Revista ARACÊ
ISSN: 2358-2472

TUBAL LIGATION AND ADENOMYOSIS: EXPLORING A POSSIBLE ASSOCIATION AND ITS CLINICAL IMPLICATIONS

https://doi.org/10.56238/arev7n2-075

Submitted on: 01/07/2025 **Publication date:** 02/07/2025

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ABSTRACT

Adenomyosis is a gynecological condition that has attracted increasing attention in recent decades, especially in relation to its possible link to tubal ligation. In view of this reality, the objective of this article is to explore and synthesize the main academic contributions and to verify whether there is a relationship between the appearance of adenomyosis after tubal ligation, postulating the hypothesis described here as the "myometrial discovery theory". To this end, the research used a comprehensive literature review, prioritizing contemporary studies between 1980 and 2025. The analysis included titre screening, detailed reading, and extraction of relevant information on adenomyosis, tubal ligation, and hormonal and endothelial changes. Potential complications of tubal ligation include post-tubal ligation syndrome (PTS), which has symptoms similar to those of adenomyosis, chronic pelvic pain, menstrual cycle irregularity, and dyspareunia. The irreversibility of the procedure can also impact emotional health, especially in younger women who later regretted the decision. The results indicate that, after tubal ligation, there may be an increase in intrauterine pressure, which, in turn, favors the penetration of blood and fragments of endometrial tissue into the myometrial system, contributing to the development of adenomyosis. Additionally, the hormonal and endothelial changes associated with the procedure can aggravate the symptoms and progression of the condition. The complexity of the interactions between tubal ligation and adenomyosis underscores the importance of comprehensive preoperative counseling. Educating patients about risks, benefits, and contraceptive alternatives is essential for informed decisions. Clinical management of these patients requires care monitoring and individualized approaches. This study concludes that the relationship between tubal ligation and adenomyosis deserves clinical and scientific attention, indicating the need for further investigations to elucidate the mechanisms involved and the implications for female reproductive health, contributing to the development of more effective preventive and therapeutic strategies.

Keywords: Endometrium. Endometriosis. Tubal Sterilization. Uterus. Myometrium.

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INTRODUCTION

Tubal ligation, often referred to as "tubal ligation" or "tubal ligation", consists of a surgical procedure created to ensure definitive contraception, by cutting or obstructing the fallopian tubes, which prevents the fertilization of the eggs. It is a surgical procedure that aims to permanently prevent conception, by cutting, blocking or tying the fallopian tubes. This action ensures that the eggs released by the ovaries cannot move towards the uterus, while the sperm cannot reach the egg either, thus obstructing fertilization definitively (Fagundes *et al.*, 2005; Mills *et al.*, 2021).

The most commonly used technique to perform tubal ligation is laparoscopic surgery, which consists of making small incisions in the abdominal region and using specific instruments to complete the procedure. It can be performed under general or local anesthesia (Fagundes *et al.*, 2005; Mills *et al.*, 2021).

Despite being widely employed as an efficient family planning strategy, the procedure has aroused interest in recent investigations due to its possible implications for female reproductive health and quality of life, especially with regard to conditions such as adenomyosis. This is a gynecological disorder that is distinguished by the anomalous growth of endometrial tissue in the muscle of the uterus (myometrium), often resulting in severe symptoms, such as heavy menstrual bleeding and pain in the pelvic region, among other manifestations (Vessey *et al.*, 1983; Ryder; Rebecca; Vaughan, 1999).

Recent research has investigated a possible association between tubal ligation and increased intraluminal blood pressure, which may favor the onset of adenomyosis. There is a possibility that changes in intrauterine pressure after the procedure may favor inadequate implantation of endometrial cells, intensifying symptoms related to adenomyosis (Loghmani *et al.*, 2019; Kho *et al.*, 2021).

However, conclusive evidence linking tubal ligation to adenomyosis remains scarce, as some investigations indicate that hormonal changes and vascular complications occurring after the surgical procedure may also have an influence on this relationship (Ferenczy, 1998; Loghmani *et al.*, 2019; Lacerda *et al.*, 2024).

The controversies related to tubal ligation encompass debates about its long-term repercussions on health and the psychological effect of irreversible sterilization, especially among younger women, who may regret this choice later. In addition, although tubal ligation is generally safe, it is essential that health professionals advise patients about the risks and potential complications, including the possibility of post-tubal ligation syndrome

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(PTSS) and its symptoms, which can simulate or aggravate adenomyosis (Goldberg; Falcone; Diamond, 2019).

The incessant analysis of these relationships highlights the importance of a comprehensive educational training for the patient, as well as the realization of more research on the implications of tubal ligation on women's health.

In view of this scenario, the objective of this article is to explore and synthesize the main academic contributions and to verify whether there is a relationship between the onset of adenomyosis after tubal ligation, postulating the hypothesis described here as the "myometrial discovery theory".

METHODOLOGY

This article was developed based on an integrative review of the scientific literature, encompassing publications that discuss the association between tubal ligation and adenomyosis. The option for integrative review as a grounded method lies in its ability to synthesize and analyze different studies, providing a broad understanding of the topic addressed.

DATA SOURCE AND INCLUSION CRITERIA

Initially, internationally renowned databases such as Pubmed, Scopus and Web of Science were consulted. The sources were chosen due to their comprehensiveness and the significance of their content in the area of gynecology and reproductive health. The criteria for inclusion included:

1. Publications dated between 1980 and 2025, ensuring the contemporaneity of the information.
2. Original research, systematic reviews, narrative reviews and meta-analyses pertinent to tubal ligation, its complications and the relationship with adenomyosis.
3. Works available in English, Portuguese or Spanish, expanding the reach and understanding of the theme.
4. Studies that investigate the clinical, pathophysiological and psychological aspects that interconnect the two subjects.

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METHODS OF DATA COLLECTION AND ANALYSIS

The searches were carried out using modifications of terms such as "tubal ligation" and "adenomyosis". The Boolean operators "AND" and "OR" were used to improve the results. Thus, 463 articles were initially identified, of which 78 were selected after applying criteria related to relevance and quality, such as the use of rigorous methodology, clarity in objectives, and the presentation of significant results.

SYNTHESIS STRATEGY

The information obtained from the analyzed studies was organized into three central axes: (1) pathophysiological changes associated with tubal ligation; (2) hormonal and vascular effects, and (3) possible clinical and emotional repercussions. These axes made it possible to organize the content of the article, evidencing pertinent information and deficiencies in current knowledge.

JUSTIFICATION OF THE TEMPORAL CHOICE

The interval between 1980 and 2025 was selected in order to ensure the incorporation of current research that represents the latest reflections and technological advances in the areas of diagnosis and treatment. Studies prior to these excerpts were considered only those that represent significant historical or conceptual milestones.

ETHICAL CONSIDERATIONS

Given that this is a review of studies, the approval of a research ethics committee was not adopted; However, the principles of scientific integrity were respected and all sources consulted were cited.

LIMITATIONS OF THE METHODOLOGY

The restrictions include the possibility of publication trips, since investigations with negative or inconclusive results may have insufficient representation in the accessed databases. In addition, the methodological diversity of the studies examined may impact the direct comparison between the results obtained.

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RESULTS AND DISCUSSION

The primary purpose of tubal ligation is to offer a definitive method of contraception to women who have chosen not to have children in the future. The procedure usually encompasses one of several approaches, such as the Pomeroy technique, which consists of tying a loop in the fallopian tubes and excising a section of the tube imposed for tying (Fagundes *et al.*, 2005; Mills *et al.*, 2021). The surgical intervention is commonly performed in a hospital or on an outpatient basis, and most women are able to return home on the same day of the procedure.

RISKS AND COMPLICATIONS

Although tubal ligation is evaluated as a safe and efficient contraceptive method, it involves risks associated with surgical procedures. Risks such as hemorrhage, infections, and lesions in adjacent organs have been described, with severe complications occurring in less than 1 in 1,000 cases (Ryder; Vaughan, 1999; Mills *et al.,* 2021).

In addition, there is a low probability (about 1 in 200 women) that conception may still occur after the procedure, usually due to inadequate closure of the fallopian tubes or an ectopic pregnancy. Women who have certain health conditions, such as diabetes, heart disease, or a history of abdominal surgery, may be at higher risk of complications (Mills *et al.,* 2021; Simon, 2005).

POST-PROCEDURE EFFECTS

After tubal ligation, it is common for women to maintain regular menstrual cycles and be able to have sexual intercourse without fear of an unplanned pregnancy (Townsend *et al.*, 1993; Ryder; Vaughan, 1999). Immediate side effects include abdominal pain or discomfort in the incision areas, which can most often be managed with analgesic medications (Townsend *et al.*, 1993). Long-term adverse effects are extremely uncommon, however, they may manifest in a small fraction of women (Long-Peterson *et al.*, 2000).

ADENOMYOSIS

Adenomyosis is a gynecological condition that is characterized by the development of endometrial tissue, which usually lines the uterus, in the myometrium, the muscular wall of the uterus (Vessey, 1983; Neurolaunch Editorial Team, 2024). This pathology can cause intense pain during the menstrual cycle, in addition to leading to other symptoms, such as

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heavy and irregular menstruation, increased uterine volume, and dyspareunia (Dias *et al.*, 1998; Neurolaunch Editorial Team, 2024). Treatment varies according to the severity of symptoms and can include the use of medications, hormonal intrauterine devices (IUDs) and even surgery (Leyendecker *et al.*, 2015; Loghmani *et al.*, 2019).

SIGNS, SYMPTOMS AND MANIFESTATIONS

Signs of adenomyosis can differ considerably between different individuals (Leyendecker *et al.*, 2015; Kho; Chen; Halvorson, 2021). While certain women may experience severe pain and excessive menstrual bleeding, others may experience mild symptoms or even no symptoms at all, such as:

- Heavy menstruation or excessive duration;
- Severe menstrual cramps or acute pelvic pain during the menstrual period (dysmenorrhea);
- Pelvic pain of a peculiar character;
- Pain during sexual intercourse (dyspareunia);
- Irregular Cycle (Days *et al.,* 1998).

In the deficiency of hormonal stimulation of the endometrial tissue that moves throughout the menstrual cycle, women affected by adenomyosis may experience intensified menstrual cramps, as well as episodes of bleeding (Dias *et al.,* 1998; Neurolaunch Editorial Team, 2024).

CAUSES AND RISK FACTORS

The precise cause of adenomyosis is still uncertain, however, it often occurs in conjunction with other gynecological conditions, such as endometriosis and uterine fibroids (Dias *et al.,* 1998; Leyendecker *et al.*, 2015). This diagnosis occurs more frequently in women aged between 32 and 38 years, and the condition may resolve spontaneously after menopause, due to the drop in hormone production (Dias *et al.,* 1998; Neurolaunch Editorial Team, 2024). The condition is also described by metaplasia, since endometrial cells show abnormal growth patterns when penetrating the muscle layer of the uterus (Leyendecker *et al.*, 2015).

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DIAGNOSIS

The diagnosis of adenomyosis is often made through imaging techniques, such as ultrasonography or magnetic resonance imaging, as they can show an enlarged uterus, among other signs that indicate the condition (Dias *et al.*, 1998; Loghmani *et al.*, 2019). A conclusive diagnosis may require a histological examination after a hysterectomy, since a condition is often related to several other gynecological disorders.

Treatment should be individualized and involves a set of actions or interventions that aim to improve an individual's health or well-being, usually involving medical care, therapies, or a specific regimen of care, according to the patient's needs.

Therapeutic alternatives for adenomyosis vary according to the intensity of symptoms, and may involve both drug and surgical options. Nonsurgical treatment methods often include hormonal therapies, such as oral contraceptives or hormonal intrauterine devices (IUDs), to control menstrual symptoms (Vessey *et al.*, 1983; Leyendecker *et al.*, 2015). In situations in which symptoms are intense and do not respond to medications, surgical alternatives, including hysterectomy (removal of the uterus), may be evaluated as a definitive therapeutic solution (Dias *et al.*, 1998; Leyendecker; Wildt, 2011). However, a deliberation on the performance of the surgery should occur individually, considering the particular risks and benefits of each patient.

INCREASED INTRALUMINAL BLOOD PRESSURE

The alternatives to the connection between tubal ligation and increased intraluminal pressure are a subject of increasing relevance in gynecological research. Although direct evidence associating tubal ligation with increased intraluminal blood pressure is still scarce, several hypotheses present potential mechanisms that may influence changes in blood flow dynamics in the reproductive system (Noe *et al.*, 1999).

Particularly in women who have a high menstrual flow, tubal ligation can result in an increase in intraluminal pressure due to tubal obstruction, which interrupted the retrograde flow, which acted as an "escape valve" for this blood, thus enabling an infiltration of endometrial tissue into the myometrium. Thus, as the obstruction/closure of this "escape valve" for the blood, there is an increase in pressure within the endometrial cavity which, depending on the flow and the level of pressure required to open the internal orifice of the cervix, allows the penetration of desquamated endometrial tissue into the myometrium. Based on this plausible theory, this article proposes the "theory of myometrial penetration"

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as a result of the increase in intraluminal pressure (Noe *et al.*, 1999), that is, due to the increased pressure within the endometrial cavity, the arrangement of the myometrial fibers and the "penetration" of the desquamated endometrial tissue into the myometrium (Leyendecker *et al.*, 2002, 2015; Leyendecker; Wildt, 2011). This cycle can repeat itself and symptoms can become progressive over the years.

RESEARCH STUDIES

OVERVIEW OF RECENT DISCOVERIES

Recent studies have analyzed the possible implications of gynecological surgical procedures, especially tubal ligation, on women's cardiovascular health and related conditions, such as adenomyosis. A significant study based on data from the Nurses' Health Study II, which covered more than 116,000 individuals, analyzed different surgical surgeries, such as hysterectomy and tubal ligation, as well as their correlations with cardiovascular events, such as heart attacks and strokes (Leyendecker *et al.*, 2002; Lacerda *et al.*, 2024).

The research aims at the possibility of a relevant observation between certain gynecological surgical investigations and an elevated risk of cardiovascular diseases (CVD). The studies conducted by the researchers indicated that, although these surgeries, such as tubal ligation, meet significant medical objectives, it is essential that the discussion about the risks of cardiovascular complications be incorporated into the counseling prior to surgery (Dias *et al.*, 1998; Noe *et al.*, 1999). Leyendecker *et al.* (2002) highlighted the relevance of analyzing these risks together with the benefits of surgeries when evaluating procedures such as hysterectomy and tubal ligation (Dias, 2009).

LIMITATIONS AND CONSIDERATIONS

While the research has offered valuable information about the risks linked to these surgical interventions, it has also had limitations. The population that participated was relatively homogeneous, which may influence the generalization of the results (Lacerda *et al.*, 2024). In addition, the study design does not determine causality and, therefore, it is not possible to conclude definitively that tubal ligation increases the risk of cardiovascular diseases or conditions such as adenomyosis (Leyendecker *et al.*, 2002).

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FUTURE ORIENTATIONS FOR RESEARCH

Further research should be conducted to investigate the mechanisms that establish the link between gynecological surgeries, such as tubal ligation, and cardiovascular risks and conditions and adenomyosis. Subsequent investigations should aim to elucidate how changes in intraluminal and/or intracavitary pressure after tubal ligation can impact the onset or intensification of adenomyosis, in addition to analyzing the interaction between existing cardiovascular disease risk factors and surgical events (Leyendecker *et al.*, 2002; Lacerda *et al.*, 2024).

HORMONAL IMBALANCES

After tubal ligation, women may experience considerable hormonal fluctuations due to changes in blood flow to the ovaries, which may influence the production and uptake of estrogen and progesterone (Ferenczy, 1998; Dias, 2009), among other hormones produced there.

The procedure can suspend the usual functioning of the ovarian hormone production system, which is tightly controlled by the Hypothalamic-Pituitary-Gonadal (HPG) axis. The involvement of the ovaries, which can occur after a surgical procedure, can also result in imbalances that manifest themselves in conditions such as adrenal fatigue and other hormonal dysfunctions (Noe *et al.*, 1999). Hormonal imbalances are related to a variety of symptoms, such as mood swings, irregularities in menstrual cycles, and physical pain, all of which are common in situations such as adenomyosis (Dias, 2009).

In addition, surgery can cause injuries to the veins and capillaries responsible for the independence of the ovaries. This vascular impairment can decrease blood flow, resulting in ovarian dysfunction and therefore further exacerbating hormonal irregularities. The relationship between ovarian health and blood flow is of utmost importance; any changes have repercussions on the reproductive endocrine system as a whole, further aggravating the situation of adenomyosis (Leyendecker; Wildt, 2011; Leyendecker *et al.,* 2015).

Although many women recover without relevant complications after tubal ligation, there are those who may have long-term problems that can impact their reproductive health. A subset of women may manifest symptoms associated with Post-Tubal Ligation Syndrome (PTLS), which encompasses several gynecological problems, including chronic pain, menstrual irregularities, and emotional disturbances (Long-Peterson *et al.,* 2000; Dias, 2009).

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A relevant aspect of the clinical consequences is the emotional and psychological influence that occurs after tubal ligation. Research shows that younger women, especially those aged 30 years or younger, have an increased risk of experiencing regret after surgery, which can result in requests for revision procedures. This highlights the relevance of comprehensive pre-surgical counseling, which considers potential risks, alternative contraceptive options, and the possibility of future reproductive desires (Long-Peterson *et al.,* 2000; Dias, 2009). Because regret can influence mental health and well-being, it is recommended that health professionals engage in comprehensive dialogues prior to procedures to ensure that a decision made is well-informed.

Due to the complexities related to tubal ligation and its possible physical, psychic and social implications, it is essential that health professionals monitor patients in the postoperative period (Dias, 2009). If signs suggestive of adenomyosis or PTLS are applied, a detailed medical history and physical examination should be performed, taking into account possible underlying conditions that may mimic these symptoms, such as endometriosis or thyroid disorders (Long-Peterson *et al.,* 2000; Leyendecker *et al.,* 2015). Individualized treatment plans, which consider the symptoms and health particularities of each patient, are essential for efficient management and to improve the quality of life after the procedure.

CONCLUSION

In summary, the "theory of myometrial penetration" presents in this article a new and thought-provoking view of the relationship between tubal ligation and adenomyosis. By understanding that the function of the fallopian tube goes beyond reproductive issues, also acting as an "escape valve" responsible for regulating intrauterine pressure during the menstrual cycle, it is possible to understand how the extirpation or blockage of these structures culminates in the increase of intracavitary or, as mentioned, intraluminal pressure, which can cause a derangement in the muscle fibers of the myometrium, leading to penetration of desquamated endometrial tissue. This relationship not only clarifies a fundamental point of female reproductive health, but also emphasizes the urgency of more rigorous monitoring and specific therapeutic interventions for women who undergo the tubal ligation procedure. Continued research is needed to corroborate these hypotheses and improve clinical management approaches, ensuring that women have access to information and care that meets their complex health needs.

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