnancy occurs
Vas Valves

Unlike other vas occlusive devices, valves can be turned on or off to either permit or restrict the passage of sperm through the vas. Use of the Bionyx Control (Phaser) was reported in "Vasectomy—Old and New Techniques," Population Reports, D-1, December 1973. Since that time, the Bionyx Control (Phaser) was placed in the vas of 23 guinea pigs in the open position and of 26 in the closed position. All of the open valve animals had sperm in their ejaculates for their duration in the study (up to 98 weeks). All of the closed valve animals became aspermic (no sperm in the ejaculate) and remained aspermic for their duration in the study (up to 91 weeks). Toxicity studies showed no difference between animals with and without the valve. Six of the animals with the valve in the open position were mated and each produced offspring, totaling 14 litters with 39 young. Six of the animals with the valve in the closed position were reversed (turned from the closed to the open position), were mated, and each produced offspring, totaling 9 litters with 30 young. The original work with human subjects was in the form of a pilot study at the New York Medical College and demonstrated the feasibility and safety of the valve in man. Definitive human clinical trials are now taking place at the University of Miami School of Medicine.

Two other valve studies with great promise are presently underway, one directed by Brueschke (see Fig. 5) at the ITT Research Institute, Chicago (USA), and the other by Free at the Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington (USA). Brueschke and associates have developed and tested two types of valves: rigid and flexible. The rigid devices consist of a silicone body with rigid valve stem inflow and outflow tubes. These rigid-end tube valves proved undesirable (29). Sperm transport was never maintained for more than a few ejaculations. Failure was due to angulation of the device and perforation of the vas wall. Modifications were made in the device to prevent angulation and surgical techniques were changed but to no avail. Based on their experience, the investigators suggested that all future valve work be done with flexible devices (29).

![Fig. 5. This flexible-end, reversible vas deferens occlusive device features suture-covered rings for tissue ingrowth thought to prevent sperm leakage and recanalization around the device. (Courtesy of Dr. E. E. Brueschke, ITT Research Institute, Chicago, Illinois.)](image-url)

More effective sperm transport in dogs for prolonged periods of time—eight to ten months in some cases—was obtained using a soft, flexible-ended valve device. Potential for reversibility with this device was indicated as well. In three of four dogs in which the valve was closed for several weeks after sperm transport had been verified, sperm transport recurred after the valve was reopened. A major innovation of this flexible-ended device is the presence of suture ingrowth rings which are believed to prevent sperm leakage and recanalization around the device (30).

Two problems that must be resolved before trials in humans begin are the large decrease in numbers of sperm (75 to 85 percent) and the somewhat decreased sperm motility (35 percent) that occurs after implantation. Further, the possibility that side effects—such as sperm agglutination and immobilizing antibodies, epididymal malfunctions, or testicular changes—might occur should be evaluated (30).

As an outgrowth of their efforts to produce a reversible vas occlusive device, Brueschke and associates have developed an artificial vas deferens which has potential application to facilitate anastomosis of the vas following vasectomy, or to replace a vas absent from birth. Preliminary experiments were carried out in dogs to assess the duration of aspermia and to test whether sperm transport would be restored. In all six dogs tested, sperm transport resumed (27).

Free and associates developed and tested in animals a valve device called the RIOD (Reversible Intravasal Occlusive Device) (20). The RIOD (see Fig. 6):  
- consists of three simple components molded from a single polymeric material;  
- contains a porous structure on the outer surface of the end-piece tubes to permit tissue ingrowth;  
- requires no transection or ligation of vas;  
- accomplishes reversal by changing the color-coded middle piece;  
- has an internal diameter very near that of the human vas.

Preliminary trials with guinea pigs demonstrated the feasibility of the RIOD concept. A modified RIOD, used in rabbit trials, was developed to counter erosion difficulties. After a brief postsurgical drop in sperm count, subsequent counts and motility were generally in the normal range when the device was open. Sperm counts of rabbits with RIOD in a closed position fell to zero after the first ejaculation and remained at zero during the remainder of the two-month study period (21).

Problems of kinking and change in the outer diameter of the vas size, causing movement of the device, led to other minor modifications. These are now incorporated in the present RIOD, considered by the investigators to be the definitive version of the device; further refinement is not expected (20).

In trials with rhesus monkeys, this most recent version of the RIOD remained in place and did not erode, and tissue ingrowth was extensive. Early inflammation at the site of the interface later disappeared. The monkey with an open RIOD had normal sperm counts with 30 to 60 percent motili-
Swartwout and Zaneveld are investigating diverting sperm transport through the use of a non-occlusive device called a Y-Valve. The Y-Valve, in its early experimental stages at present, diverts sperm transmission over a long length of tubing, resulting in loss of viability. Flow is diverted through a short pathway when fertility is once again desired (146).

RESEARCH PRIORITIES

Research priorities affecting reversibility were identified jointly by Perry, Speidel, and Winter at a workshop on control of male fertility sponsored by the Program for Applied Research in Fertility, Minneapolis, Minnesota (USA) in June 1974 (142). Among these priorities were:

- fundamental research on normal male reproductive physiology and vasectomy consequences;
- identification of suitable animal models for testing new approaches;
- comparative studies of various vasectomy and vas anastomosis techniques to develop better ones;
- development and clinical application of vas occlusive devices.

BIBLIOGRAPHY

Studies to date on experimental vas occlusive devices have identified the following reasons for their failure:

- lack of tissue ingrowth with device (29, 109);
- fibrosis while wearing device (35, 87);
- perforation of the vas wall (12, 48);
- epididymal changes affecting sperm transport (35, 49, 87);
- autoimmune response (13, 48);
- lumen dilation (87);
- migration (35);
- scar tissue forming obstruction (40, 87).


11. ANONYMOUS. The reversible intravasal occlusive device (RIOD) is shown here: top photo, installed in the vas deferens; bottom photo, installed in a closed mode in the vas deferens of a guinea pig. (Courtesy of Dr. M. J. Free, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington.)

12. ANONYMOUS. Vascular occlusion techniques to develop better ones; development and clinical application of vas occlusive devices.


POPINFORM, A Computerized Information Service

POPINFORM (Population Information), a computerized information service, provides up-to-date published and unpublished materials—international in scope—on contraceptive technology, family planning programs and services, and population. The service, based in the metropolitan Washington, D.C. area, is available to persons in the population field and is particularly useful to those working in areas distant from large urban centers and research facilities.

The POPINFORM files currently contain over 32,000 citations, most with abstracts, and are representative of journal articles, book chapters, unpublished reports, papers presented at conferences, government and United Nations' reports, questionnaire forms, and technical manuals. The time period covered is approximately 1971 to the present.

POPINFORM's data base has six files that can be searched concurrently or separately. Information in these files is provided by the Population Information Program and the Prostaglandin Information Center of The George Washington University, the Center for Population and Family Health (a division of the International Institute for the Study of Human Reproduction) at Columbia University, the International Statistical Programs Center of the US Census Bureau, the Family Planning Evaluation Division of the US Center for Disease Control in Atlanta, and the East-West Communication Institute in Honolulu.

Documents included in the POPINFORM files are drawn from the fields of medicine, sociology, psychology, anthropology, statistics, economics, public health, administrative methodology, demography, geography, nutrition, and combinations of these. The areas covered include family planning programs, contraceptive technology, population law and policy, prostaglandins, program evaluation, some census citations and data, pregnancy termination, population education and communication.

A POPINFORM search in any of these subject areas will yield a bibliography and abstracts. If complete texts are desired, POPINFORM will provide copies where feasible.

A request to POPINFORM should include a description of the topic or topics for which a literature search is required; geographic areas, if any, to which a search should be limited; the time period to be covered; and any other pertinent details which may help in providing as complete a search as possible.

Information on how the material will be used—for example, practical help in solving a problem, keeping abreast of latest developments—will also be helpful in formulating the search.

POPINFORM's service is provided free of charge to persons or organizations in developing countries.*

Requests should be sent to:

Helen K. Kolbe
Project Director
Population Information Program
2001 S Street, N.W.
Washington, D.C. 20009 USA

or

Kathryn H. Speert
Head Librarian
Center for Population and Family Health
International Institute for the Study of Human Reproduction
Columbia University
60 Haven Avenue
New York, New York 10032 USA

*In the US, POPINFORM is available on-line by subscription.
**PUBLICATIONS OF THE POPULATION INFORMATION PROGRAM**

(Copies are available to health personnel in developing countries.)

<table>
<thead>
<tr>
<th>Series</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>Oral Contraceptives—50 Million Users (F, S)</td>
</tr>
<tr>
<td>A-2</td>
<td>Advantages of Orals Outweigh Disadvantages (F)</td>
</tr>
<tr>
<td>A-3</td>
<td>Minipill—A Limited Alternative for Certain Women</td>
</tr>
<tr>
<td>B-1</td>
<td>Copper IUDs—Performance to Date (F, S, P)</td>
</tr>
<tr>
<td>B-2</td>
<td>IUDs Reassessed—A Decade of Experience</td>
</tr>
<tr>
<td>C-1</td>
<td>Laparoscopic Sterilization—A New Technique (F, S, P)</td>
</tr>
<tr>
<td>C-2</td>
<td>Laparoscopic Sterilization II; What Are the Problems? (F, S, P)</td>
</tr>
<tr>
<td>C-3</td>
<td>Colpotomy—The Vaginal Approach (F, S, P)</td>
</tr>
<tr>
<td>C-4</td>
<td>Laparoscopic Sterilization with Clips (F)</td>
</tr>
<tr>
<td>C-5</td>
<td>Female Sterilization by Mini-Laparotomy (F)</td>
</tr>
<tr>
<td>C-6</td>
<td>Female Sterilization Using the Culdoscope (F, S, P)</td>
</tr>
<tr>
<td>C-7</td>
<td>Tubal Sterilization—Review of Methods</td>
</tr>
<tr>
<td>D-1</td>
<td>Vasectomy—Old &amp; New Techniques (F, S, P)</td>
</tr>
<tr>
<td>D-2</td>
<td>Vasectomy—What Are the Problems? (F)</td>
</tr>
<tr>
<td>D-3</td>
<td>Vasectomy Reversibility—A Status Report</td>
</tr>
<tr>
<td>E-1</td>
<td>Eighteen Months of Legal Change (F, S)</td>
</tr>
<tr>
<td>E-2</td>
<td>World Plan of Action &amp; Health Strategy Approved</td>
</tr>
<tr>
<td>E-3</td>
<td>Abortion Law &amp; Practice: A Status Report</td>
</tr>
<tr>
<td>E-4</td>
<td>Recent Law and Policy Changes in Fertility Control</td>
</tr>
<tr>
<td>F-1</td>
<td>Five Largest Countries Allow Legal Abortion on Broad Grounds (F, S, P)</td>
</tr>
<tr>
<td>F-2</td>
<td>Menstrual Regulation—What Is It? (F, S, P)</td>
</tr>
<tr>
<td>F-3</td>
<td>Uterine Aspiration Techniques (F, S, P)</td>
</tr>
<tr>
<td>F-4</td>
<td>Menstrual Regulation Update (F, S)</td>
</tr>
<tr>
<td>G-1</td>
<td>Clinical Use of PGs in Fertility Control (F, S)</td>
</tr>
<tr>
<td>G-2</td>
<td>Fertility Control Research Maps &amp; Directory (F, S)</td>
</tr>
<tr>
<td>G-3</td>
<td>A Review: Modulation of Autonomic Transmission by Prostaglandins (F, S)</td>
</tr>
<tr>
<td>G-4</td>
<td>“Prostaglandin Impact” for Menstrual Induction (F)</td>
</tr>
<tr>
<td>G-5</td>
<td>Physiology and Pharmacology of PGs in Parturition</td>
</tr>
<tr>
<td>G-6</td>
<td>Prostaglandins Promise More Effective Fertility Control</td>
</tr>
<tr>
<td>H-1</td>
<td>Condom—An Old Method Meets a New Social Need (F, P, S)</td>
</tr>
<tr>
<td>H-2</td>
<td>The Modern Condom—A Quality Product for Effective Contraception</td>
</tr>
<tr>
<td>H-3</td>
<td>Vaginal Contraceptives—Reappraisal</td>
</tr>
<tr>
<td>H-4</td>
<td>Diaphragm &amp; Other Intravaginal Barriers</td>
</tr>
<tr>
<td>I-1</td>
<td>Birth Control Without Contraceptives (F, S)</td>
</tr>
<tr>
<td>I-2</td>
<td>Sex Prescition—Not Yet Practical</td>
</tr>
<tr>
<td>J-1</td>
<td>Family Planning Programs &amp; Fertility Patterns (F, S, P)</td>
</tr>
<tr>
<td>J-2</td>
<td>World Fertility Trends, 1974 (F, S)</td>
</tr>
<tr>
<td>J-3</td>
<td>Advanced Training in Fertility Management (F, S, P)</td>
</tr>
<tr>
<td>J-4</td>
<td>Breast-feeding—Aid to Infant Health &amp; Fertility Control (F, S, P)</td>
</tr>
<tr>
<td>J-5</td>
<td>Contraceptive Distribution—Taking Supplies to Villages and Households (F, S, P)</td>
</tr>
<tr>
<td>J-6</td>
<td>Training Nonphysicians in Family Planning Services, &amp; a Directory of Training Programs (F, P, S)</td>
</tr>
<tr>
<td>J-7</td>
<td>Pregnancy Tests, The Current Status (F, P)</td>
</tr>
<tr>
<td>J-8</td>
<td>Effects of Childbearing on Maternal Health</td>
</tr>
<tr>
<td>J-9</td>
<td>Postcoital Contraception, An Appraisal</td>
</tr>
<tr>
<td>K-1</td>
<td>Injectable Progestogens—Officials Debate but Use Increases (S)</td>
</tr>
</tbody>
</table>

**INDEXES**

<table>
<thead>
<tr>
<th>Index</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index 1972-1973</td>
<td></td>
</tr>
<tr>
<td>Index 1974</td>
<td></td>
</tr>
</tbody>
</table>

All publications are available in English. Many are available in French, Spanish, and Portuguese as indicated directly after each title. Check preferred language: English ☐, French ☐, Spanish ☐, Portuguese ☐. Indicate number of copies desired, cut along dash and mail to:

Population Information Program  
Department of Medical and Public Affairs  
The George Washington University Medical Center  
2001 S Street, N.W., Washington, D.C. 20009 U.S.A.

Name ___________________________  
Organizational Affiliation ___________________________  
Address ___________________________  
City ___________________________  
Country ___________________________  

CHECK ONE ☐ Please add my name to the Population Reports mailing list.  
☐ I am already on the Population Reports mailing list.  
☐ I do not want to receive Population Reports regularly.