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REVIEW

Fertility-Sparing Surgery in Early-Stage Cervical Cancer

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Abstract: Abstract Cervical cancer remains a major global public health challenge, especially affecting women of reproductive age. In the context of a societal shift towards delayed childbearing, fertility preservation has become an integral component of oncologic care for early-stage disease. Radical trachelectomy has emerged as a viable fertility-sparing surgical option in carefully selected patients. This review aims to assess the role of fertility-sparing radical trachelectomy in the modern management of early-stage cervical cancer by emphasizing the evolving criteria for patient selection, advances in surgical techniques, and the critical balance between oncologic safety and reproductive potential. An analysis of the literature from the past two decades shows that radical trachelectomy, whether performed via vaginal or abdominal routes, provides excellent oncologic control for early-stage lesions. Therefore, optimal results of such a technique depend on careful patient selection along with a multidisciplinary approach in order to reduce obstetrical complications.

Keywords: fertility sparing surgery, radical trachelectomy, cervical cancer, minimally invasive technique.

INTRODUCTION

Despite widespread cervical cancer screening programs and the increasing implementation of Human Papillomavirus (HPV) vaccination in many countries, cervical cancer remains the fourth most common cancer among women worldwide. The staging system established by the International Federation of Gynecology and Obstetrics (FIGO) continues to guide treatment strategies, with radical hysterectomy currently considered the standard of care for early-stage disease, including FIGO 2018 stages IA2 to IB2 and IIA1 [1]. However, a significant proportion of women affected by cervical cancer are of reproductive age. According to the Surveillance, Epidemiology, and End Results (SEER) database in the United States, approximately 36% of cervical cancer patients are under the age of 45. For many of these women, the possibility of preserving fertility is a critical aspect of treatment planning [2]. In response to this need, fertility-sparing surgical approaches have been developed. One of the most notable advancements was introduced by Dargent in 1986: radical vaginal trachelectomy (RVT) together with bilateral pelvic lymphadenectomy, initially indicated for tumors smaller than 2 cm. Since then, radical trachelectomy, whether performed vaginally, abdominally, or via minimally invasive methods, has gained recognition as a viable alternative to radical hysterectomy in selected cases, offering comparable oncologic outcomes while preserving reproductive potential [3]. However, radical trachelectomy is associated with higher obstetric morbidity, particularly an increased risk of miscarriage and preterm birth. As a result, less radical approaches, such as cervical conization or simple trachelectomy, are being explored and increasingly recommended, especially for patients with favorable histologic and staging characteristics. For instance, conization or simple hysterectomy is typically adequate for FIGO 2018 stage IA1 disease without lymphovascular space invasion (LVSI). For patients with stage IA1 with LVSI, IA2, or IB1 stage disease, multiple treatment options-including radical and less radical fertility-sparing procedures-are endorsed

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by guidelines such as those from the National Comprehensive Cancer Network (NCCN) and European Society of Gynaecological Oncology (ESGO) [3, 4]. This review aims to provide a comprehensive summary of current surgical treatments for early-stage cervical cancer, with a focus on fertility-sparing strategies in patients with FIGO 2018 stages ranging from IA with LVSI to IB2. It highlights the evolution of surgical approaches, their oncologic and reproductive outcomes, and the ongoing efforts to balance effective cancer control with the preservation of fertility and quality of life.

Evolution of Fertility-Sparing Procedures in Cervical Cancer

Historically, the best treatment for early-stage cervical cancer has been known to be radical hysterectomy, which, while effective from an oncologic standpoint, eliminates the possibility of future pregnancy. The growing awareness of fertility preservation, especially in younger patients diagnosed at an early stage, has led to significant advancements in surgical approaches over the past few decades. A seminal advancement in this domain was the introduction of radical vaginal trachelectomy (RVT) by Daniel Dargent. First performed in 1986 and subsequently detailed in the medical literature by 1994, this procedure was conceived to reconcile oncological safety with uterine conservation. The technique entails the transvaginal resection of the cervix, a circumferential margin of parametrial tissue, and the upper vagina, coupled with a laparoscopic pelvic lymphadenectomy [5]. The rationale behind RVT was to maintain oncologic safety by resecting the same structures removed during a radical hysterectomy (i.e., except the uterine body), while preserving the capacity for future pregnancy. Over the past three decades, RVT has become a well-established procedure for selected patients with early-stage cervical cancer, primarily FIGO 2018 stages IA2 and IB1 with tumor sizes ≤2 cm, no LVSI, and negative lymph nodes [3, 5].

Patient Selection Criteria

Careful patient selection is critical to the success of RVT. Ideal candidates typically meet the following criteria [3, 5, 6]:

- Histologically confirmed squamous cell carcinoma, adenocarcinoma, or adenosquamous carcinoma,
- FIGO 2018 stage IA2 to IB1,
- Tumor size ≤2 cm on imaging and/or cone biopsy,
- Absence of LVSI (relative),
- Negative lymph node status confirmed preoperatively or intraoperatively,
- No evidence of parametrial involvement or distant spread, and
- Strong desire to preserve fertility and informed understanding of potential risks.

Magnetic resonance imaging (MRI) is often employed to assess tumor size, depth of stromal invasion, and proximity to the internal os. Preoperative conization is frequently performed to confirm diagnosis, assess margin status, and determine suitability for conservative surgery.

Surgical Technique

The procedure involves two main operative phases. The initial phase consists of a laparoscopic pelvic lymphadenectomy, performed to histologically confirm the absence of nodal metastasis. The identification of positive lymph nodes typically constitutes an indication to abort the fertility-preserving procedure in favor of radical hysterectomy or chemoradiation. The subsequent phase, the RVT, involves the amputation of the cervix approximately 5-10 mm below the internal os, en bloc with the resection of the surrounding parametria and 1-2 cm of the upper vagina. A permanent or temporary cerclage (i.e., a McDonald or Shirodkar stitch) is placed at the uterine isthmus to provide mechanical support during future pregnancies. The vagina is reattached to the uterine isthmus to restore continuity. The uterus is preserved, thereby maintaining its endocrine and reproductive functions. Compared to abdominal routes, the vaginal approach offers advantages in terms of reduced operative time and accelerated recovery. This benefit is counterbalanced by the procedure's greater technical complexity and its prerequisite for specialized skill in vaginal surgery [4, 5, 7].

Oncologic Outcomes

Multiple retrospective studies and systematic reviews have demonstrated that RVT offers oncologic outcomes comparable to radical hysterectomy in appropriately selected patients. Recurrence rates range between 3% and 5%, with 5-year disease-free survival exceeding 95% in most studies. Factors associated with recurrence include tumor size >2 cm, LVSI and incomplete resection margins. Long-term data suggest excellent local control and low mortality rates, making RVT a safe option from an oncologic standpoint for tumors ≤2 cm [6, 8].

Fertility and Obstetric Outcomes

RVT allows for the possibility of future pregnancy, but obstetric outcomes are influenced by the extent of cervical resection and surgical disruption of the uterine-cervical junction [9]:

- Pregnancy rate: 40–70% among those attempting conception;

- Miscarriage rate: 15–25%, particularly in the second trimester;
- Preterm birth: Up to 30–50% of live births occur before 37 weeks;
- Delivery: Cesarean section is recommended due to the absence of the cervix and cerclage in place;
- Assisted reproductive techniques may be needed, and multidisciplinary obstetric care is essential. Cervical stenosis and infertility remain risks, but many women successfully conceive and deliver after RVT.

Over the past three decades, numerous case series, cohort studies, and meta-analyses have evaluated the efficacy and safety of RVT in well-selected patient populations [9, 10]. A comprehensive meta-analysis including over 2,400 patients undergoing fertility-sparing surgery revealed a pooled recurrence rate of 2.3% (95% CI: 1.3–3.4%) and a cancer-related mortality rate of just 0.7% [11]. These figures support the conclusion that, in appropriately selected cases-typically those with FIGO stage IA2–IB1 disease, tumor size ≤2 cm, negative lymph nodes, and absence of LVSI-RVT provides excellent oncologic control. Moreover, a 2019 systematic review by Prodromidou et al. comparing radical trachelectomy to radical hysterectomy found no significant difference in 5-year disease-free or overall survival, further validating RVT as a safe oncologic alternative to more radical interventions [12]. These outcomes underscore the importance of rigorous preoperative evaluation, including pelvic MRI and cone biopsy, to ensure that the disease is confined and amenable to conservative management. The low recurrence rates reported in these studies showed that RVT, when performed by experienced surgeons in high-volume centers, maintains oncologic outcomes similar to more extensive procedures [13]. A principal factor driving the adoption of radical vaginal trachelectomy is its favorable fertility profile, compared to other fertility-sparing procedures [14]. A systematic review by Smith et al. confirms a post-procedure pregnancy rate of 55% among women attempting to conceive, a finding sustained by the recent multicenter FERTISS study, which reported a cumulative pregnancy rate of 60.8% [15, 16]. These rates are particularly favorable when compared to abdominal radical trachelectomy (ART), which has demonstrated lower overall pregnancy rates (~36%) [4, 17]. The superior fertility outcomes of the vaginal approach are a compelling argument for its use in eligible patients, although this advantage must be weighed against its specific technical demands and patient selection criteria. However, RVT is not without reproductive risks. The spontaneous abortion rate following RVT is estimated at 24%, with most losses occurring in the second trimester. Additionally, preterm delivery affects approximately 27% of pregnancies, often due to cervical insufficiency or ascending infection, despite prophylactic cerclage placement. Cesarean delivery is generally recommended and multidisciplinary care involving maternal-fetal medicine specialists is critical throughout gestation [8, 9]. However, among all fertility-sparing procedures, RVT remains the best-studied technique, with the most consistent long-term data supporting its dual role in controlling disease and fertility preservation.

Complications and Limitations

Despite its advantages, RVT is associated with potential complications, including cervical stenosis, leading to infertility or dysmenorrhea, intraoperative bleeding, infection or pelvic abscess, need for further adjuvant therapy if margins or nodes are positive, emotional impact due to prolonged follow-up, and uncertainty regarding reproductive outcomes. Moreover, not all patients are candidates for RVT, and strict adherence to selection criteria is necessary to ensure safety [5, 10]. RVT remains the most studied and validated fertility-sparing surgical technique for early-stage cervical cancer. With the emergence of alternative approaches, such as conization or simple trachelectomy for selected patients with low-risk features, and the use of neoadjuvant chemotherapy for tumors >2 cm, the role of RVT is evolving. Future directions include integrating imaging biomarkers, molecular profiling, and surgical innovations to further refine patient selection and reduce morbidity. Multicenter registries and long-term follow-up studies are ongoing to better define its place in the treatment algorithm.

Abdominal and Minimally Invasive Trachelectomy

While RVT remains a standard fertility-sparing option in early-stage cervical cancer, the technical demands of vaginal surgery and limited accessibility to skilled surgeons have driven the development of alternative surgical routes. ART, first reported by Smith and colleagues in the early 2020s, was introduced to address these limitations [15]. This approach follows the same oncologic principles as RVT-resection of the cervix, upper vagina, and parametrial tissue while preserving the uterus-but is performed through a transabdominal route. With advances in surgical technology, minimally invasive techniques such as laparoscopic or robotic-assisted radical trachelectomy have also been adopted to reduce surgical morbidity and improve visualization, particularly in complex pelvic dissections [18, 19].

Indications and Patient Selection

The indications for ART largely overlap with those of RVT. Ideal candidates typically meet the following criteria [17]:

- FIGO 2018 stage IA2 to IB1,
- Tumor size ≤2 cm (some centers cautiously extend to ≤4 cm with neoadjuvant chemotherapy),
- Negative pelvic lymph nodes,
- No evidence of parametrial invasion,

- Strong fertility desire and informed consent.

Advanced imaging, such as MRI or positron emission tomography-computed tomography (PET-CT), is used preoperatively to assess tumor size, depth of invasion, and lymph node status. Lymph node evaluation is performed intraoperatively via pelvic lymphadenectomy or sentinel node mapping.

Surgical Technique

ART is a fertility-preserving surgical procedure that mirrors the steps of a type C1 radical hysterectomy, as classified by the Querleu–Morrow system, with the critical distinction being the preservation of the uterine body. The procedure begins with either a midline laparotomy or the use of minimally invasive techniques such as laparoscopy or robotic-assisted surgery, depending on the surgeon's expertise and institutional protocols. Following abdominal access, a bilateral pelvic lymphadenectomy is performed to assess for lymph node metastases and guide the need for further treatment. Once nodal status is confirmed to be negative, the surgical resection proceeds with the removal of the entire cervix, the surrounding parametrial tissue, and a portion of the upper vaginal cuff, ensuring oncologically sound margins. A crucial step in ART is the placement of a cerclage, either permanent or removable, at the level of the uterine isthmus to provide mechanical support for future pregnancies, given the loss of the cervix. To restore the anatomical continuity of the genital tract, a vaginal–uterine anastomosis is performed, connecting the upper vagina to the remaining uterine segment. This reconstruction not only facilitates potential menstruation and conception but also minimizes the risk of ascending infection. ART thus combines radical oncologic resection with fertility preservation and requires significant surgical expertise due to the complexity of parametrial dissection and reproductive tract reconstruction [19, 20].

Oncologic Outcomes

Multiple series and reviews have reported favorable oncologic outcomes following ART. For tumors ≤2 cm, 5-year disease-free survival rates are typically ≥95%, comparable to those of radical hysterectomy and RVT. In selected patients with tumors between 2 and 4 cm treated with neoadjuvant chemotherapy followed by ART, outcomes remain promising, although long-term data are limited [13, 14]. A multicenter retrospective study by Wethington et al. reported low recurrence rates and acceptable oncologic safety in 29 patients who underwent robotic-assisted ART for tumors up to 2 cm [19]. However, recent concern has emerged regarding the oncologic safety of minimally invasive techniques. Following the Laparoscopic Approach to Cervical Carcinoma (LACC) trial, which demonstrated inferior survival outcomes for minimally invasive radical hysterectomy compared to open surgery, similar caution is being applied to minimally invasive trachelectomy. Although these findings cannot be directly extrapolated, they have prompted a more conservative approach to laparoscopic and robotic trachelectomy, with some centers returning to open ART [21]. The 2018 LACC trial, a study of 631 women with early-stage cervical cancer (FIGO 2009 stages IA1 with LVSI, IA2, or IB1), showed that minimally invasive radical hysterectomy was associated with significantly inferior disease-free and overall survival compared to the open abdominal approach. As a result, open surgery should remain the standard of care for radical hysterectomy in this population [3, 21, 22]. Impact on Clinical Practice is that the results led to widespread reevaluation of minimally invasive surgery for cervical cancer. The implications of the LACC trial have also raised caution around minimally invasive radical trachelectomy, though this was not directly studied in the LACC trial [21].

Fertility and Obstetric Outcomes

ART preserves fertility with success rates comparable to RVT:

- Pregnancy rate: Approximately 40–60% in women actively trying to conceive,
- Live birth rate: Around 50% of pregnancies reach term,
- Increased risk of second-trimester miscarriage, preterm birth, and cervical stenosis remains,
- The obstetric risks are largely related to mechanical weakening of the cervical support structures and scarring at the isthmic level. Delivery is typically by elective cesarean section. Interdisciplinary coordination with maternal-fetal medicine specialists is crucial for managing high-risk pregnancies after ART [9, 18].

Advantages and Limitations

The abdominal approach to radical trachelectomy offers distinct advantages, including its familiarity to gynecologic oncologists and the superior surgical exposure it provides, which facilitates a comprehensive pelvic lymphadenectomy and parametrial resection. This method may also present a more feasible option for managing tumors situated high within the endocervical canal or for larger lesions following neoadjuvant chemotherapy. However, these benefits are counterbalanced by significant limitations. The procedure is generally associated with a longer operative time, greater intraoperative blood loss, and potentially higher overall morbidity compared to the vaginal approach. Furthermore, the abdominal technique is not without controversy, particularly as the adoption of minimally invasive methods has raised concerns regarding oncologic safety in light of data from studies such as the LACC trial [21]. Finally, the procedure entails considerable technical complexity, specifically in performing the uterovaginal anastomosis and placing the isthmic cerclage when utilizing laparoscopic or robotic platforms. ART and its minimally invasive variations continue to play an

important role in fertility-preserving surgery, especially in centers where RVT is less commonly performed. However, their use must be carefully balanced with oncologic risk, particularly in light of concerns raised by the LACC trial [21]. Ongoing prospective trials and registry data are expected to better clarify the long-term oncologic safety and reproductive success rates of these approaches. For now, open ART remains a valuable option for well-selected patients, particularly when vaginal access is not possible or when pelvic anatomy poses a challenge.

Extended Clinical Role of Abdominal and Minimally Invasive Trachelectomy

The clinical role of abdominal radical trachelectomy and its minimally invasive variants has evolved significantly over the past two decades. While RVT remains the most established fertility-sparing option, ART offers a valuable alternative in settings where vaginal surgery is technically challenging, contraindicated, or not widely practiced. In contemporary gynecologic oncology, ART has emerged as a pragmatic solution to expand access to fertility preservation, especially in centers lacking extensive experience with RVT [23]. RVT, though effective, requires advanced training in vaginal surgery and familiarity with pelvic anatomy from a caudal approach, skills that are increasingly rare in the modern surgical curriculum. ART, by contrast, can be performed by surgeons trained in radical abdominal hysterectomy, making it more accessible. The abdominal approach to radical trachelectomy demonstrates particular utility in specific clinical contexts. It is often the preferred technique in cases of unfavorable vaginal anatomy, such as a high vaginal fornix or distorted surgical access, which may be encountered in nulliparous patients, individuals with obesity, or those with a significant history of prior pelvic surgery. Furthermore, this method offers a distinct advantage for tumors situated high within the endocervical canal, as the abdominal exposure allows for superior visualization to achieve precise resection margins. Finally, the procedure's adoption is frequently guided by surgeon preference and institutional proficiency, making it a common choice in high-volume oncology centers where expertise in complex abdominal surgery is well-established. In these situations, ART serves as a technically reliable and oncologically sound fertility-sparing alternative [18].

ART has a defined role in managing borderline cases, including select patients with tumors exceeding 2 cm. In this context, it is often employed following neoadjuvant chemotherapy (NACT), which aims to achieve sufficient tumor downstaging to permit a fertility-sparing procedure. Although this strategy remains investigational, several institutions have reported successful obstetric outcomes in women with FIGO IB2 disease who exhibited a favorable response to chemotherapy. The abdominal approach is particularly advantageous in these complex scenarios, as it provides superior visualization, enables a controlled dissection, and allows for a thorough assessment of the parametria, which are critical for ensuring oncologic safety when operating at the limits of conservative surgery [24].

The role of minimally invasive techniques for radical trachelectomy has been significantly re-evaluated following the publication of the LACC trial. Prior to this, laparoscopic and robotic approaches were gaining traction due to demonstrable perioperative benefits, including reduced blood loss and shorter hospital stays. However, the oncologic concerns raised by the LACC trial, though based on radical hysterectomy data, have prompted a cautious reassessment of their use in trachelectomy, particularly for tumors approaching 2 cm or those with other high-risk features [21]. Despite these concerns, robotic-assisted trachelectomy continues to be utilized in highly selected cases at specialized centers that adhere to stringent tumor-minimizing protocols, such as vaginal closure prior to colpotomy and the use of protective endoscopic bags. Its application is generally reserved for very early-stage tumors (<2 cm) without lymphovascular space invasion or deep stromal invasion, and is contingent upon institutional expertise and high surgical volume [25]. Nevertheless, open ART remains the preferred route in most cases, especially when oncologic safety is prioritized.

The decision to proceed with ART is central to a comprehensive, multidisciplinary fertility preservation strategy. Patient counseling for early-stage cervical cancer, especially in cases involving tumors larger than 1.5 cm or borderline stage IB1/IB2 disease, must include a discussion of ART alongside other options such as radical vaginal trachelectomy, simple trachelectomy, and conization, with the choice guided by individual oncologic risk profiles [26]. The successful execution of these procedures is critically dependent on their performance within specialized tertiary care centers. Such centers offer the necessary confluence of expertise in fertility-preserving oncology, on-site gynecologic pathology support, high-resolution imaging, and integrated access to maternal-fetal medicine and reproductive endocrinology specialists to manage subsequent high-risk pregnancies [26].

Abdominal radical trachelectomy continues to serve as a foundational platform for integrating surgical innovations aimed at enhancing oncologic and reproductive outcomes. Key advancements include its integration with sophisticated sentinel lymph node mapping techniques, the utilization of intraoperative frozen section analysis to verify negative resection margins, and the refinement of nerve-sparing and vascular-preserving dissections to optimize postoperative fertility and functional outcomes [27]. Furthermore, the procedure's role is being refined through the application of advanced preoperative biomarkers and imaging to improve patient selection and minimize overtreatment. Within the spectrum of fertility-sparing interventions, ART occupies a strategic position, offering a more radical resection than conization or simple trachelectomy while preserving the uterus, and providing a more universally accessible alternative to the technically demanding radical vaginal approach, thus representing a pivotal option in the evolving landscape of gynecologic oncology [28].

Neoadjuvant Chemotherapy Followed by Surgery

For women with tumors >2 cm and early-stage cervical cancer, fertility preservation poses a clinical challenge. Tumors in this category (often FIGO stage IB2 or select IB1 lesions ≥2 cm) are generally considered unsuitable for immediate surgery, such as radical trachelectomy, due to the higher risk of lymph node metastasis and local recurrence [29]. To address this, the use of NACT has emerged as a strategy to downsize tumors, potentially converting patients previously ineligible for fertility-sparing procedures into candidates for conservative treatment. This approach aims to maintain oncologic safety while expanding the scope of fertility preservation [26].

Treatment Strategy

The established management strategy for patients with locally advanced cervical cancer who desire fertility preservation involves a carefully sequenced, multidisciplinary approach [30]. The initial assessment necessitates comprehensive clinical staging, incorporating MRI and often PET-CT to accurately determine tumor size and exclude nodal or distant metastasis. This must be coupled with histologic confirmation of tumor type and a documented, strong patient desire for fertility preservation in the absence of contraindications to chemotherapy. The subsequent therapeutic phase typically involves the administration of NACT, with regimens such as cisplatin and paclitaxel administered over two to three 21-day cycles. The objective of NACT is to achieve sufficient tumor volume reduction to a residual size of ≤2 cm, without parametrial involvement or LVSI. Following chemotherapy, a rigorous re-evaluation is conducted via post-treatment imaging and potentially a repeat biopsy to assess the treatment response. If a complete or partial response is confirmed, resulting in a residual tumor meeting the criteria for fertility-sparing surgery, a surgical procedure is pursued. The specific surgical option, ranging from conization to radical trachelectomy, is then individualized based on the extent of residual disease and the feasibility of obtaining clear surgical margins [30].

Evidence for the efficacy of neoadjuvant chemotherapy followed by fertility-sparing surgery is primarily derived from several small case series and retrospective studies [31]. Plante et al. reported on women with stage IB1 tumors >2 cm who underwent NACT followed by radical vaginal trachelectomy, achieving high rates of complete pathological response (~30–40%) and low recurrence [32]. Zhang et al. showed that fertility-sparing surgery following neoadjuvant chemotherapy resulted in a pathologic complete response rate ranging from 17% to 73%, with an overall pregnancy rate of approximately 44%. Among those who achieved pregnancy, the live birth rate was favorable at roughly 75%. However, recurrence rates, particularly for larger tumors, were reported between 5% and 10% [11]. While these oncologic and reproductive outcomes are encouraging, this combined modality remains an experimental strategy that should be reserved for specialized centers employing rigorous patient selection and stringent long-term follow-up protocols.

Current Recommendations and Future Directions

While NACT and conservative surgery remain off-guideline for many standard protocols, it is increasingly considered within clinical trials or centers with expertise. The ongoing CONTESSA trial (Conservative Treatment in Selected Patients with Cervical Cancer) and other registries are expected to provide more definitive data on the safety and efficacy of this approach [32]. Future investigative efforts should be directed toward several critical domains to optimize this fertility-preserving strategy. A primary objective is the rigorous definition of optimal NACT regimens, including the ideal number of cycles and drug combinations, to maximize tumor response while minimizing toxicity. Concurrently, research must prioritize the identification of reliable predictive biomarkers, potentially through molecular profiling or advanced imaging parameters, to better select patients who are most likely to achieve a complete pathologic response and thus benefit from subsequent conservative surgery. Finally, there is a need to establish standardized, evidence-based protocols for long-term oncologic surveillance and obstetric follow-up to ensure both the safety and reproductive success of patients undergoing this treatment pathway.

Oncologic Safety of Fertility-Preserving Surgery Across Histologic Subtypes

The histologic subtype of cervical cancer significantly influences prognosis and treatment planning. Squamous cell carcinoma (SCC) remains the most common subtype, followed by adenocarcinoma, which accounts for approximately 20–25% of cases. While SCC incidence has declined in high-resource settings due to widespread HPV vaccination and effective screening programs, adenocarcinoma has shown a modest but steady increase [33].

Historically, adenocarcinoma and adenosquamous carcinoma were thought to have worse prognoses than SCC, leading to reluctance in offering fertility-sparing surgery for non-SCC histologies. However, emerging evidence has begun to challenge this assumption. A retrospective study by Zusterzeel et al., involving 132 patients who underwent radical vaginal trachelectomy, found SCC in 72%, adenocarcinoma in 24.2%, and adenosquamous carcinoma in 3.8% of cases. Overall recurrence was 6.8%, with histology-specific rates of 4.2% for SCC, 12.5% for adenocarcinoma, and 20% for adenosquamous carcinoma [34]. Although the higher recurrence in glandular and mixed subtypes raised concern, the small sample size, particularly for adenosquamous carcinoma, limits broader conclusions [33, 35, 36]. In contrast, larger studies have not demonstrated a significant difference in oncologic outcomes between SCC and adenocarcinoma. A recent multicenter cohort study of 733 patients who underwent fertility-sparing surgery (i.e., radical trachelectomy or conization) found that histologic subtype was not an independent predictor of recurrence. Tumor size >2 cm emerged as the only statistically significant risk factor, underscoring tumor burden as the primary determinant of recurrence risk [16].

These findings suggest that while adenocarcinoma and other non-SCC subtypes may have distinct biology, they do not inherently preclude fertility-sparing surgery when standard eligibility criteria are met (i.e., tumor ≤2 cm, no lymphovascular space invasion, negative lymph nodes). Adjuvant therapy may still be warranted based on final pathology, but histology alone should not exclude patients from fertility-preserving options [33, 37]. Therefore, fertility-sparing surgery appears to be oncologically safe in appropriately selected patients with adenocarcinoma. However, adenosquamous carcinoma, due to its higher recurrence and more aggressive nature, may require heightened caution and closer surveillance [37].

Follow-Up After Radical Trachelectomy

Postoperative follow-up after radical trachelectomy is a critical, long-term undertaking designed to monitor for oncologic recurrence, facilitate reproductive goals, and manage procedural complications. Given that this patient population is typically young and highly motivated to preserve fertility, a comprehensive and multidisciplinary approach is essential for optimizing outcomes [38].

Oncologic Surveillance

Although the risk of recurrence in carefully selected patients is low (<5–7%), vigilant oncologic surveillance is mandatory, with the highest risk occurring within the first three postoperative years. A standardized follow-up schedule is recommended, with evaluations every 3-4 months for the first two years, every six months from years three to five, and annually thereafter. Each assessment should include a detailed pelvic examination with inspection and palpation of the neocervix, cervical cytology (i.e., Pap smear) with endocervical sampling as needed, and HPV testing, particularly for those with a history of high-grade lesions [38, 39]. While not routinely performed at every visit, pelvic imaging with MRI or ultrasound is indicated in the presence of suspicious symptoms or findings, and advanced imaging (e.g., PET-CT) is warranted if recurrence is suspected.

Fertility and Reproductive Monitoring

Patients should be referred early to reproductive endocrinology and maternal-fetal medicine specialists. Cervical length and uterine integrity should be assessed prior to attempting conception [40]. Cervical stenosis occurs in up to 15% of patients and may hinder menstruation, fertility, or embryo transfer during assisted reproduction. Dilation may be required. Cerclage management: A permanent cerclage is often placed at the uterine isthmus during trachelectomy. If not, a transvaginal cerclage is usually placed early in pregnancy. High-risk obstetric monitoring is essential due to the elevated risks of second-trimester miscarriage and preterm birth. Cesarean section is indicated in nearly all cases to avoid trauma to the anastomosis and prevent uterine rupture [41].

Psychosocial and Sexual Health

The profound psychological impact of a cancer diagnosis, coupled with fertility concerns, necessitates integrated psychosocial support. Patients may experience sexual dysfunction postoperatively, including dyspareunia and decreased satisfaction, which should be proactively addressed during follow-up visits [42]. Referrals to counseling, pelvic floor physical therapy, or sex therapy should be offered as part of a holistic care model.

Long-Term Considerations

Long-term follow-up extends beyond the immediate oncological and reproductive timeline. Survivors should be monitored for potential late effects of pelvic surgery, such as adhesive disease or bladder dysfunction, as well as menstrual abnormalities. Continued counseling regarding future reproductive planning remains important.

However, a systematic and patient-centered follow-up protocol, managed by a dedicated multidisciplinary team, is indispensable for ensuring the oncologic safety, reproductive success, and overall quality of life for women who have undergone radical trachelectomy [42].

Psychological Implications of Fertility-Sparing Surgery

The psychological burden of cervical cancer is considerable, especially for young women diagnosed during their reproductive years. Fertility-sparing procedures such as radical trachelectomy not only aim to preserve reproductive potential but also impact the patient's psychological well-being, identity, relationships, and long-term life planning. As such, emotional and psychosocial support is a vital component of comprehensive care [43].

Cancer-Related Anxiety and Fear of Recurrence

Even with favorable oncologic outcomes, patients often experience long-term anxiety about disease recurrence. The knowledge that the uterus and part of the cervix were preserved, rather than removed, may paradoxically heighten fear of incomplete treatment or future relapse. Studies have shown that nearly one-third of women experience clinically significant anxiety or depressive symptoms in the first year after diagnosis and treatment, regardless of surgical type.

Regular follow-up visits may trigger anticipatory anxiety and uncertainty about the durability of the cure, which can affect quality of life. However, some patients may feel guilt or ambivalence about choosing fertility over radical treatment [43].

Impact on Reproductive Identity and Fertility-Related Stress

For many patients, preserving fertility is not just a medical goal but a core part of their identity and future aspirations. The availability of radical trachelectomy offers hope, yet it also comes with uncertainty:

- fear of infertility, miscarriage, or obstetric complications can lead to emotional distress

- couples may delay pregnancy due to fear of recurrence, creating prolonged periods of psychological strain, and

- failed attempts at conception post-surgery can lead to grief, guilt, or feelings of inadequacy [44].

Sexual Health and Body Image

Beyond its physical impact, radical trachelectomy can significantly affect psychosexual well-being. The resection of the cervix and the upper vaginal cuff may lead to anatomical and neurological changes that directly influence sexual function, manifesting as altered vaginal sensation, impaired lubrication, and dyspareunia. These physiological alterations are frequently compounded by profound psychological sequelae. Patients commonly report a diminished libido, reduced sexual satisfaction, and heightened concerns regarding body image and femininity following their cancer diagnosis and treatment. Furthermore, these physical and emotional challenges can create significant communication barriers with intimate partners, potentially hindering the restoration of a healthy sexual relationship and overall quality of life. These issues may be compounded by surgical scars, ongoing surveillance, and fears of "damaging" the reconstructed genital tract during intercourse [43, 44].

The Role of Psychological Support and Counseling

Given the multidimensional psychological burden of radical trachelectomy, proactive mental health support is strongly recommended:

- referral to oncologic psychologists or counselors should be considered early in the treatment process,

- fertility counseling by reproductive specialists can improve understanding and reduce fear,

- peer support groups and survivorship programs can provide validation and shared experiences, and

- sex therapy or pelvic floor physiotherapy may help address dyspareunia and sexual health concerns [44].

CONCLUSION

Fertility-sparing radical trachelectomy offers the most secure treatment for women with early-stage cervical cancer, particularly when strict selection criteria are applied. Our research supports the fact that radical trachelectomy, whether performed via vaginal or abdominal, could provide excellent oncologic control for early-stage lesions and reduce obstetric complications, especially for women who desire future fertility.

ABBREVIATIONS

HPV – Human Papilloma Virus

FIGO - International Federation of Gynecology and Obstetrics

SEER - Surveillance, Epidemiology, and End Results

RVT - Radical Vaginal Trachelectomy

LVSI - Lymphovascular Space Invasion

MRI - Magnetic Resonance Imaging

NCCN - National Comprehensive Cancer Network

ESGO - European Society of Gynecological Oncology

ART - Abdominal Radical Trachelectomy

PET-CT - Positron Emission Tomography-Computed Tomography

NACT - Neoadjuvant Chemotherapy

SCC - Squamous Cell Carcinoma

LACC - Laparoscopic Approach to Cervical Carcinoma

ASCO - American Society of Clinical Oncology

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The authors declare no conflict of interest.

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Authors' contribution

Conceptualization, Mihnea Andrei Nicodin, Ana Elena Martiniuc; writing—original draft preparation, Mihnea Andrei Nicodin, Ana Elena Martiniuc; writing—review and editing- Mariam Dalaty, Diana Badiu, Laura Nicodin-Tigoianu; supervision, Ovidiu Vasile Nicodin, Nicolae Suciu; project administration. Alice Elena Munteanu, Silviu Dumitrescu. All authors have read and agreed to the published version of the manuscript.

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