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Tubal surgery in the era of assisted reproductive technology: clinical options

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We reviewed the place of tubal surgery in the era of assisted reproductive technology. Reversal of tubal ligation is one of the main indications for tubal microsurgery. Adhesiolysis has the best results if the adhesion is the only factor responsible for infertility. There are no differences between adhesiolysis by laparoscopy or by laparotomy, and so laparoscopy must be preferred. Proximal tubal obstructions can be successfully treated by microsurgical tubocornual anastomosis. As far as distal tubal lesions are concerned, success rates depend strictly on the pre-existing tubal disease in distal tubal lesions and tubal surgery frequently fails; in-vitro fertilization (IVF) must therefore be considered in such circumstances. In conclusion, we think that IVF and tubal surgery must be considered to be complementary rather than competitive procedures. Adequate selection of patients is crucial to find the best therapeutic approach.

Key words: female/laparoscopic surgery/microsurgery/surgical therapy/tubal infertility

Introduction

Tubal factor is responsible for ~25% of female infertility (Sorensen 1980). The degree of tubal occlusion, the presence of endosalpingeal destruction and the presence and type of peritubal adhesions are the factors causing this type of female infertility (Boer-Meisel *et al.*, 1986; Donnez and Casanas-Roux, 1986b).

The results of tubal surgery using conventional techniques were traditionally rather poor (Hochuli, 1979). Improved results were obtained following the introduction of tubal microsurgery from the 1970s onwards (Diamond, 1979; Winston 1980a; Decherney and Kase, 1981). Louise Brown, the first baby conceived after in-vitro fertilization (IVF) was born in 1978, after which a new era opened in infertility practice (Edwards *et al.*, 1980), although in the meantime operative laparoscopy had been introduced to promote fertility; clinical use of operative laparoscopy was to increase in the 1980s (Gomel, 1975).

Following the introduction of IVF, tubal microsurgery was partly replaced by

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Table I. Adhesiolysis by microsurgery

Author	No. patients	Duration of follow-up	No. intrauterine preg.	No. ectopic preg.	No. term preg.
Diamond (1979)	140	>1 year	86 (61)	8 (6)	80 (57)
Hulka (1982)	23 filmy	6 months–4 years	9 (39)	0 (0)	8 (35)
	24 dense		5 (21)	1 (4)	4 (17)
Frantzen and Schlosser (1982)	49	>1 year	20 (41)	2 (4)	19 (39)
Kelly and Roberts (1983)	21	1 year	5 (24)	0 (0)	4 (19)
Donnez and Casanas-Roux (1986b)	42	28 months	NS[i]	1 (2)	27 (64)
Luber *et al.* (1986)	13	12–86 months	8 (62)	1 (8)	7 (54)
Jacobs *et al.* (1988)	15	3 years	7 (47)	0 (0)	6 (40)
Singhal *et al.* (1991)	78	50 months	32 (41)	4 (5)	29 (37)
Oelsner *et al.* (1994)	19 filmy	55 months	13 (68)	3 (16)	8 (42)
	32 dense	101 months	11 (34)	1 (3)	6 (19)

[i] NS: Not stated. Preg.= pregnancy.
Values in parentheses are percentages.

laparoscopic surgery. We have reviewed the place of tubal surgery either by microsurgical techniques or laparoscopy in the era of current assisted reproductive technologies.

Microsurgery

Adhesiolysis by microsurgery

Overall intrauterine pregnancy rates following adhesiolysis by microsurgery vary from 21 to 62% (Table I) (Diamond, 1979; Hulka, 1982; Luber *et al.*, 1986). Intrauterine pregnancy rates were 39 and 21% in patients with filmy and dense adhesions respectively (Hulka, 1982). Kelly and Roberts (1983) reported a 24% intrauterine pregnancy rate following adhesiolysis by microsurgery in a period of follow-up of 1 year. They found a mean time interval between microsurgery and pregnancy of 5.2 months.

Term pregnancy and ectopic pregnancy rates were reported (64 and 2% respectively) following adhesiolysis by microsurgery (Donnez and Casanas-Roux, 1986b).

In patients with filmy adhesions, the cumulative pregnancy rate after 24 months was 68% after microsurgical adhesiolysis (Oelsner *et al.*, 1994). This was clearly better than the rate reported by Tan *et al.* (1992, 51%) and by Guzick *et al.* (1986, 49%) after five IVF cycles. Adhesiolysis may therefore be the preferred treatment for patients with filmy adhesions. However, the delivery rate fell sharply to 19% in the presence of dense adhesions following microsurgical adhesiolysis (Oelsner *et al.*, 1994). For this reason, the patients with dense adhesions are best referred to IVF.

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Table II. Proximal tubal operations by microsurgery

Author	No. patients	Duration of follow-up	No. intrauterine preg.	No. ectopic preg.	No. term preg
McComb and Gomel (1980a)*	38	NS[i]	23 (61)	2 (5)	20 (53)
Winston (1980a)*	43	NS[i]	NS[i]	1 (2)	16 (37)
Frantzen and Schlosser (1982)*	28	>1year	12 (43)	2 (7)	12 (43)
Gomel (1983)*	48	>1 year	30 (63)	3 (6)	27 (56)
McComb (1986)*	26	6–29 months	15 (58)	3 (12)	14 (54)
Jacobs *et al.* (1988)*	17	3 years	11 (65)	1 (6)	8 (50)
Donnez and Casanas-Roux (1986a)*	82	NS[i]	NS[i]	6 (7)	36 (44)
Singhal *et al.* (1991)*	27	50 months	9 (33)	2 (8)	6 (22)
Rock *et al.* (1979)**	52	50 months	13 (25)	2 (4)	8 (15)
Singhal *et al.* (1991)**	9	50 months	2 (22)	0 (0)	1 (11)
Dubuisson *et al.* (1997)*	120	3 years	89 (74)	13 (11)	68 (57)

[i] NS: Not stated. *Tubocornual anastamosis, **tubouterine implantation. Values in parentheses are percentages.

Microsurgery in proximal tubal lesions

Following tubocornual anastomosis, term pregnancy and ectopic pregnancy rates were found to be 43 and 7% (Frantzen and Schlosser, 1982) and 56 and 6% (Gomel, 1983) (Table II). Intraoperative prognostic factors which negatively affect pregnancy rates after tubocornual anastamosis were the reduced residual length (Winston, 1980a; Donnez and Casanas-Roux, 1986a), the damaged intramural portion, the presence of chronic inflammation, the presence of tubal inclusion in the tubal wall and the presence of tubal endometriosis (Donnez and Casanas-Roux, 1986a).

The term pregnancy rate was 45% where the resected segment of the isthmus is less than 1 cm following tubocornual anastamosis (Winston, 1980a), but 22% when the resected segment of the isthmus was more than 1 cm (Winston, 1980a). Proximal tubal occlusion, and even the progressive abnormalities such as salpingitis isthmica nodosa can be successfully treated with tubocornual anastomosis alone (McComb, 1986).

Following tubocornual anastomosis, 15 out of 26 patients (58%) had an intrauterine pregnancy and three out of 26 (12%) had ectopic pregnancies with a mean conception time of 11 (± 9.33) months (McComb, 1986). McComb and Gomel (1980) reported a 53% term pregnancy rate. Jacobs *et al.* (1988) reported a 65% intrauterine pregnancy rate and 6% ectopic pregnancy rate in patients undergoing intramural-isthmic anastamosis; the follow-up period being 3 years.

Recently, 120 patients with proximal tubal occlusion were treated by tubocornual anastamosis; a 57% term pregnancy rate and a 11% ectopic pregnancy rate were reported at the end of 3 years following surgery (Dubuisson *et al.*, 1997). The average time between the operation and the occurrence of pregnancy was 10.1 months (Dubuisson *et al.*, 1997). Guzick *et al.* (1986) reported a 49.3%

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cumulative delivery rate following five cycles of IVF in patients with tubal infertility. Term delivery rates following tubocornual anastomosis by microsurgery were similar to that following five cycles of IVF (McComb and Gomel, 1980; Gomel, 1983; McComb, 1986; Jacobs *et al.*, 1988).

Attempts to treat cornual occlusion by tubouterine implantation have also been made. Term pregnancy rates were reported to be 15% and 11% following tubouterine implantation (Rock *et al.*, 1979; Singhal *et al.*, 1991) (Table II.). The success rate of tubouterine implantation is low and so tubouterine implantation has had to be replaced by tubocornual anastamosis.

Microsurgery in distal tubal lesions

There are two types of operations for the microsurgical treatment of distal tubal lesions, i.e. salpingostomy and fimbrioplasty. Salpingostomy has the lowest success rate among the tubal operations by microsurgery (Gomel and Swolin, 1980). Pregnancy rates following fimbrioplasty are better than those after salpingostomy (60 versus 31%) (Donnez and Casanas-Roux, 1986c).

Pregnancy outcome after distal tubal microsurgery has been related to several factors such as pre-existing tubal disease, the extent of adhesions, the presence of dense adhesions, ampullary dilatation, fimbrial ciliated cell percentages, tubal wall thickness and lack of normal rugal pattern on hysterosalpingography (Young *et al.*, 1970; Hulka *et al.*, 1978; Boer-Meisel *et al.*, 1986; Donnez and Casanas-Roux 1986b; Schlaff *et al.*, 1990).

In a prospective study three factors were found to be associated with almost complete pregnancy failure in patients with complete fimbrial occlusions (Boer-Meisel *et al.*, 1986). These were: (i) extensive adhesions, almost all small pelvic organs attached to each other, the pouch of Douglas obliterated, the ovaries almost completely encapsulated (odds ratio: 0.15); (ii) fixed and dense adhesions (odds ratio: 0.12); (iii) thick tubal wall (odds ratio: 0.10); pregnancy success was mainly related with the presence of normal endosalpinx (odds ratio: 3.45) and to the absence of adhesions (odds ratio: 2.35).

The authors classified the patients with complete distal fimbrial occlusions in two groups with good and poor prognoses. The patients who satisfied at least two of the following criteria: many adhesions, fixed adhesions, thick tubal wall and abnormal mucosal appearance of the endosalpinx, were accepted having a poor prognosis, whereas the patients who satisfied none of these criteria were expected to have a good prognosis. The term pregnancy rate following tubal surgery was significantly reduced in the poor prognosis group (3%) compared with the good prognosis group (59%). Microsurgery should therefore remain the first choice of treatment for the good prognosis group because of the excellent results as compared to IVF. Tan *et al.* (1992) and Pouly *et al.* (1995) reported 38 and 46% term pregnancy rates after five IVF cycles respectively.

In the salpingostomy group, pregnancy rates decrease and ectopic pregnancies increase as severity of the tubal lesions increases. Patients with mild disease (absent or small hydrosalpinx, no significant peritubal adhesions, the presence

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Table III. Salpingostomy by microsurgery

Author	No. patients	Duration of follow-up	No. intrauterine preg.	No. ectopic preg.	No. term preg
Swolin (1975)	33	8–13 years	13 (39)	8 (24)	12 (36)
Gomel (1978)	41	>1 year	12 (29)	5 (12)	11 (27)
DeCherney and Kase (1981)	54	>2 years	20 (37)	4 (7)	14 (26)
Mage and Bruhat (1983)	68	>18 months	19 (28)	6 (9)	14 (21)
Tulandi and Vilos (1985)	67	2 years	15 (22)	3 (4)	NS[i]
Russel *et al.* (1986)	68	6 years	28 (42)	12 (18)	28 (42)
Jacobs *et al.* (1988)	71	3 years	29 (41)	8 (11)	23 (32)
Donnez and Casanas-Roux (1986b)	83	42 months	NS[i]	6 (7)	26 (31)
Luber *et al.* (1986)	17	12–86 months	2 (12)	2 (12)	2 (12)
Schlaff *et al.*(1990)	95	4 years	19 (20)	7 (7)	NS[i]
Winston and Margara (1991)	323	1–10 years	106 (33)	32 (10)	72 (23)
Singhal *et al.* (1991)	97	50 months	33 (34)	6 (6)	28 (29)
Audebert *et al.* (1991)	135	2 years	38 (28)	16 (12)	NS[i]

[i] NS: Not stated. Preg. = pregnancies. Values in parentheses are percentages.

of normal rugal pattern on hysterosalpingography) had a conception rate of 80%, whereas patients with severe disease (large hydrosalpinx, common and dense adhesions or frozen pelvis) had a conception rate of only 16% following neosalpingostomy (Schlaff *et al.*, 1990). Luber *et al.* (1986) reported identical rates of intrauterine (12%) and ectopic pregnancies (12%) in the salpingostomy group (Table III). Winston and Margara (1991) reported a sharp decrease in pregnancy rate following microsurgical salpingostomy in the presence of a thick-walled hydrosalpinx with marked mucosal damage. However the overall take-home-baby rate of 23% (Winston and Margara, 1991) was comparable with that for patients with tubal factor after three cycles of IVF (26.6%) (Tan *et al.*, 1992). They suggested that salpingostomy still has a place, particularly for young women and for those with limited tubal damage (Winston and Margara, 1991). On the other hand, severe cases are candidates for IVF.

Tubal epithelium repairs itself following surgery. After salpingostomy, therefore, acceptable cumulative pregnancy rates can be achieved only by the end of 2 years (Gomel and Swolin 1980). Russell *et al.* (1986) reported a 28% intrauterine pregnancy rate 2 years after surgery. When the time of follow-up was extended to 6 years, the intrauterine pregnancy rate increased to 42%. This increase in pregnancy rate may reflect the potential of the Fallopian tube for ciliogenesis and intrinsic repair. However, waiting for a period of more than 2 years after surgery is not a rational approach in the era of assisted reproductive technology.

DeCherney and Kase (1981) reported a 37% intrauterine pregnancy rate, and Mage and Bruhat (1983) reported a 28% intrauterine pregnancy rate following salpingostomy by microsurgery. Swolin (1975) reported a 39% intrauterine pregnancy rate and a 24% ectopic pregnancy rate following salpingostomy by laparotomy after a long follow-up period of more than 8 years. Tulandi and Vilos

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Table IV. Fimbrioplasty by microsurgery

Author	No. patients	Duration of follow-up	No. intrauterine preg.	No. ectopic preg.	No. term preg
Patton (1982)	35	2 years	21 (60)	1 (3)	NS
Jacobs *et al.* (1988)	29	3 years	20 (69)	2 (7)	17 (59)
Donnez and Casanas-Roux (1986b)	132	36 months	NS[i]	2 (2)	79 (60)
Luber *et al.* (1986)	20	12–86 months	6 (30)	3 (15)	3 (15)
Audibert *et al.* (1991)	76	2 years	27 (36)	5 (7)	NS[i]

[i] NS: Not stated. Preg. = pregnancies. Values in parentheses are percentages.

(1985) reported a 22% intrauterine pregnancy rate and a 4% ectopic pregnany rate in patients with bilateral hydrosalpinx following salpingostomy by microsurgery after a period of 2 years follow-up.

In 1982 Patton reported a 60% intrauterine pregnancy rate and a 3% ectopic one following fimbrioplasty by microsurgery (Table IV). It is of interest that 44% of the patients achieving a pregnancy did so within 3 months of surgery (Patton, 1982). Donnez and Casanas-Roux (1986b) reported a 60% term pregnancy rate and Jacobs *et al.* (1988) a 59% one following fimbrioplasty by microsurgery.

Term pregnancy rates were higher and ectopic pregnancy rates lower in patients undergoing fimbrioplasty by microsurgery than in patients undergoing salpingostomy by microsurgery (Tables III and IV). The time interval between surgery and the occurrence of pregnancy was shorter in fimbrioplasty than salpingostomy (Patton, 1982). Pouly *et al.* (1995) reported a cumulative delivery rate of 41% following three IVF cycles in patients with tubal infertility. This was lower than the term pregnancy rates reported by Jacobs *et al.* (1988, 59%) and by Donnez and Casanas-Roux (1986c, 60%) following fimbrioplasty by microsurgery (Table IV).

Reversal of tubal ligation by microsurgery

Gomel (1980b) reported a 64% intrauterine pregnancy rate and 1% ectopic one following the reversal of tubal ligation by microsurgery (Table V). When he resurveyed some of the data published previously, the intrauterine pregnancy rate went as high as 80.8% after a follow-up period of more than 18 months. Most of the patients had been sterilized according to Pomeroy's method (Goud, 1980b). The mean time interval between the operation and the occurrence of pregnancy was 10.2 months.

The type of sterilization may affect pregnancy rates in reversal of tubal ligation. The probability of pregnancy achieved after the reversal of sterilization by Falope ring or clips was higher than that achieved after reversal following sterilization by cautery or by the Pomeroy technique (Rock *et al.*, 1987; Trimbos-Kemper, 1990).

Intra-operatively there have been two main factors associated with a reduced pregnancy rate: firstly the smaller tubal length and secondly the necessity of

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Table V. Reversal of tubal ligation by microsurgery

Author	No. patients	Tubal ligation techniques	Type of anastamosis	Duration of follow-up	No. intrauterine preg.	No. ectopic preg.	No. term Preg.
Winston (1977)	16	Partial resection, diathermy	Tubocornual	NS [i]	11 (69)	1 (6)	NS
Gomel (1980b)	118	Mostly Pomeroy	Tubotubal	Up to 40 months	76 (64)	1 (1)	69 (58)
Silber and Cohen (1980)	25	Mostly coagulation	Tubocornual (*n*:14) Tubotubal (*n*:11)	>1 year	14 (56)	1 (4)	NS
Winston (1980b)	62	NS [i]	Tubotubal	NS [i]	37 (60)	2 (3)	NS
	43	NS [i]	Tubocornual		26 (60)	1 (2)	
Rock *et al.* (1987)	22	Falope ring	Tubotubal	40 months	20 (91)	2 (9)	19 (86)
	58	Unipolar cautery	Tubotubal	40 months	38 (66)	8 (14)	30 (52)
Trimbos-Kemper (1990)	45	Coagulation	NS [i]	12–29 months	15 (33)	3 (7)	26 (33)*
	9	Pomeroy			5 (56)	0 (0)	
	24	Rings and clips			15 (63)	0 (0)	

[i] NS: Not stated. * Term pregnancy rate for the whole group was given Preg. = pregnancies. Values in parentheses are percentages.

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Table VI. Adhesiolysis by laparoscopy

Author	No. patients	Duration of follow-up	No. intrauterine preg.	No.ectopic preg.	No. term preg
Bruhat *et al.* (1983)	66 moderate 27 severe	>18 months	36 (55) 12 (44)	5 (8) 2 (7)	NS [i]
Fayez (1983)	49	2 years	28 (57)	2 (4)	23 (47)
Donnez (1987)	32 (avascular) 22 (vascular)	18 months	NS [i]	NS [i]	20 (62) 11 (50)
Gomel (1989)	92	>9 months	57 (62)	5 (5)	54 (59)

[i] NS: Not stated. Preg. = pregnancies. Values in parentheses are percentages.

ampullary-isthmic instead of isthmo-isthmic anastamosis (Silber and Cohen, 1980; Winston, 1980b; Rock *et al.,* 1987). There was no significant difference in the pregnancy rate between patients undergoing ampullary-isthmic anastomosis and patients undergoing ampullary cornual anastamosis (Silber and Cohen, 1980). Gomel and Swolin (1980) reported an inverse relationship between total length of reconstructed oviduct and the interval between the surgery and the occurrence of pregnancy. Total tubal length and not ampullar length is the critical factor in success following reversal of tubal ligation by microsurgery, so long as there is at least 1 cm of ampulla (Silber and Cohen, 1980). A normal pregnancy occurred in every case if the total tubal length was ⩾5 cm. The pregnancy rate decreased by 50% if the length was 3–4 cm and no patient became pregnant if they had ⩽3 cm of tube (Silber and Cohen, 1980). Tubocornual anastamosis may be required in cases where a tubal ligation by diathermy and partial excision has been performed. Winston reported 60 to 69% intrauterine pregnancy rates following reversal of tubal ligation by tubocornual anastamosis (Winston, 1977, 1980b).

Trimpos-Kemper (1990) reported an overall intrauterine pregnancy rate of 45% following the reversal of sterilization in women >40 years of age. She also reported that the mean interval between the operation and the onset of pregnancy was 5.5 months (Trimpos-Kemper, 1990). The probability of conception was 10% after three cycles of IVF for women >40 years of age (Tan *et al.*, 1992). Thereafter, the probability of conception decreased sharply to 0% after three cycles of IVF (Tan *et al.*, 1992). We therefore think that the reversal of tubal ligation by microsurgery is an acceptable treatment of choice for older women who have been previously sterilized, if they have failed to become pregnant following three cycles of IVF.

Laparoscopy

Adhesiolysis by laparoscopy

Excellent results have been reported after laparoscopic adhesiolysis (Bruhat *et al.*, 1983) (Table VI). High intrauterine pregnancy rates (57%) and reduced ectopic

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Table VII. Distal tubal surgery by laparoscopy

Author	No. patients	Type of operation	Duration of follow-up	No. intrauterine preg.	No. ectopic preg.	No. term preg.
Fayez (1983)	14	fimbrioplasty	2 years	3 (21)	2 (14)	3 (21)
	19	salpingoneostomy	2 years	0 (0)	2 (11)	0 (0)
Daniell and Herbert (1984)	21	salpingostomy	18 months	4 (19)	1 (5)	2 (10)
Dubuisson *et al.* (1990)	31	fimbrioplasty	18 months	8 (26)	3 (10)	(23)*
	34	salpingoneostomy	18 months	10 (29)	1 (3)	
Canis *et al.* (1991)	87	fimbrioplasty salpingostomy	3 years	29 (33)	6 (7)	NS [i]
Audebert *et al.* (1991)	24	fimbrioplasty	2 years	4 (17)	1 (4)	NS[i]
	31	salpingostomy		4 (13)	2 (6)	
Mc Comb and Paleologou (1991)	22	salpingostomy	>1 year	NS[i]	1 (5)	5 (23)
Dubuisson *et al.* (1994)	81	salpingostomy	3–60 months	26 (32)	4 (5)	26 (32)
Audebert *et al.* (1998)	35	fimbrioplasty	2–5 years	18 (51)	8 (23)	13 (37)

[i] NS: Not stated. *Overall term pregnancy rate was given for the total group including both fimbrioplasty and salpingoneostomy groups. Preg. = pregnancies. Values in parentheses are percentages.

pregnancy rates (6%) were reported in cases of complete removal of adhesions, where a good anatomical relationship existed between tube and ovary, and in the absence of peritoneal damage to serosa following laparoscopic adhesiolysis. On the other hand, intrauterine pregnancy rates fell to 17% and ectopic pregnancy rates rose to 17% if one of the preceding criteria was not fulfilled.

Pregnancy rates of 62 and 57% have been demonstrated following adhesiolysis by laparoscopy (Donnez, 1987; Gomel, 1989). Almost half (46%) the intrauterine pregnancies occurred within 6 months after the operation (Gomel, 1989). A 57% intrauterine pregnancy rate was reported after adhesiolysis by laparoscopy (Fayez, 1983). High pregnancy rates after adhesiolysis are obtained if the adhesions are the only possible cause of infertility.

Results of adhesiolysis by laparoscopy are comparable with those obtained by microsurgery (Gomel, 1989). However, lysis of dense adhesions is occasionally difficult by laparoscopy, especially if these are localized between fimbriae and ovaries. Laparotomy by microsurgery may occasionally be useful to lyse such adhesions.

Laparoscopy for distal tubal lesions

Daniell and Herbert (1984) reported a 19% intrauterine pregnancy rate and a 5% ectopic pregnancy rate following laparoscopic salpingostomy in selected cases (Table VII); Canis *et al.* (1991) obtained a 33% intrauterine pregnancy rate and

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a 7% ectopic pregnancy rate following laparoscopic distal tuboplasty in 87 women (Table VII). 86.7% of intrauterine pregnancies occurred within one year of the operation. However, most of the patients were classified as minimal (36.8%) and mild (42.5%) cases and the mean duration of infertility was short (33 ± 25.9 months). Conception rate was 35% in fimbrioplasty and 10% in a period of more than 1 year after the operation (Fayez, 1983). A waiting interval of 2 years may therefore be required before pregnancies occur after surgery.

The advantages of laparoscopy are minimal physical stress, shorter hospitalization and recovery time, reduced cost, reduction of postoperative adhesion formation and absence of abdominal scars.

A 23% pregnancy rate and a 5% ectopic pregnancy rate were reported by McComb and Paleologou (1991) in 22 women following salpingostomy by laparoscopy. Success rates were frequently better in fimbrioplasty than in salpingostomy by laparoscopy (Fayez, 1983; Daniell and Herbert, 1984; Audebert *et al.*, 1998). However, Dubuisson *et al.* (1990) found comparable results in the two groups. Audebert *et al.* (1991) reported a 13% intrauterine pregnancy rate following salpingostomy by laparoscopy and 28% following salpingostomy by microsurgery. The relatively low intrauterine pregnancy rates may be attributed to a short follow-up period, i.e. 2 years after microsurgery and 2 years after laparoscopy. However, in reviewing the literature it has been shown that pregnancy rates achieved by microsurgery are comparable to or slightly better (Gomel 1980a; Russell *et al.*, 1986; Donnez and Casanas-Roux, 1986b; Jacobs *et al.*, 1988; Dubuisson *et al.*, 1990; Mc Comb and Paleologou, 1991; Winston and Margara, 1991) than those following laparoscopic surgery in patients with distal tubal pathologies. So far, no prospective randomized study has been conducted to compare the results of laparoscopies with those of laparotomies in the treatment of distal tubal pathologies.

Success rates of laparoscopic surgery for the treatment of distal tubal lesions are directly related to the severity of pre-existing tubal disease (Dubuisson *et al.*, 1994). Intrauterine pregnancy rates decrease concomitantly with the severity of the tubal damage. Following salpingostomy by laparoscopy, intrauterine pregnancy rates of 44% (26 out of 59) have been reported in patients demonstrating normal tubal mucosa or a moderate attenuation of mucosal folds (Dubuisson *et al.*, 1994). On the other hand, no pregnancy ensued in patients with no folds or with honeycomb appearance (0 out of 22) (Dubuisson *et al.*, 1994). Recently Audebert *et al.*, (1998) treated 35 cases by laparoscopic fimbrioplasty. Thirteen of these delivered a healthy baby although eight had ectopic pregnancies. The high ectopic pregnancy rates (23%) may be attributed to the presence of severe tubal lesions.

The effect of hydrosalpinx on IVF outcome

In a large series of 3275 female patients (including 1662 with tubal factor infertility), no significant differences were reported between patients with diseased

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Fallopian tubes and patients with other causes of infertility in terms of the major indicators of successful outcome of IVF (i.e. number of gestational sacs identified by ultrasound per number of embryos transferred, miscarriage rate, ectopic pregnancy rate or delivery rate per cycle with transfer) (Oehninger and Muasher, 1995). However, the negative effect of hydrosalpinx on the outcome has been suggested by several authors (Akman *et al.*, 1996; Katz *et al.*, 1996; Shelton *et al.*, 1996; Sowter *et al.*, 1997; Freeman *et al.*, 1998; Murray *et al.*, 1998).

The main mechanisms by which the presence of a hydrosalpinx may exert a negative effect on IVF outcome are considered to be, flushing the embryos into a damaged Fallopian tube at the time of embryo transfer and leakage of hydrosalpinx liquid into the uterine cavity. Hydrosalpinx fluid has a toxic effect on mouse embryos (Mukherjee *et al.*, 1996; Rawe *et al.*, 1997; Sachdev *et al.*, 1997). Leakage of hydrosalpinx fluid into the uterus may therefore render the intra-uterine environment toxic to the embryo *in vivo*. Endometrial damage occurring simultaneously with acute-phase tubal damage may be responsible for the alteration of uterine receptivity (Strandell *et al.*, 1994). It has been suggested that adrenergic denervation and the subsequent disturbance of ovum myosalpingeal transport might explain the poor pregnancy rate in cases with hydrosalpinx (Donnez *et al.*, 1986). The adverse effects of hydrosalpinx in natural cycles after the replacement of cryopreserved-thawed embryos have been demonstrated retrospectively (Katz *et al.*, 1996; Sowter *et al.*, 1997; Freeman *et al.*, 1998; Murray *et al.*, 1998).

However, human cytotrophoblasts obtained from third trimester placentae have been cultured *in vitro* with hydrosalpinx fluid and no deleterious effect from hydrosalpinx fluid was found on human trophoblast viability *in vitro* (Sawin *et al.*, 1997). The fluid of hydrosalpinx may therefore not be directly toxic to all human embryos. Some authors did not confirm a negative effect of hydrosalpinx on IVF outcome when an antibiotic regimen (doxycycline 100 mg twice daily for 10 days) was given prior to assisted reproductive treatment (Sharara *et al.*, 1996). The presence of a hydrosalpinx may have an adverse effect on uterine receptivity. The epithelial endometrial $\alpha v\beta 3$ integrin levels, as a marker of endometrial receptivity, were found to be significantly reduced in concentration in patients with hydrosalpinx as compared to controls (Meyer *et al.*, 1997). Following surgical correction of the hydrosalpinx, $\alpha v\beta 3$ expression increased in 70% of women who had previously had low concentrations.

Whether prophylactic salpingectomy may improve pregnancy rate in IVF cycles is still an unanswered question. Puttemans and Brosens (1996) did not propose routine salpingectomy in cases of hydrosalpinx. They suggested that salpingoscopy must first be done to decide whether or not to remove the salpinx. Salpingectomy must be performed only in the presence of severe clinical pathology of the ampullary mucosa or of a sign of chronic inflammation such as increased thickness of the wall.

Shelton *et al.* (1996) showed that excision of the hydrosalpinx improves the pregnancy rate in patients with repeated IVF failures. They advise that

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salpingectomy is performed for patients with hydrosalpinx before IVF. The study was prospective but not randomized and the number of cases was limited to 10.

It has been shown retrospectively that bilateral salpingectomy does not compromise ovarian stimulation or pregnancy rates as compared to healthy Fallopian tubes in an IVF cycle (Verhulst *et al.*, 1994). Freeman *et al.* (1998) and Murray *et al.* (1998) also demonstrated retrospectively that patients with surgically corrected hydrosalpinx had better results in IVF. The abortion rate was as high as 46.7% in patients undergoing IVF with hydrosalpinx (Healy *et al.*, 1995), but fell by 20% in IVF cycles when the hydrosalpinx was surgically removed (Healy *et al.*, 1995). The hydrosalpinx probably has a negative effect on IVF outcome. However, no prospective comparative studies have been published so far to demonstrate that salpingectomy improves IVF outcome in patients with hydrosalpinx.

Microsurgery versus IVF

Clinical comparison

Cumulative delivery rates comparing IVF to tubal surgery are not available. Furthermore, it is difficult to compare IVF with surgery since the probability of an IVF pregnancy is limited by the number of cycles performed. The overall delivery rate per ovum retrieval was 20.3% in patients with tubal infertility undergoing IVF (Pouly *et al.*, 1995). The term delivery rates achieved by microsurgery after 24 months has been reported to be between 47 and 64% (Fayez, 1983; Donnez and Casanas-Roux, 1986b; Jacobs *et al.*, 1988; Dubuisson *et al.*, 1997). The birth rate per embryo replaced at IVF (12–16%) is still lower than that of the natural cycle (25%), despite the major advances in fertilization rates (Cohen *et al.*, 1990). Tubal surgery must therefore be considered if the tubal factor is the sole cause of infertility. On the other hand, IVF should be considered in the presence of combined infertility factors (male factor, severe endometriosis, etc.).

One of the most important factors to affect IVF outcome is maternal age. The cumulative delivery rate in IVF decreases sharply in women >35 years (Tan *et al.*, 1992; Pouly *et al.*, 1995). The rate reaches 41% at the end of the fourth cycle of IVF and remains steady thereafter in patients aged 35–39 years (Pouly *et al.*, 1995). So far as the women >39 years are concerned, the cumulative delivery rate reaches a plateau of 16.7% following the second cycle of IVF (Pouly *et al.*, 1995). A waiting period of 1–2 years is needed in order to achieve a pregnancy following any type of tubal surgery. IVF may therefore be considered the first therapeutic option for patients >35 years of age (Winston, 1992). Surgery may be considered if IVF fails to achieve a pregnancy in such patients. An excellent success rate might be obtained by the reversal of tubal ligation in women even older than 40 years (Trimbos-Kemper, 1990). In fact, microsurgical reversal of sterilization yields excellent success rates if the tubes have previously

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been sterilized by Fallopian rings or clips. Patients previously sterilized by partial resection of the tube will have a worse prognosis following tubal surgery. If a fimbriectomy has been performed, the outcome of reproductive surgery is frequently poor and IVF should be considered for such patients (Gomel and Taylor, 1992).

Duration of infertility may affect both IVF and tubal microsurgery outcomes (Singhal *et al.*, 1991; Pouly *et al.*, 1995). The cumulative delivery rate following three cycles of IVF was 46.8% in the group whose infertility had lasted <5 years, while the rate was 37.2% in the group whose infertility had lasted >7 years (Pouly *et al.*, 1995). Women with long-standing infertility were less likely to conceive after tubal surgery (Singhal *et al.*, 1991; Dubuisson *et al.*, 1997).

Microsurgery may first be considered for patients with proximal tubal obstruction. Tubocornual anastomosis yields a take-home-baby rate of between 37 and 56% (McComb and Gomel, 1980a; Winston, 1980a; Gomel, 1983). Filmy adhesions can be treated successfully with tubal surgery either by laparoscopic surgery or microsurgery. On the other hand, dense adhesions are best treated by IVF (Oelsner *et al.*, 1994). As far as distal tubal pathologies are concerned, the success rates are strongly related to previous tubal damage and tubal surgery should be attempted only in patients with distal stenosis, which can be treated easily by fimbrioplasty, and sometimes in patients with fine wall hydrosalpinx with preserved mucosal folds (Boer-Meisel *et al.*, 1986). IVF must be considered for all other patients with distal tubal pathologies. Tubal surgery is contraindicated for patients with irreparable tubal damage and genital tuberculosis (Gomel and Taylor, 1992; Winston, 1992). Most of the patients conceive within 2 years after the tubal surgery (Singhal *et al.*, 1991). If a pregnancy does not ensue in the 2 years following any type of surgery, IVF must be attempted. Tubal surgery for bipolar tubal disease frequently yields a poor outcome (McComb *et al.*; 1991; Singhal *et al.*, 1991) and IVF should be considered as the primary therapeutic approach in patients with bipolar tubal disease (Gomel and Taylor, 1992). IVF must be attempted for patients with frozen pelvis and patients who have already had two ectopic pregnancies.

IVF is a palliative technique which does not eliminate the problem whereas tubal surgery is curative. Considering the high discontinuation rate after three cycles of IVF (Pouly *et al.*, 1995), the curative characteristic of tubal surgery seems to be obviously advantageous. More than one pregnancy may ensue after microsurgery (Swolin, 1975; Gomel, 1980a,b; Luber *et al.*, 1986). A previous pelvic surgical procedure has no effect on the response to ovarian stimulation, fertilization or pregnancy rates (Oehninger *et al.*, 1989)

Microsurgery requires experienced surgeons and specific instruments. On the other hand, complications such as thromboembolism, haemorrhage and increased frequency of ectopic pregnancy are a disadvantage of tubal surgery. The risks of tubal surgery are related to anaesthesia and to the surgery itself. IVF is an outpatient procedure. The risk of ovarian hyperstimulation syndrome and of multiple pregnancies, the need for frequent blood analysis and laboratory conditions and the suspicion of a relationship between ovarian cancer and fertility

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drugs are disadvantages of IVF. However, no prospective randomized study has been conducted to compare the results of tubal surgery with those of IVF as treatment for infertility resulting from tubal disease.

Financial comparison

Performing a cost-analysis comparison for IVF and tubal microsurgery is difficult. The costs of IVF and of tubal microsurgery fluctuate in different countries according to accepted rates and the presence or absence of insurance cover.

The cost of tubal surgery has been reported to be US$3000 in the UK (Effective Health Care, 1992), US$3500 in the Netherlands (Haan, 1991), US$4000 in Norway (Holst *et al.*, 1991) and US$8000–10,000 in the USA (Oehninger and Muasher, 1995).

The cost of a cycle of IVF has been found to be US$1500 in Norway (Holst *et al.*, 1991), US$1600 in the Netherlands (Haan, 1991) and US$7000–11,000 in the USA (Neumann *et al.*, 1994; Oehninger and Muasher, 1995).

As far as calculated costs per live birth are concerned, an estimated cost of having a baby after tubal microsurgery has been found to be US$17000 in Norway (Holst *et al.*, 1991) and US$50000 in the USA (Collins, 1994). The cost of having a baby after IVF has been found to be US$12000 in Norway (Holst *et al.*, 1991), US$12000–16000 in the Netherlands (Haan, 1991) and US$66000 in the USA (Neumann *et al.*, 1994).

Conclusion

IVF and tubal surgery must be considered complementary rather than competitive procedures. Adequate selection of patients is the key to finding the best therapeutic approach.

Reversal of tubal ligation is one of the main indications for tubal microsurgery. Adhesiolysis has the best results if the adhesion is the only factor responsible for the infertility. There are no differences between adhesiolysis by laparoscopy or by laparotomy and so laparoscopy must be preferred. Proximal tubal obstructions can be treated successfully by tubocornual anastomosis by microsurgery. As far as the distal tubal lesions are concerned, success rates depend strictly on the pre-existing tubal disease in distal tubal lesions and tubal surgery frequently fails. IVF must therefore be considered in such circumstances. There is a total lack of prospective randomized studies with regard to this question.

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