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Prevalence and Risk Factors of Complications in Canine Laparoscopic Ovariectomy and Ovariohysterectomy: A Meta-Analysis

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ABSTRACT

This meta-analysis investigated the pooled prevalence and risk factors of intra- and postoperative complications in dogs undergoing laparoscopic ovariectomy (LOVE) or laparoscopic ovariohysterectomy (LOVH). A comprehensive search of PubMed, Scopus, Web of Science, Science Direct, and Google Scholar was performed for studies published between January 2000 and October 2025. Eligible studies provided numerical data on intraoperative and/or postoperative complications and clearly reported the number of laparoscopic ports used. Forty-three studies comprising 45 analytical arms and 2.548 female dogs met the inclusion criteria. The pooled prevalence of total complications was 14.4% (95% CI 10.5–18.8) under the random-effects model, indicating high heterogeneity (I^2=87.1%). For LOVE, the pooled prevalence was 10.6% (95% CI 7.4–14.3), whereas for LOVH it was 31.6% (95% CI 21.3–42.9), both showing substantial heterogeneity (I^2>75%). The odds of complications were significantly lower for LOVE than for LOVH (OR=0.23, 95% CI 0.18–0.30, p<0.001), suggesting an approximately 4.3-fold higher risk during LOVH. When analysed by port configuration, the one-port approach was associated with a significantly higher complication risk than the two-port technique (OR=2.13, 95% CI 1.37–3.32, p<0.001), while no difference was found between one- and three-port procedures (OR=1.24, 95% CI 0.83–1.85, p=0.29). The two-port configuration showed the lowest odds of complications compared with the three-port approach (OR=0.58, 95% CI 0.44–0.77, p<0.001). In conclusion, LOVE was associated with a significantly lower prevalence of complications compared with LOVH. When analysed by port configuration, the two-port technique demonstrated a significantly lower odds of complications compared with the one- and three-port approaches. These findings indicate that both surgical procedure type and port number are important factors influencing complication risk in canine laparoscopic sterilization.

Keywords: *Complication, Dog, Meta-analysis, Laparoscopy, Ovariectomy, Ovariohysterectomy.*

ÖZ

Köpeklerde Laparoskopik Ovariektomi ve Ovariohisterektomi Sonrası Meydana Gelen Komplikasyonların Prevalansı ve Risk Faktörleri: Bir Meta-Analiz Çalışması

Bu meta-analizde, köpeklerde laparoskopik ovariektomi (LOVE) veya laparoskopik ovariohisterektomi (LOVH) uygulanan bilimsel çalışmalarda intraoperatif ve postoperatif komplikasyonların birleşik prevalansı ve risk faktörleri araştırılmıştır. Ocak 2000 ile Ekim 2025 tarihleri arasında yayımlanan çalışmalar için PubMed, Scopus, Web of Science, Science Direct ve Google Scholar veri tabanlarında kapsamlı bir tarama yapılmıştır. İntraoperatif ve/veya postoperatif komplikasyonlara ilişkin sayısal veriler ve kullanılan laparoskopik port sayısının açıkça bildirildiği çalışmalar araştırmaya dahil edilmiştir. Buna göre sunulan çalışma 43 çalışma, 45 analitik kol ve toplam 2.548 dişi köpeği kapsamıştır. Rastgele etkiler modeli altında toplam komplikasyonların birleşik prevalansı %14.4 (%95 GA %10.5-18.8) olarak hesaplanmış ve yüksek heterojenite (I^2=%87.1) gözlenmiştir. LOVE için birleşik prevalans %10.6 (%95 GA %7.4-14.3), LOVH için ise %31.6 (%95 GA %21.3–42.9) olarak bulunmuş, her iki analizde de belirgin heterojenite (I^2>%75) saptanmıştır. Komplikasyon olasılığı, LOVE'de LOVH'ye göre anlamlı derecede daha düşük bulunmuştur (OR=0.23, %95 GA 0.18-0.30, p<0.001). Buna göre LOVH sırasında yaklaşık 4.3 kat daha yüksek bir risk olduğu görülmektedir. Port konfigürasyonuna göre yapılan analizde, tek port yaklaşımı iki port tekniğine kıyasla anlamlı derecede daha yüksek komplikasyon riski ile ilişkili bulunurken (OR=2.13, %95 GA 1.37-3.32, p<0.001) tek port ile üç portlu yöntem arasında fark saptanmamıştır (OR=1.24, %95 GA 0.83-1.85, p=0.29). İki port konfigürasyonu, üç port yaklaşımına kıyasla en düşük komplikasyon olasılığını göstermiştir (OR=0.58, %95 GA 0.44-0.77, p<0.001). Sonuç olarak, LOVE prosedürü LOVH'ye kıyasla anlamlı derecede daha düşük komplikasyon prevalansı ile ilişkilidir. Port konfigürasyonuna göre yapılan analizde, iki port tekniğinin tek ve üç portlu yaklaşımlara kıyasla komplikasyon olasılığının anlamlı derecede daha düşük olduğu gösterilmiştir. Bu bulgular, köpeklerde laparoskopik sterilizasyon sırasında cerrahi prosedür tipi ve kullanılan port sayısının komplikasyon riski üzerinde belirleyici faktörler olduğunu ortaya koymaktadır.

Anahtar Kelimeler: *Komplikasyon, Köpek, Laparoskopi, Meta-analiz, Ovariektomi, Ovariohisterektomi.*

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INTRODUCTION

In female dogs, surgical sterilization is one of the most frequently performed elective procedures, generally achieved by either ovariohysterectomy (OVH) or ovariectomy (OVE) (Reichler 2009; Sendag et al. 2025). Although these surgeries are considered routine, they can still induce postoperative complications and systemic inflammatory responses involving multiple organ systems (Siracusa et al. 2008). To minimize such risks, minimally invasive techniques have been developed, and laparoscopic surgery has become increasingly preferred over conventional open methods (Freeman et al. 2010). Laparoscopic ovariohysterectomy (LOVH) and laparoscopic ovariectomy (LOVE) have been associated with reduced tissue trauma, lower postoperative pain, and faster recovery compared with traditional celiotomy (Culp et al. 2009; Case et al. 2011). However, these techniques require specialized instrumentation and advanced surgical training, which may increase costs and limit widespread application (Culp et al. 2009). Laparoscopic sterilization can be performed using one, two, or three ports depending on the surgical technique and available equipment. Operative duration, complication rate, and postoperative pain may vary according to the number of ports used (Buote and Fransson 2022). Although the three-port approach has traditionally been the standard, two- and single-port techniques have recently gained attention for their potential to reduce surgical stress and improve cosmetic outcomes (Lacitignola et al. 2021; Buote 2022). However, the existing literature provides inconsistent findings regarding the impact of port number on complication rates. Therefore, this meta-analysis aimed to quantitatively assess intra- and postoperative complication risks associated with LOVE and LOVH in female dogs, comparing outcomes among one-, two-, and three-port techniques.

MATERIAL AND METHODS

Literature Search and Study Selection

This systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al. 2009). A comprehensive electronic search was performed in PubMed, Scopus, Web of Science, Science Direct, and Google Scholar for studies published between January 2000 and October 2025. "A combination of the following search terms was used: ("laparoscopy" or "laparoscopic" or "minimally invasive") and ("ovariohysterectomy" or "ovariectomy" or "spay" or "sterilization") and ("dog" or "bitch" or "canine"). Reference lists of relevant reviews and primary articles were also manually screened to identify additional eligible studies.

Inclusion and Exclusion Criteria

Studies were included if they (i) reported intraoperative and/or postoperative complications associated with LOVE or LOVH in dogs, (ii) provided numerical data on the number of operated animals and complications or adverse events, and (iii) clearly stated the number of laparoscopic ports used (single, dual, or triple). Studies were excluded if they (i) focused on ovarian remnant syndrome, hybrid or Natural Orifice Transluminal Endoscopic Surgery (NOTES) techniques, or combined surgeries, (ii) involved cadaveric or simulation models, or (iii) included fewer than ten animals.

Data Extraction and Complication Classification

From each eligible study, the following information was extracted: author and year of publication, procedure type (LOVE or LOVH), number of operated animals, number of ports, and counts of intraoperative and postoperative complications or adverse events. Complications were categorized as intraoperative (events occurring during surgery, such as splenic puncture, pedicle hemorrhage, or conversion to laparotomy) and postoperative (events occurring after surgery, including wound infection, seroma, hernia, or systemic signs such as vomiting or fever). For each analytical arm, the absolute numbers of intraoperative and postoperative complications were recorded, and the total complication rate (n, %) was calculated relative to the total number of operated animals.

Statistical Analysis

Each analytical arm was treated as an independent observational unit. Proportions were logit-transformed using a 0.5 continuity correction to stabilize variance. Pooled prevalence estimates were calculated using both the fixed-effects (inverse-variance) and DerSimonian–Laird random-effects models (DerSimonian and Laird 2015). Subgroup meta-analyses were conducted separately for procedure type and port number. Between-study heterogeneity was assessed using Cochran's Q statistic to quantify inconsistency among studies, its associated p-value, and Higgins' I^2 index with 95% confidence intervals (CIs) to quantify the degree of inconsistency. Egger's regression test (Egger et al. 1997) was applied to evaluate potential publication bias. In addition, odds ratio (OR) analyses were performed to compare the likelihood of complication events between laparoscopic techniques (LOVE vs. LOVH) and across all procedures according to port number (one-, two-, and three-port configurations combined). The analyses were based on the total numbers of complication and non-complication events, as multiple complications could occur in the same animal; thus, the OR reflects the odds of complication events rather than animals. All analyses were performed using MedCalc version 20.110 (MedCalc Software Ltd., Ostend, Belgium).

RESULTS

A total of 43 studies comprising 45 analytical arms and 2.548 female dogs undergoing laparoscopic sterilization were included in the quantitative synthesis (Figure 1). Across all study arms, 299 intraoperative or postoperative complications were reported (Table 1). The pooled prevalence of total complications (minor+major combined) was 9.95% (95% CI 8.82–11.16) under the fixed-effects model and 14.41% (95% CI 10.52–18.80) under the random-effects model. A high level of heterogeneity was observed (Q=341.0, df=44, p< 0.0001; I^2=87.13%, 95% CI 83.65–89.86).

Table 1: Summary of included studies reporting intraoperative and postoperative complications in laparoscopic ovariectomy (LOVE) and laparoscopic ovariohysterectomy (LOVH) in dogs.

No	Author and Year	Proc.	n	Ports	Intraop. Comp. (n)	Postop. Comp. (n)	Total Comp. (n, %)
1	Arntz 2019	LOVE	202	2	-	4	4 (%2)
2	Bianchi et al. 2021	LOVE	30	2	4	-	4 (13.3%)
3	Bydzovsky et al. 2019	LOVH	41	1	-	12	12 (29.3%)
4	Charlesworth and Sanchez 2019	LOVE	154	3	-	22	22 (14.3%)
5	Coutinho et al. 2018	LOVE	12	1	2	-	2 (16.7%)
6	Costa et al. 2025	LOVE	30	3	-	-	- (0%)
7	Culp et al. 2009	LOVE	10	2	3	-	3 (30%)
8	Davidson et al. 2003	LOVH	16	3	7	5	12 (75%)
9	Degani et al. 2023	LOVE	24	2	1	-	1 (4.2%)
10	Delaune et al. 2020	LOVE	30	2	6	-	6 (20%)
11	Devitt et al. 2005	LOVH	10	2	-	-	- (0%)
12	Dupré et al. 2009	LOVE	22	2	2	-	2 (9%)
			20	1	2	-	2 (10%)
13	Dutta et al. 2010	LOVE	20	3	3	-	3 (15.0%)
		LOVH	40		15	-	15 (37.5%)
14	Driessen et al. 2023	LOVE	21	3	3	0	3 (14.28%)
15	Espadas-González et al. 2022	LOVE	52	3	-	-	- (0%)
16	Espadas-González et al. 2023	LOVE	25	3	-	-	- (0%)
17	Forbes and Monnet 2023	LOVE	10	1	-	-	- (0%)
18	Fuertes-Recuero et al. 2024	LOVE	13	3	1	-	1 (7.69)
19	Freeman et al. 2010	LOVE	10	2	-	-	- (0%)
20	Guadalupi et al. 2025	LOVE	36	2	9	-	9 (25%)
21	Granados et al. 2017	LOVE	60	2	-	1	1 (1.66%)
22	Heblinski and Brückner 2018	LOVH	12	2	5	-	5 (41.7%)
23	Manassero et al. 2012	LOVE	40	1	5	-	5 (12.5%)
24	Martin et al. 2021	LOVE	18	3	8	-	8 (44.4%)
25	Matsunami 2022	LOVH	147	3	8	24	32 (21.8%)
26	Mayhew and Brown 2007	LOVH	30	3	16	-	16 (53.3%)
27	Moxon et al. 2025	LOVE	213	2	3	-	3 (1.4%)
28	Nylund et al. 2017	LOVE	161	2	24	-	24 (14.9%)
29	Öhlund et al. 2011	LOVE	10	3	1	-	1 (10.0%)
30	Paolini et al. 2022	LOVE	20	3	-	-	- (0%)
31	Pope and Knowles 2014	LOVE	618	3	13	12	25 (4.0%)
32	Romero et al. 2020	LOVE	16	2	-	1	1 (6.25%)
33	Runge and Mayhew 2013	LOVE	18	1	1	-	1 (5.6%)
34	Runge et al. 2014	LOVE	27	1	2	-	2 (7.4%)
35	Ruiz et al. 2008	LOVH	20	3	3	1	4 (20%)
36	Silva et al. 2015	LOVH	13	1	2	-	2 (15.4%)
37	Spillebeen et al. 2016	LOVE	22	3	4	-	4 (18.2%)
38	Tavares et al. 2023	LOVE	20	3	-	-	- (0%)
39	Tez et al. 2023	LOVE	46	2	9	-	9 (19.6%)
40	Tiosso et al. 2025	LOVH	26	1	7	-	7 (26.9%)
41	Van Goethem et al. 2012	LOVE	40	3	10	4	14 (14.3%)
42	Van Goethem et al. 2003	LOVE	103	3	11	12	23 (22.3%)
43	Van Nimwegen and Kirpensteijn 2007	LOVE	40	3	11	-	11 (27.5%)
TOTAL			2.548		201	98	299 (%11.8)

Comp.: Complication; Intraop.: Intraoperative; Postop.: Postoperative; Proc.: Procedure.

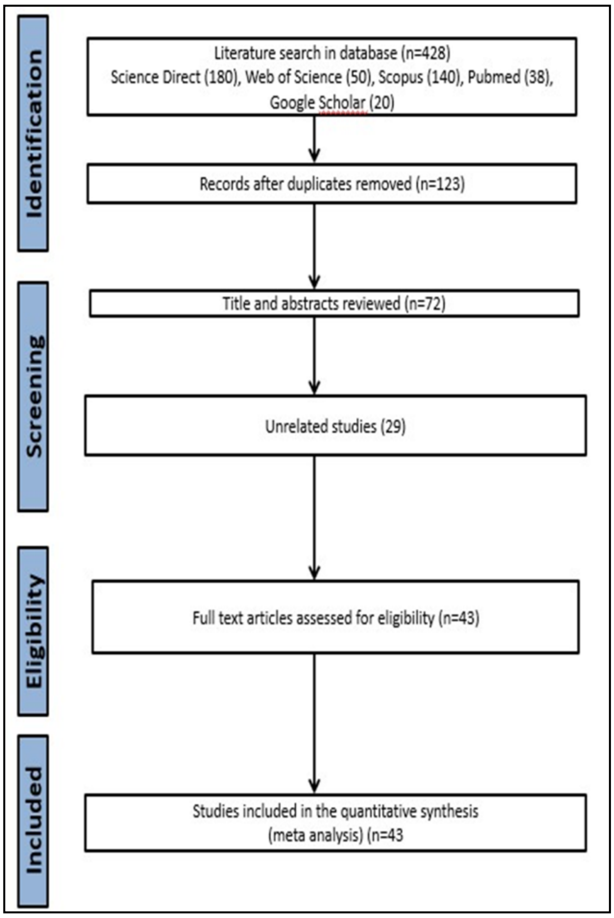

Figure 1: PRISMA flow diagram summarizing the identification, screening, eligibility, and inclusion of studies in the systematic review and meta-analysis of intra- and postoperative complications following LOVE and LOVH in female dogs.

For LOVE, the pooled prevalence of total complications was 7.63% (95% CI 6.56–8.81) under the fixed-effects model and 10.60% (95% CI 7.36–14.34) under the random-effects model, showing significant heterogeneity (Q=197.52, df=34, p<0.001; I^2=82.79%). For LOVH, the corresponding pooled prevalence was 29.22 % (95% CI 24.61–34.18) under the fixed-effects model and 31.60% (95% CI 21.31–42.89) under the random-effects model, also indicating high heterogeneity (Q=37.82, df=9, p<0.0001; I^2=76.21%). An odds ratio analysis comparing LOVE and LOVH showed that 194 complication events occurred in 2.193 procedures for LOVE and 105 in 355 procedures for LOVH. The odds of complications were significantly lower for LOVE than for LOVH (OR=0.23, 95% CI 0.18–0.30, p<0.001), indicating that complication events were approximately 4.3 times more likely during LOVH.

A total of 2.548 laparoscopic sterilization procedures were evaluated, comprising 207 one-port, 882 two-port, and 1.459 three-port surgeries. The numbers of reported complication events were 33, 72, and 194, respectively. One-port configuration was associated with a significantly higher likelihood of complication events compared with the two-port technique (OR=2.13, 95% CI 1.37–3.32, p<0.001). No significant difference was observed between the one-port and three-port approaches (OR = 1.24, 95% CI 0.83–1.85, p=0.29). In contrast, the two-port configuration showed a significantly lower odds of complications compared with the three-port technique (OR=0.58, 95% CI 0.44–0.77, p<0.001). The pooled estimates of intraoperative, postoperative, and total complications, stratified by surgical procedure (LOVE vs LOVH), are summarized in Figure 2, which illustrates individual study proportions and pooled prevalence under both fixed- and random-effects models.

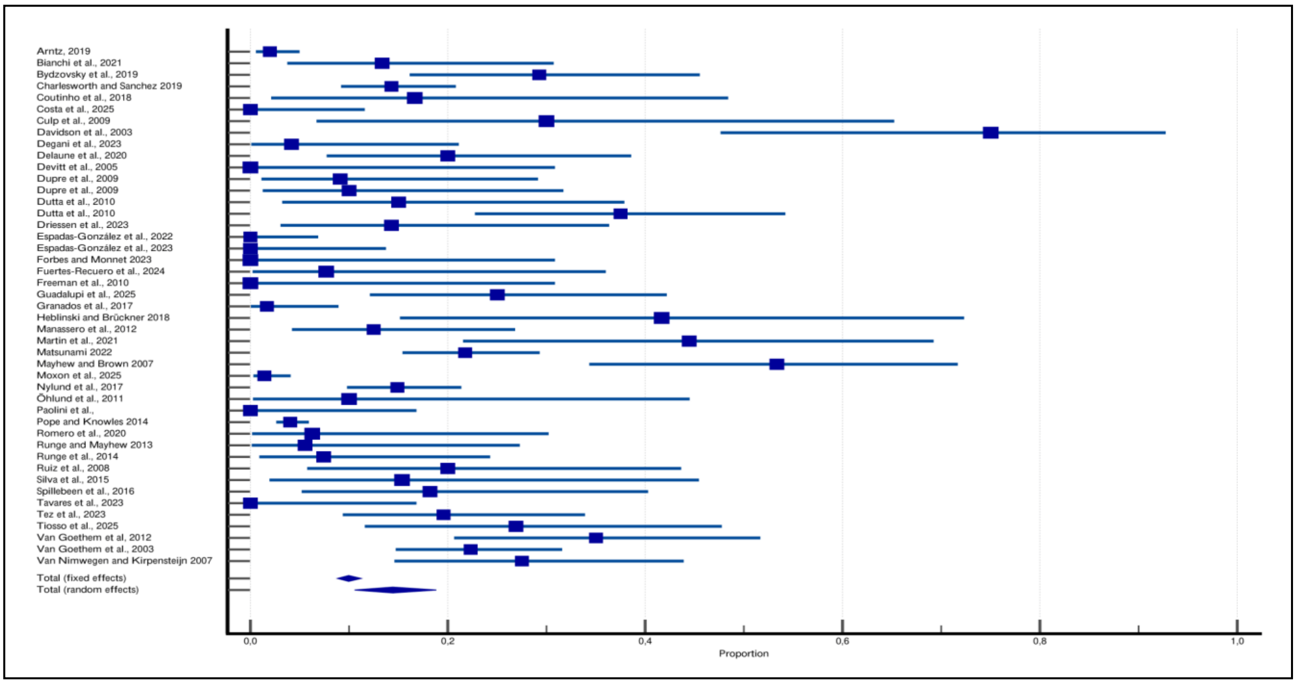

Figure 2: Forest plot illustrating the pooled prevalence of intraoperative or postoperative complications in dogs undergoing laparoscopic ovariectomy (LOVE) or ovariohysterectomy (LOVH). Each horizontal line represents an individual study with its corresponding 95% confidence interval, while the size of the blue square indicates the study weight. The diamond shapes denote the overall pooled estimates under fixed- and random-effects models.

DISCUSSION AND CONCLUSION

The most prominent finding of this meta-analysis was that LOVH in dogs carried a significantly higher complication risk compared with LOVE. This difference appears to arise primarily from the greater anatomical complexity, longer operative duration, and increased tissue manipulation inherent to LOVH. Ovariectomy confines surgical dissection to the ovarian pedicles and suspensory ligaments, while LOVH extends caudally to include the uterine body, necessitating traction, sealing, and transection of more vascular structures (Davidson et al. 2004; Freeman et al. 2010). These additional manipulations heighten the likelihood of hemorrhage, uterine tearing, or inadvertent visceral contact (Mayhew and Brown 2007; Corriveau et al. 2017). Moreover, the prolonged pneumoperitoneum and extended anesthetic duration required for LOVH may exacerbate physiological stress responses and impair postoperative recovery (Siracusa et al. 2008). Collectively, these factors explain the approximately fourfold higher complication risk observed with LOVH compared to LOVE, thereby supporting laparoscopic ovariectomy as the preferred technique for routine sterilization in bitches.

The technical simplicity of LOVE likely contributes to its superior safety profile. Because only ovarian vasculature requires sealing, the operative field remains limited and easily visualized. This simplicity reduces dependence on complex energy devices and advanced triangulation, resulting in shorter learning curves and more consistent outcomes (Culp et al. 2009; Runge and Mayhew 2013). In contrast, LOVH involves greater instrument coordination and tension on deep pelvic structures, which can challenge even experienced surgeons. Minor deviations in dissection angle or energy application may lead to incomplete coagulation or localized hemorrhage (Van Goethem et al. 2003; Ohlund et al. 2011). Indeed, multiple studies have demonstrated that complication frequency strongly correlates with surgeon experience, particularly for multi-step laparoscopic procedures (Pope and Knowles 2014; Runge et al. 2014; Nylund et al. 2017). As proficiency increases, complication rates decline sharply-emphasizing the importance of structured surgical training and mentorship in veterinary laparoscopy (Van Goethem et al. 2012).

The association between port configuration and complication risk also has clear mechanical and ergonomic explanations. Single-port approaches, while cosmetically advantageous, impose significant technical limitations: all instruments share a single access axis, leading to instrument collision, reduced triangulation, and compromised depth perception (Manassero et al. 2012; Lacitignola et al. 2021). These ergonomic constraints can cause excessive tissue traction, increased torque on the abdominal wall, and suboptimal angles during sealing, which may predispose to splenic punctures or pedicle slippage (Dupre et al. 2009; Bydzovsky et al. 2019). Dual-port configurations, in contrast, restore partial triangulation and permit more controlled manipulation, thereby minimizing iatrogenic trauma (Buote and Fransson 2022). The slightly higher complication tendency observed with triple-port techniques may reflect their preferential use in complex or pathological cases requiring extensive dissection (Corriveau et al. 2017; Degani et al. 2023). Furthermore, each additional trocar insertion increases the risk of bleeding, emphysema, or local pain (Freeman et al. 2010).

Obesity, high body weight, or abundant ovarian and uterine fat complicate tissue visualization and increase the difficulty of proper pedicle sealing (Runge and Mayhew 2013; Coutinho et al. 2018). In addition, high insufflation pressures and extended operative times can transiently impair venous return and splanchnic perfusion, thereby increasing postoperative discomfort or ileus (Siracusa et al. 2008). Variability in anesthetic and analgesic protocols may also influence complication recording; inadequate postoperative analgesia could result in over-reporting of pain-related complications, while under-detection may occur in heavily sedated patients (Degani et al. 2023). Such methodological discrepancies partly explain the high heterogeneity detected among studies. The considerable heterogeneity identified in this analysis reflects the multifactorial nature of laparoscopic outcomes in clinical populations. Variations in breed, age, reproductive status, and surgeon proficiency contribute substantially to this variability (Runge and Mayhew 2013; Charlesworth and Sanchez 2019). Furthermore, inconsistency in how complications are defined across studies, ranging from the inclusion of minor transient findings such as mild bleeding or emphysema (Case et al. 2011; Lacitignola et al. 2021) to the reporting of only major adverse events requiring intervention (Corriveau et al. 2017), hampers direct comparison.

Potential publication bias cannot be excluded, as smaller studies reporting low complication rates may be underrepresented (Egger et al. 1997; Moher et al. 2009). Early studies often prioritized demonstrating technical feasibility and innovation over comprehensive outcome reporting (Freeman et al. 2010). Future research should therefore emphasize prospective, multicenter designs with transparent and uniform complication documentation. Standardization of perioperative variables, combined with adequate sample sizes and detailed follow-up, will enable more accurate risk stratification and refinement of laparoscopic techniques in canine sterilization.

Several limitations of the present meta-analysis should be acknowledged. Substantial heterogeneity among the included studies reflects considerable variation in design, case selection, and perioperative management. Most data originated from retrospective or non-randomized clinical reports, increasing susceptibility to selection and reporting bias. Definitions of intraoperative and postoperative complications were inconsistent across studies, with some including minor events such as splenic puncture or emphysema and others reporting only major complications requiring intervention. This lack of standardization may have influenced pooled estimates and led to inaccurate reflections of true complication rates. Limited reporting of patient-related variables, anesthetic protocols, and surgical parameters also prevented adjustment for potential confounders. Because most studies were conducted in referral or academic centers, publication bias toward technically successful outcomes cannot be excluded. Furthermore, the present analysis was based on the total number of reported complication events rather than the number of affected animals, as multiple complications could occur in the same dog. This approach may have slightly overestimated the true incidence of complications at the individual level. Future prospective, multicenter investigations with standardized definitions and uniform reporting are needed to validate these findings and strengthen evidence-based recommendations for laparoscopic sterilization in dogs.

In conclusion, this systematic review and meta-analysis provides a comprehensive evaluation of intra- and postoperative complications in canine laparoscopic sterilization. The pooled evidence shows that LOVE carries a substantially lower risk of complications than LOVH, likely due to the reduced tissue manipulation and shorter operative time. Among port configurations, the dual-port approach offers the best balance between minimal invasiveness, stability, and safety, while single-port techniques, although cosmetically advantageous, remain technically demanding and more prone to error. These results support LOVE as the preferred method for sterilization in healthy bitches. Standardized complication reporting, objective outcome assessment, and structured surgeon training are essential to enhance procedural consistency and patient safety.

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

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AUTHOR CONTRIBUTIONS

Idea/Concept: AÇ, ARA
Supervision/Consultancy: AÇ, ARA
Data Collection and/or Processing: AÇ, ARA
Analysis and/or Interpretation: AÇ, ARA
Writing the Article: AÇ, ARA
Critical Review: AÇ, ARA

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