Reconstructive Surgery in Distal Tubal Disease

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Tubal factor infertility is one of the most frequent causes of female infertility. Despite the rising usage of artificial reproductive technologies, surgery remains an important therapy option among this group of patients. However, the effectiveness of tubal reconstructive surgery against another treatment approaches has not been appropriately evaluated. There are no randomized controlled trials that compare surgery versus IVF or expectant management. Clinical practice is guided on the basis of observational studies. Researchers use different classifications and inclusion criteria. Surgical techniques are not uniform. As a result, published data differ substantially and interpreting of outcomes is consequently made more difficult.

Keywords: tubal disease ; peritubal adhesions ; hydrosalpinx ; tubal infertility ; reproductive surgery

1. Etiopathogenesis and Morphology of Distal Tubal Disease

Tubal factor infertility is responsible for 25–40% of female infertility [1][2][3][4]. Damage can involve the proximal, distal, or entire tube [5]. Most frequently, tubal disease occurs in the distal segment (about 80%) manifesting as hydrosalpinx, while in 10–25% it affects the proximal section of the fallopian tube [6]. Gebeh and Metvally divide fallopian tube disease with subsequent obstruction into three groups: proximal, mid-segment, and distal segment blockage [1]. Proximal tubal obstruction can be caused by amorphous debris and mucus plugs, pelvic inflammatory disease, salpingitis isthmica nodosa, endometriosis, obliterative intraluminal fibrosis, uterine synechiae, fibroids, or polyps situated over the tubal ostium. Mid-segment tubal blockage is usually connected to previous surgery, tubal sterilization, partial salpingectomy for ectopic pregnancy, or may be a congenital segmental absence. Reasons for distal segment obstruction include pelvic inflammatory disease, endometriosis, and post-surgical adhesions [1].

The most common cause of tubal damage is pelvic inflammatory disease, responsible for more than 50% of cases [3]. PID usually results from prior sexually transmitted disease due to *Chlamydia trachomatis* or *Neisseria gonorrhoeae* [7]. Polymicrobial infection occurs in 30–40% of cases [8]. Inflammation leads to the destruction of ciliated cells of the tubal endothelium, especially in the ampullary and infundibular sections. These specialized cells are crucial for the transport of both gametes and embryo, and often are unable to recover even after resolution of the infection. Loss of ciliated endothelial cells and post-inflammatory fibrosis of the wall impair the physiologic function of the salpinges while intraluminal and peritubal adhesions can cause occlusion of the fimbrial end. Unable to drain, the fallopian tube accumulates fluid and distends. Despite clinically successful treatment of the infection, the risk of persistent tubal damage varies between 8 and 12%. A second episode of PID increases this risk twofold, and a third episode up to 54% [1].

Endometrial lesions involve the salpinges in 6% of women with endometriosis and endometriosis-related adhesions affect the fallopian tubes in up to 26% of cases [9]. Based on the location of implants, tubal endometriosis is divided into serosal/subserosal and intraluminal [10]. In the first case, endometriotic implants are seen on the peritoneal surface of the salpinges. Cyclic local hemorrhages in the implants cause fibrosis and scarring of the tubes. In the less common intraluminal endometriosis, ectopic lesions occur on the mucosal surface of the tube wall. Repeated hemorrhages of the implants can lead to distention of the salpinx.

Regardless of the reason, hydrosalpinx is usually asymptomatic; however, some patients may present with lower abdomen pain [8]. Most frequently, it is detected accidentally or during work-up for infertility. In 10–13%, hydrosalpinges are diagnosed during ultrasound examination [11][12]. Equally, up to 30% of cases are discovered during hysterosalpingography (seen as dilated contrast-filled tube, with absence of free spillage), laparoscopy, and laparotomy [13][14][15]. Incidentally, hydrosalpinx can also be seen in a CT scan, as a fluid-attenuation tubular juxtauterine structure, separate from the ovaries [8].

The typical US image of hydrosalpinx is a complex, C- or S-shaped anechoic tubular structure, with a thin or thick wall [8]. It reveals incomplete septa that result from the distended tube folding. The pathognomonic features for hydrosalpinx are

thickened longitudinal folds producing a “cogwheel” appearance [16]. Hydrosalpinx is usually well separated and distinct from both ovary and uterus [8].

In cases in which adnexal mass cannot be sufficiently evaluated with US, MR imaging remains the method of choice. On MR images, a dilated fallopian tube is seen as a fluid signal intensity tubular structure (i.e., hypointensity on T1-weighted and hyperintensity on T1-weighted images) with incomplete septa [8].

2. Operative Techniques in Reconstructive Distal Tubal Surgery

The principal goal of surgical treatment is to restore the normal anatomy of the tubes and their functional integrity. The main surgical procedures include adhesiolysis (salpingo-ovariolysis), fimbrioplasty, and neosalpingotomy.

Periadnexal adhesions interfere with the anatomic relationship between the fimbrial end of the tube and surface of the ovary and impair the act of oocyte capture. Adhesiolysis aims at the operative removal of scar tissue from around both the ovary and the salpinx and restoration of the normal anatomy.

Fimbrioplasty is applied in case of fimbrial stenosis. Its goal is to open or widen the distal end of the tube. It may involve deglutination of the fringes, dilatation of the external ostium and/or adhesiolysis for fimbrial adhesions. If necessary, the fimbrial end should be everted and ligated to the distal tubal serosa to minimize the risk of reocclusion.

Neosalpingotomy is the most advanced procedure of tubal reconstructive surgery and means the creation of a new tubal opening. First, the ampullary portion of the fallopian tube is distended by intrauterine administration of the contrast medium and the occluded ostium is identified. Then, the fallopian tube is opened in the avascular area by three to four incisions with scissors, or alternatively by electrosurgery or laser [6][17]. After a new opening is formed, the edges of the distal tube are everted and sutured using 3.0–6.0 suture to the proximal serosa of the salpinx circumferentially. Preferred are nonabsorbable monofilament sutures, as they may be less likely to elicit an inflammatory response with subsequent secondary adhesions. Eversion of the edges may also be achieved by superficial coagulation of the serosal surface of the fallopian tube using bipolar or laser energy; however, this method seems to be less effective and connected with a higher risk of reocclusion [6][18][19].

Initially, the reconstructive tubal surgery was carried out microsurgically by laparotomy [20][21][22][23]. Currently, it is reckoned that both fimbrioplasty and neosalpingostomy should be performed via laparoscopy because of comparable efficacy and lower risk of adverse events [24][25][26]. A meta-analysis of five nonrandomized controlled trials revealed a pooled intrauterine pregnancy rate of 28.9% in patients who underwent laparoscopic operation and 30.9% in women after open procedure. The difference was not statistically significant. The intrauterine pregnancy rates in mild hydrosalpinx subgroup after laparoscopic and laparotomic repair were 39.5% and 32.8%, respectively. Additionally, those results did not differ significantly [27].

Regardless of the operative technique, the crucial element of each reproductive surgery is the prevention of secondary adhesions. Numerous studies demonstrated reduced de novo adhesion formation after laparoscopic procedures compared to laparotomy [28][29][30][31][32][33][34][35]. Traditionally, this was explained by avoiding tissue desiccation as a cause of inflammatory reaction with subsequent adhesion formation and minimalization of mechanical serosal damage, which is a prerequisite for adhesion development [1]. Multiple reports from recent years have shown that oxidative stress, metabolic state, hypoxia, as well as genetic factors may play an important role in the postoperative adhesion formation [36][37]. The current understanding of the pathogenesis of pelvic adhesions is reflected in devising agents for postoperative adhesion prevention. Approval of the U.S. FDA for the reduction in postoperative adhesions received oxidized regenerated cellulose, 4% icodextrin solution, modified hyaluronic acid, and carboxymethylcellulose [38]. The application of an adhesion barrier should be considered, especially for patients with endometriosis or pelvic inflammatory disease as being at high risk of forming clinically significant adhesions [39]. Another preventive strategy is the separation of the structures during the 3–5-day healing process, considered as critical for adhesion development [38]. In reproductive surgery, this means temporary ovarian suspension to keep them separate from the pelvic side wall peritoneum or other pelvic organs. Although some reports demonstrate the effectiveness of this procedure in reduction in the rate and severity of postoperative adhesions, this still requires further investigations [38][40][41][42].

3. Reproductive Outcomes

Pregnancy rates after reconstructive distal tubal surgery strictly depend on the severity of tubal disease. Patients with periadnexal adhesions and patent tubes have the most favorable prognosis. Numerous studies indicate that about 80% of

women with periadnexal adhesions have normal endosalpinx. Within 1 year after laparoscopic adhesiolysis, about 70% of these women will be pregnant and have a term delivery [43][44][45][46]. According to another report, spontaneous intrauterine pregnancy within 2 years after adhesiolysis for mild adhesions is 72.09%, while in the case of moderate and severe adhesions it is 51.95% and 27.91%, respectively [47].

Fimbrioplasty, another reconstructive technique, offers high success rates. In a large case series of 273 patients, Tran reports 79.8% pregnancy rate and 71.5% live-birth rate after this procedure [48].

Reproductive outcomes after neosalpingostomy markedly differ depending on the extent of tubal damage. Meta-analysis of 22 observational studies from 1972 to 2014, including 2810 patients who underwent salpingoneostomy for hydrosalpinx, revealed a pooled natural clinical pregnancy rate of 27% with a pooled live-birth rate of 25% [49]. Surprisingly, the clinical pregnancy rate in women with bilateral salpingoneostomy was 29%. It is worth emphasizing that the cited meta-analysis did not investigate the correlation between the pregnancy rate and severity of tubal disease which is essential for an objective interpretation of the results. Reproductive outcomes after neosalpingectomy are much more favorable in good-prognosis cases. As good prognosis is considered a patient with limited filmy periadnexal adhesions, only mildly dilated salpinges (<3 cm) with thin pliable wall, and a lush, normally folded mucosa [50]. Intrauterine pregnancy rates after salpingostomy for mild hydrosalpinx range from 58% to 77% [51]. Winston et al. reported a live-birth rate of 39% in women after salpingostomy for tubal disease stage I, and only 9% in stage III [20]. In a retrospective study including 3254 patients, an intrauterine pregnancy rate of 72.8% and live-birth rate of 66.8% were reported for neosalpingostomy and salpingo-ovariolysis [52]. In other research evaluating 434 women, clinical pregnancy rate was lower, showing a strong correlation with the severity of tubal disease: 43% in stage I, 33.6% in stage II, 19.5% in stage 3, and 13.8% in stage 4 [19]. Zhou et al., in a study including 1290 patients treated operatively for tubal infertility factor, revealed intrauterine pregnancy rates of 43.6%, 34.0%, and 19.4% in mild, moderate, and severe disease, respectively [53]. In the most recent research by Nian et al., natural pregnancy rate within 2 years after neosalpingostomy for mild hydrosalpinx was 50%, 17.39% for moderate, and 15.6% for severe hydrosalpinx [47].

Unfortunately, reconstructive tubal surgery can not only result in desired intrauterine pregnancy, but also in ectopic pregnancy. The tubal pregnancy rate correlates with the severity of tubal damage achieving 2–8% in good-prognosis patients and up to 17% in women with poor prognosis [20][51]. According to Chu et al., the pooled ectopic pregnancy rate after neosalpingostomy for hydrosalpinx is 10% [49].

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