**UNIVERSIDADE DE LISBOA**

**Faculdade de Medicina Veterinária**


# Comparison of clinical and physiologic parameters, complications, and techniques, between laparoscopic ovariectomy and ovariohysterectomy in dogs


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DISSERTAÇÃO DE MESTRADO INTEGRADO EM MEDICINA VETERINÁRIA

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**RESUMO**

**Comparação de parâmetros clínicos e fisiológicos, complicações e técnicas entre ovariectomia por laparoscopia e ovariohisterectomia em cães.**

A gonadectomia é um dos procedimentos cirúrgicos realizados com maior frequência na medicina veterinária, podendo ser realizado por várias técnicas como por exemplo, a ovariohisterectomia (OVH) ou ovariectomia por laparoscopia (LapOVE). Uma vez que estes procedimentos são realizados por rotina na prática clínica, este trabalho tem por objetivo comparar os parâmetros temperatura e glucose, as complicações (intraoperatórias e pós-operatórias), os tempos de execução das técnicas cirúrgicas e dor para avaliar se alguma delas poderá ser superior à outra..

Este estudo decorreu ao longo de seis meses do estágio intracurricular no "Kingston Veterinary Group", no Hospital de Park Street. Para o realizar utilizaram-se dois grupos, - o da LapOVE com 14 animais e o da OVH com 10 animais, nos quais se registaram e de seguida compararam os parâmetros já mencionados.

Os resultados obtidos permitem verificar que o tempo necessário para preparar o paciente e para realizar a cirurgia, bem como o tempo total do procedimento foram superiores no grupo LapOVE do que no grupo OVH. Para se avaliar se houve um efeito significativo do procedimento sobre a temperatura e a glucose realizou-se uma análise com modelos lineares mistos, tendo-se verificado um efeito significativo do procedimento ao longo do tempo na temperatura ($P < 0.0003$) tendo a OVH um menor impacto sobre o paciente pois a temperatura antes e depois da cirurgia variou menos. O procedimento escolhido teve um efeito significativo na glucose ($P < 0.016$), o que poderá ser indicativo de menor dor cirúrgica no procedimento da LapOVE. Em relação à dor pós-cirúrgica, apesar de existir uma pequena diferença nas primeiras três horas após os pacientes serem extubados, não houve diferença pronunciada entre os dois procedimentos, mesmo quando a pontuação da dor no grupo OVH foi superior ao grupo LapOVE. No grupo LapOVE houve mais complicações intraoperatórias e pós-operatórias. Assim e apesar da técnica laparoscópica, apresentar algumas vantagens para este procedimento específico, a gonadectomia, as mesmas não são suficientemente fortes ou importantes para que se prefira a realização da LapOVE em vez de OVH convencional.

**Palavras-Chave:** Ovariectomia por laparoscopia; Ovariohisterectomia; Glucose; Pontuação de dor; cirurgia

## ABSTRACT

**Comparison of clinical and physiologic parameters, complications, and techniques, between laparoscopic ovariectomy and ovariohysterectomy in dogs**

Gonadectomy is one of the most frequently performed surgical procedures in veterinary medicine, this can be achieved by several techniques, for example ovariohysterectomy (OVH) or laparoscopic ovariectomy (LapOVE). Given that these procedures are performed routinely, the objective of this work is to compare the parameters temperature and glucose, complications (intraoperative and post-operative), the time it takes to execute the surgical techniques and pain to evaluate if one is superior to the other.

This study was done throughout the six months of traineeship at Kingston Veterinary Group at Park Street Hospital. To accomplish it, two groups were used, - the LapOVE with 14 animals and the OVH with 10 animals, in which the parameters above mention, were recorded and compared.

We can conclude from the results obtained, that the time to prepare the patient, perform the surgical procedure and the total procedure is longer for the LapOVE group as opposed to the OVH group. To evaluate if there was a significant effect of the procedure over temperature and glucose a linear mixed model analysis was performed. There was a significant effect of the procedures over time on temperature levels ($P < 0.0003$) with OVH having a less impact on the patient, given that the temperature before and after the surgery varied less.

The procedure chosen had a significant effect on glucose P ($<0.016$). Which can mean less operative pain in the LapOVE procedure. Regarding post-operative pain, although a very slight difference existed in the first three hours after the patients were extubated, there were no major differences between the two procedures, even when the pain score in the OVH group was higher than the LapOVE. In the LapOVE group there were more intraoperative and post-operative complications. Even though the laparoscopic technique presented several advantages, for this specific procedure, gonadectomy, they were not substantial or important enough to choose performing a LapOVE over a conventional OVH.

**Key Words:** Laparoscopic Ovariectomy; Ovariohysterectomy; Glucose; Pain scores; Surgery

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## LIST OF ABBREVIATIONS

3D = Three dimensional

CCU = Camera control unit

CCD = Semiconductors

CMPS = Glasgow Composite Measure Pain Scale

CMPS-SF = Glasgow Composite Measure Pain Scale and its short form

HALO = Harmonic scalpel-assisted laparoscopy

IASP = International Association for the Study of Pain

IAP = Intra-abdominal pressure

i.e. = *id est*

LapOVE = Laparoscopic ovariectomy

LAOVH = Laparoscopic-assisted ovariohysterectomy

MIS = Minimally invasive surgery

NRS = Numerical rating scale

OVE = Ovariectomy

PATs = Pain assessment tools

SDS = Simple descriptive scale

SILS = Single incision laparoscopic surgery

VAS = Visual analogue scale

UMPS = University Melbourne Pain Scale

**Internship activity description**

The current dissertation under the subject of “Comparison of clinical and physiologic parameters, complications, and techniques, between Laparoscopic ovariectomy and ovariohysterectomy in dogs”, was elaborated in the context of the curricular internship of the Integrated Master’s degree in Veterinary Medicine from the “Faculdade de Medicina Veterinária - Universidade de Lisboa”. The internship was carried out at Kingston Veterinary Group mainly at the Park Street Hospital and the several branches, located in Kingston Upon Hull, for the period of 6 months between September 2018 and March 2019, with a workload of more than 45 hours per week accounting for over 1000 hours. It took place under the supervision of Dr. David Robinson and the co-supervision of Professor Berta São Braz.

During the internship, I assisted and participated in numerous procedures carried out in different areas of small animal veterinary medicine. In the Surgery department, led by Dr. David Robinson, I cooperated by helping in several orthopaedic procedures (e.g. CWO, Fabello-tibial Suture, Tibial Tuberosity Transposition, Fracture repairs, stabilization of coxofemoral luxation using the Toggle Pin Method), soft tissue surgeries (e.g. exploratory laparotomies, laparoscopic ovariectomy, cystotomies, splenectomies, gastrotomy, enterotomy, perineal hernia repair, anal sacculectomy, incisional/excisional biopsies, BOAS surgery, grid keratectomy, temporary eyelid tacking, cherry eye repair, caesarean section, gastric dilatation volvulus) and post-operative care of the patients. Furthermore, I was also given the opportunity to develop my surgical skills by performing several surgical procedures under the supervision of senior surgeons, such as dog and cat castrations, dog and cat ovariohysterectomies, dewclaw removal, superficial nodule/mass excisions, dentistry procedures, scaling and polishing. The same applies in terms of anaesthesia, considering I was able to practice procedures such as induction, intubation and general anaesthetic monitoring. In the Internal Medicine department, I improved my clinical case solving skills and participated in the care and treatment of the inpatients, practicing procedures such as drugs administration, blood sampling, blood typing, collection and transfusion, venous and urinary catheterization, cystocentesis and running several diagnostic tests (e.g. haematology, biochemistry, urinalysis). In addition, I accompanied clinicians during consultations and was also able to take the lead and develop my consulting skills. Finally, with regards to the Diagnostic Imaging department, I assisted the surgeons during endoscopy (rhinoscopy, bronchoscopy, gastroscopy) and ultrasound, MRI and CT scans. Moreover, I was able to practice patient positioning for radiographic examination. During and after these procedures, I was taught by senior vets how to interpret the results and to take conclusions towards diagnostic and treatment planning in specific clinical cases. During this period, I was also able to write a case report titled “Case report of an anal gland malignant melanoma in a dog” with Dr. Hugo Martins which is currently up to revision.

# I. Comparison of clinical and physiologic parameters, complications, and techniques, between laparoscopic ovariectomy and ovariohysterectomy in dogs

## 1. Introduction to the dissertation subject

Gonadectomy is one of the most frequently performed surgical procedures in veterinary practice

given that it is the most reliable means of controlling a pet population (Goethem, Schaefers-Okkens, & Kirpensteijn, 2006).

That result can be achieved by different techniques, although in this dissertation we will emphasize on comparing ovariohysterectomy (OVH) and laparoscopic ovariectomy (LapOVE), given that these were the main procedures that were used at the hospital where the results for this dissertation were obtained.

OVH is the preferred technique for gonadectomy in dogs and cats, and for most uterine diseases, that includes but are not restricted to: pyometra, congenital anomalies and uterine prolapse, uterine rupture, among others that will be discussed in more detail more ahead, it is also described among other reports that it is the preferred technique for gonadectomy in this species (Goethem et al., 2006), and it is the most common surgical procedure performed in veterinary medicine (Davidson, Moll, & Payton, 2004). The combined incidence of intraoperative complications associated with traditional open OVH in healthy female dogs has been reported to be as high as 20.6% (Burrow, Batchelor, & Cripps, 2005).

Laparoscopic procedures have become quite common in human medicine, awareness of these techniques has increased amongst the general public. Pet owners now expect these minimally invasive techniques to also be an choice for their animals (Howe, 2006).

There are several studies that document the advantages for patients undergoing laparoscopic *versus* open surgery that have been published for both human and veterinary patients. In female dogs, laparoscopic sterilization provides a greatly improved view of the surgical field given the enhanced illumination and magnification provided by the instrumentation, which in return may decrease the risk of several intraoperative complications such as incomplete removal of ovarian tissue or haemorrhage (Corriveau, Giuffrida, Mayhew, & Runge, 2017).

Significantly lower pain scores, plasma cortisol levels, plasma glucose levels and plasma creatine phosphokinase levels have been reported in medium-breed dogs undergoing LapOVE (Rosewell, 2016).

The purpose of this dissertation is to compare both, clinical and physiologic parameters, complications, and techniques, to evaluate if one is superior to the other.

## 2. Bibliographic review

### 2.1 Anatomy of the female dog reproductive system

The female genital organs consist of ovaries, uterine tubes, uterus, vagina, vestibule, pudendum femininum (vulva), and clitoris, figure 1. The ovaries contain the oocytes, which are intermittently ovulated, engulfed by the infundibulum, fertilized or not in the uterine tube, and carried to the uterus. If fertilization takes place the blastocysts develop in the uterine tube and are passed into the uterine horns to be distributed and implanted in either uterine horn (Evans & De Lahunta, 2013).

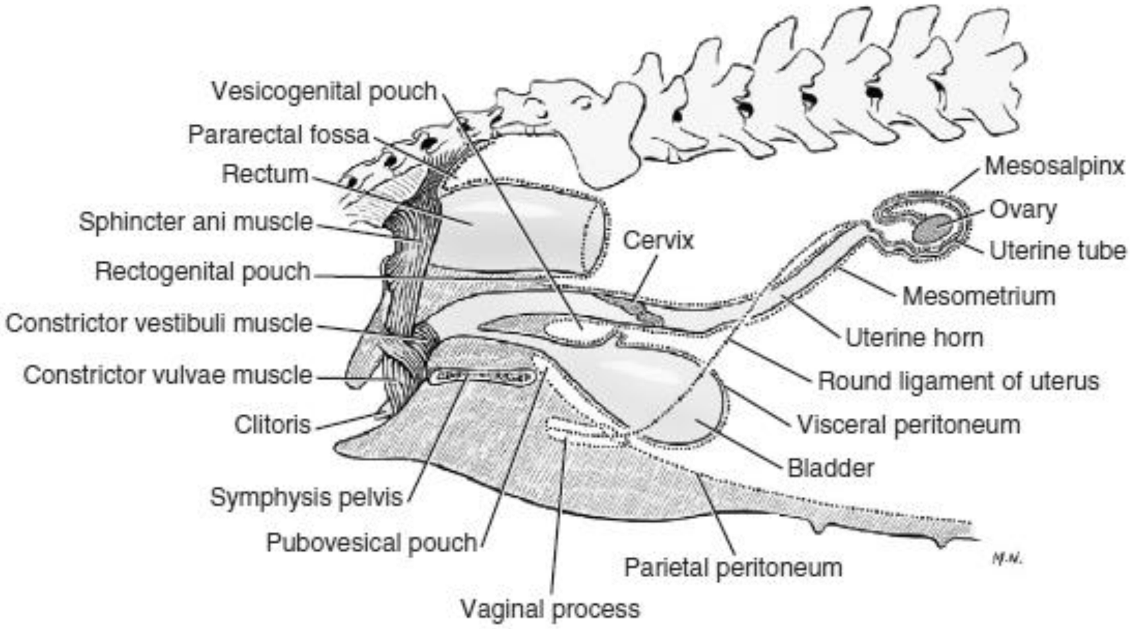


Figure 1 Diagram of peritoneal reflections and the female genitalia of the dog (adapted from Evans & De Lahunta, 2013)

#### 2.1.1 Ovaries

The ovary, is a paired oval organ, attached by a mesovarium to the body wall and the mesosalpinx. The mesovarium proximale extends from the body wall to the origin of the mesosalpinx, and the mesovarium distale extends from the origin of the mesosalpinx to the ovary and forms part of the wall of the ovarian bursa. The ovary lies caudal to the kidney (as can be seen in figure 2) and contains all of the oocytes that the female will ovulate in her lifetime. It is also the source of several hormones. In its normal position, an ovary may be described as having tubal and uterine extremities, a free border, and medial and lateral surfaces. The tubal end is nearest the infundibulum. The uterine end is the end attached to the uterus by the proper ligament of the ovary. The ovary is smooth in appearance before estrus, which occurs for the first time between 6 and 9 months of age. In multiparous bitches, the surface may be rough and nodular (Evans & De Lahunta, 2013).

The ovary usually lies between the abdominal wall and the descending colon. The ventral border and medial surface of the ovary are in contact with the mesovarium. Frequently fat is deposited within the mesosalpinx partially obscuring the ovary (Evans & De Lahunta, 2013).

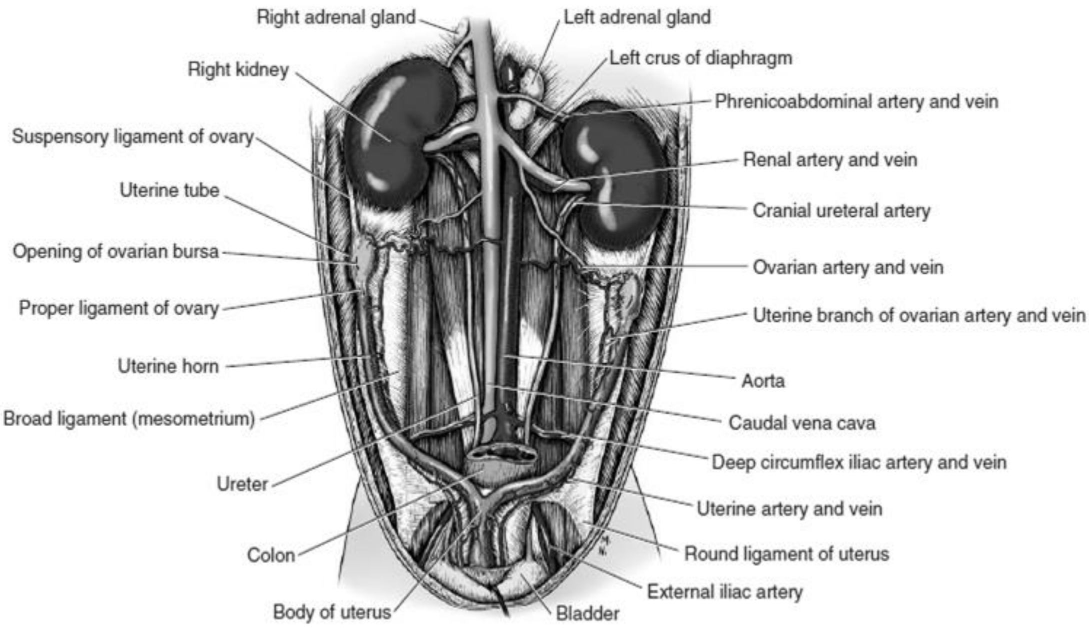


Figure 2 Female urogenital system in situ, ventral aspect. (Adapted from Evans & De Lahunta, 2013)

### 2.1.2 Uterine Tube

The paired uterine tubes (also termed oviducts or salpinx) receive and transport the oocytes to the uterus. They also carry the sperm in their ascent. Fertilization normally happens within the tubes. Each tube is suspended by the mesosalpinx and connects the peritoneal cavity with the uterine cavity and therefore with the external environment. The ovarian extremity of the uterine tube; which receives the oocyte after ovulation, takes the form of a funnel and is termed the infundibulum. The free edges of the infundibulum are bordered by numerous diverging processes, called fimbria, which contact and sometimes adhere to the surface of the ovary. The inside of the funnel is marked by folds, which converge to border a small opening in the depths of the funnel, the abdominal ostium (Konig & Liebich, 2004).

The abdominal ostium leads to the ampulla (ampulla tubae uterinae), where fertilisation normally takes place. The embryo stays in the ampulla for a few days before it is transported to the apex of the horn of the uterus through the narrower, more convoluted distal part of the tube, the isthmus. The uterine tube opens into the uterine horn through the uterine ostium

(ostium uterinum tubae) and marks the site of the uterotubal junction. It´s an abrupt junction in carnivores, in which the uterine ostium is located on top of a papilla, thus forming a barrier against ascending infections (Konig & Liebich, 2004).

### 2.1.3 Uterus

The uterus, which lies mainly dorsal to the small intestine, consists of a very short body from which two long and slender horns diverge. The body is close to the pubic brim but may be abdominal or pelvic in position. The cervix is also quite short however, the tissue thickening extends beyond the external ostium as a fold on the roof of the vagina. Transverse grooves often divide this fold into cranial, middle, and caudal tubercles; these become much swollen at certain stages of the cycle. The ostium of the cervix generally faces caudoventrally, and this orientation, combined with the asymmetry of the fornix and the fissuration of the cervical prolongation, could make its identification rather difficult, even with the aid of an endoscope (Dyce, Sack, & Wensing, 2010).

The uterus is composed of three tunics or layers: serosa, muscularis (myometrium), and mucosa (endometrium) with the last one being the thickest of the three (Fransson, 2018).

### 2.1.4 Vagina

The vagina is a dilatable canal, extending from the uterus to the vestibule. Cranially, the vagina is limited by the fornix, which extends ventral to the cervix. The fornix is the deepest part of the vagina and lies ventral and cranial to the cervix. The length of the dorsal vaginal wall is less than that of the ventral wall because of the oblique position of the cervix. The vagina ends just cranial to the urethral opening. It is delineated from the vestibule by a transverse mucosal ridge that extends dorsally on each side of the midventral line. No definite hymen is present at this point in the bitch, although its vestige may sometimes be found at the vaginovestibular junction. Both the diameter and length of the vagina increase significantly during pregnancy and during parturition. The longitudinal folds of the vaginal mucosa are high, permitting an expansion in diameter. Smaller transverse folds connecting the longitudinal folds allow craniocaudal stretching of the vagina (Evans & De Lahunta, 2013).

### 2.1.5 Vestibule

The vestibule constitutes the caudal part of the copulatory organ. It spreads from the external urethral opening to the external vulva and combines reproductive and urinary functions. It´s shorter than the vagina and lies mostly behind the ischial arch, which allows it to slope ventrally to its opening at the vulva. The resulting inflection of the axis of the genital passage must be taken into consideration when introducing a vaginal speculum or other instruments. The wall of the vestibule contains vestibular glands, the secretion of which retains the mucosa of the vestibule moist and facilitates coitus and parturition. At oestrus, the odour of the secretion has a sexually stimulating effect upon the male animal. In the bitch the glands are small, but numerous and the duct openings are arranged in linear series. Darker patches of the lateral walls betray the position of the vestibular bulbs, a concentration of veins forming erectile tissue, regarded as the homologue of the bulb of the penis (Dyce et al., 2010). The entire clitoris in normal bitches is a relatively small, with the glans clitoris projecting into the fossa clitoridis.The clitoral fossa is encountered when the vulvar labia are separated. The clitoral fossa should not be confused with the vestibule, which lies dorsal and cranial to the clitoral fossa (Johnston, Kustritz, & Olson, 2001). The clitoris the homologue of the male penis, is composed of paired roots, a body, and a glans. The roots and body are homologues of the male corpora cavernosa penis, and the glans clitoridis is homologous with the glans penis, although it is not bipartite in structure. The body of the clitoris in the dog has both erectile and fatty tissue. It is covered by the tunica albuginea (Evans & De Lahunta, 2013).

#### 2.1.6 Vulva

The vulva lies caudal to the vestibule and consists of two lips, labii joined dorsally and ventrally by commissures and separated by a narrow cleft, the *rima pudendi*. The labia form the external boundary of the vulva and in part are homologous with the scrotum of the male. The labia are soft and pliable, composed of fibrous and elastic connective tissue, striated muscle fibers, and an abundance of fat. The vaginal processes, containing the round ligaments of the uterus, often end in the subcutaneous connective tissue of the labia. The dorsal commissure lies at or slightly ventral to the dorsal plane passing through the symphysis pelvis. The ventral portions of the labia, with their uniting commissure, form a pointed projection extending ventrally and caudally from the body, usually with a tuft of hair (Evans & De Lahunta, 2013).

### 2.2 Blood supply, lymphatic drainage and innervation of the female genital organs

Blood supply to the female genital organs is provided by four paired arteries: ovarian artery; uterine artery; vaginal artery and internal pudendal artery. After dividing from the aorta, the ovarian artery follows a convoluted course to the ovary. It supplies the ovary and detaches branches to the uterine tube and to the tip of the uterine horn. The uterine branch anastomoses with the uterine artery within the broad ligament. The rest of the female genital tract is supplied by the uterine and vaginal arteries, which are branches of the internal iliac artery and by the continuation of the vaginal arteries, the internal pudendal artery. The uterine artery passes to

the uterus within the broad ligament. It detaches a series of branches to the body and horn of the uterus (Konig & Liebich, 2004).
In dogs and cats, the uterine artery is a branch of the vaginal artery. The major blood supply to the uterus is provided by the uterine branch of the ovarian artery. The caudal parts of the female genital tract are supplied by branches of the internal pudendal and vaginal arteries; the pattern of branching varies in different animals (Konig & Liebich, 2004).
The ovarian vein drains the majority of the uterus. The adjacent vessel walls are substantially thinner than the others and facilitate transmural transportation of Prostaglandin F2α from the vein into the artery. The vaginal vein vascularizes an extensive plexus in the walls of the vagina and vestibule (Konig & Liebich, 2004).
The lymphatics of the female genital tract drain primarily into the medial iliac lymph nodes and to the lumbar aortic lymph nodes (Konig & Liebich, 2004).
Innervation of the female genital organs is provided by the autonomic nervous system. The ovaries receive sympathetic fibers from the intermesenteric and the caudal mesenteric plexus and parasympathetic fibers from the vagus. The rest of the female genital tract receives parasympathetic and sympathetic innervation via the pelvic plexus (Konig & Liebich, 2004).

## 2.3 Sterilization of the female dog

### 2.3.1 Advantages

There are innumerous reasons supporting the gonadectomy of female dogs, that range from prevention of diseases and pregnancy to population control.
Elective sterilization of dogs has a dual benefit given that it counteracts overpopulation by preventing reproduction and lowers the likelihood that an individual animal will be relinquished to a humane organization. It may also correct sexually dimorphic aggression, a negative behavioral interaction that occurs between females or between males housed with females (Fransson, 2018).
The removal of the ovaries in bitches is associated with absence of ovarian diseases (such as, ovarian tumors and ovarian cysts), as well with a decreased risk of mammary and uterine diseases like: mammary neoplasia and pyometra, respectively, and also false pregnancy, estrogen-related diseases (vaginal hyperplasia/prolapse, persistent estrus, bone marrow aplasia), pregnancy-related diseases (pregnancy complications, uterine prolapse) or parturition-related diseases (dystocia, uterine prolapse, subinvolution of placental sites (Romagnoli, 2008).

A positive effect on survival was also noted when ovariohysterectomy was performed as an adjunctive treatment for canine mammary gland carcinoma. In the case of pyometra, that is quite a common disease in intact female dogs, it is estimated that 23% to 24% of intact bitches require treatment for pyometra by 10 years of age (Fransson, 2018).

Female dogs gonadectomized prior to puberty have a 95% reduction of the risk of developing mammary tumors as opposed to bitches spayed after the first heat (8% risk), after second heat (26% risk) or bitches spayed after 2.5 years of age or left intact (100% or full risk) (Romagnoli, 2008).

It is also well documented that neutered animals have a longer life span than intact animals. The increased life expectancy in gonadectomized animals may be due to the preventive effect on diseases of the reproductive tract and ⁄or the reduced risk-associated behavior (Reichler, 2009).

### 2.3.2 Disadvantages

The benefits of spaying pets cannot be overstated. Nonetheless, there are some conditions that have been reported with increased frequency in gonadectomized dogs compared with sexually intact animals (Kustritz, 2007).

Disadvantages of gonadectomy include anaesthetic and surgical complications, increased risk of neoplasia of various organ systems, increased incidence of some musculoskeletal and endocrinologic disorders, obesity and urinary incontinence in bitches, as it can be seen on, table 1 (Kustritz, 2012).

Table 1 Side effects of ovariectomy/ovariohysterectomy in the bitch, adapted from (Romagnoli, 2008)

| **Side Effects** | **Bitch** |
|---|---|
| Generic surgical risk | 7-27% |
| Obesity | 25-50% |
| Urinary incontinence | 5-12% |
| Osteoporosis | Reported |
| Behavioural changes | Reported |

The most commonly reported factor for increased risk of obesity is gonadectomy. Spayed female dogs have increased food intake and appetite after ovariohysterectomy, most likely resulting from the loss of estrogen, which may act as a satiety factor (Fransson, 2018).

However, a study showed that differences related to obesity in entire neutered dogs, were not associated with differences in diet or exercise duration, frequency and intensity, which means it can be managed (Robertson, 2003).

Urinary incontinence is also a problem of spayed female dogs it can have an incidence of 5.1% (Angioletti, De Francesco, Vergottini, & Battocchio, 2004). These authors also showed that the relationship between acquired urinary incontinence and the type of surgery performed did not show meaningful values. Others disadvantages vary according to the surgical technique that is used.

### 2.3.3 Techniques

There are several of techniques for surgically sterilizing of female dogs that have been described. Each one has advantages and disadvantages to both the surgeon and patient. Techniques that have been described include traditional midline ovariohysterectomy, lateral flank ovariohysterectomy or ovariectomy, laparoscopic ovariohysterectomy or ovariectomy. However, no matter the technique used, strict adherence to sound surgical technique and asepsis is mandatory for good surgical outcome with minimal complications (Howe, 2006).

#### 2.3.3.1 Ovariohysterectomy

##### 2.3.3.1.1 Technique

In dogs, ovariohysterectomy is traditionally performed through a small ventral midline incision. In adult female dogs, the incision typically begins at, or not more than 1 cm caudal to, the umbilicus. Once the reproductive tract has been identified, the suspensory ligament should be carefully broken using caudolateral or caudomedial traction with the index finger of the dominant hand, while holding traction on the proper ligament using the nondominant hand. Several techniques have been described for clamping and ligating the ovarian and uterine pedicles, including the single-, double-, and triple-clamp methods. Regardless of the technique selected, it is important to visualize or carefully palpate the ovary between the thumb and index finger, and then to ‘‘pinch’’ the thumb and forefinger together (while holding and protecting the ovarian tissue) deep to the ovary prior to placement of the clamp. This will prevent inadvertent clamping of the ovarian tissue, which could result in ovarian remnant tissue syndrome. Double ligations, utilizing an encircling and a transfixing ligature on all ovarian pedicles in adult dogs are recommended. When ligating the uterine body, it is important to place the most caudal ligature at the junction of the cervix and uterine body, so to avoid leaving any viable uterine body tissue that could result in a stump pyometra in the future. The second ligature is placed cranial to the first and is appropriately spaced so as to avoid leaving excessive devitalized tissue (Howe, 2006).

#### 2.3.3.1.2 Complications

Burrow et al., (2005), the authors of a study involving 142 ovariohysterectomy of female dogs reported complications similar to those published in previous studies: haemorrhage of the ovarian arteries during surgery (nine out of 141), haemorrhage after surgery (four out of 141), wound inflammation (12 out of 141) and other types of complication (four out of 141), as can be seen on table 2. The rates of intraoperative, post-operative and total complications were 6.3, 14.1 and 20.6 per cent, respectively. Haemorrhage is one of the most common complications secondary to an ovariohysterectomy, and death of the patient can occur if it is severe (Howe, 2006). Common causes of intraoperative bleeding in elective ovariohysterectomy performed by inexperienced surgeons include tearing of the perirenal peritoneum while strumming the suspensory ligament, incomplete ligation of the mesovarium and associated ovarian vessels, and loose ligatures on the mesovarium (Fransson, 2018).

Careful use of technique while breaking the suspensory ligament, handling and manipulating the ovarian and uterine pedicles, and placing ligatures is important in preventing haemorrhage. Proper placement, spacing, and tightness of ligatures is also critical to prevent intraoperative and post-operative haemorrhage. Careful examination of each pedicle with tension relieved, prior to release of the pedicle, is also an important step to prevent this type of complication (Howe, 2006).

Table 2 Type and number of complications that occurred during and after OVH in 141 bitches performed by final-year students (adaptation from Burrow et al., 2004)

| **Complication** | | **Number (%)** |
|---|---|---|
| **During Surgery** | | |
| | Haemorrhage of right ovarian artery | 7 (5.0) |
| | Haemorrhage of left ovarian artery | 2 (1.4) |
| **Total during surgery** | | 9 (6.4) |
| **After surgery** | | |
| | Haemorrhage in unidentified location (self-resolving) | 3 (2.1) |
| | Haemorrhage of subcutaneous tissue | 1 (0.7) |
| | Diarrhoea | 1 (0.7) |
| | Tracheitis | 1 (0.7) |
| | Pancreatitis | 1 (0.7) |
| | Wound inflammation | 7 (5.0) |
| | Wound inflammation and discharge | 5 (3.5) |
| | Pseudopregnancy | 1 (0.7) |
| **Total after surgery** | | 20 (14.2) |
| **Overall total** | | 29 (20.6) |

Ovarian remnant syndrome is the presence of functional ovarian tissue in the abdomen following ovariohysterectomy, due to not removing all ovarian tissue as a result of inappropriate ovariohysterectomy technique, that may result in signs of proestrus, estrus, and rarely false pregnancy. Stump pyometra may occur following ovariohysterectomy if a portion of the uterine horns or uterine body is not removed and the animal has increased progesterone concentrations (Howe, 2006).

Granuloma formation at uterine or ovarian pedicle remnants has been reported in up to 28% of dogs undergoing ovariohysterectomy (Fransson, 2018).

Accidental ligation of a ureter, which can result in hydronephrosis or atrophy of the kidney, is quite preventable by careful identification of the uterine horns, uterine body, and cervix prior to ligation of the uterine body, and avoidance of ligation of any extraneous peribladder fat which may contain a ureter (Howe, 2006).

#### 2.3.3.2 Lateral flank approach for ovariohysterectomy

There are certain conditions for which the lateral flank approach technique is preferred for ovariohysterectomy, they include excessive mammary gland development due to lactation or mammary gland hyperplasia. On a lactating animal, using the lateral flank approach can avoid potential complications that may be associated with the ventral midline approach, such as excessive hemorrhage from the skin and subcutaneous tissue, wound inflammation or infection, and leakage from mammary tissue. In addition, using the lateral flank approach in lactating animals minimizes disruption to the mammary glands so that those animals are more likely to continue nursing appropriately after surgery (Mcgrath, Hardie, & Davis, 2004). Advantages of this technique include the reduced potential for eventration if wound dehiscence occurs (Mcgrath et al., 2004).

##### 2.3.3.2.1 Technique

The lateral approach is performed through a dorsoventral incision that is placed just caudal to the midpoint between the last rib and iliac crest. The incision length is approximately 3 cm in dogs, however, it can differ depending upon the size of the animal. The abdominal wall is entered via a grid approach using blunt dissection through the separate layers of muscle. Once the uterus and ovary have been identified, the ovarian pedicle is isolated and ligated in standard fashion. After the ovarian pedicle is ligated, and the broad ligament to that side is torn, the uterine horn is traced to the bifurcation, and the second uterine horn identified and traced cranially to the second ovary. Visualization of the contralateral ovarian pedicle can be difficult through a small flank incision, and it may be necessary to enlarge the incision. Once the second ovarian pedicle has been ligated, and the broad ligament divided, traction is applied to both uterine horns to expose the ligation site on the uterine body. The uterus is then ligated in standard fashion. After verifying lack of hemorrhage, the body wall musculature should be closed in two layers. Subcutaneous tissue and skin closure is routine (Howe, 2006).

#### 2.3.3.2.2 Contraindications

Contraindications for the lateral flank approach for ovariohysterectomy include uterine distention due to pregnancy or pyometra, obesity, or patient age younger than 12 weeks. It can also cause visible scarring or imperfections in hair color or regrowth. The primary disadvantage of the flank approach is limited exposure to the abdomen if complications arise. It is also difficult to properly identify animals that already had an ovariohysterectomy because the incision scar may be in the flank region and not in the typical ventral midline location. The exposure of the uterine stump and contralateral ovarian pedicle is generally more limited, making it difficult to achieve hemostasis if a pedicle is accidentally dropped or if bleeding occurs in these areas (Mcgrath et al., 2004).

### 2.3.3.3 Ovariectomy

The most common indication for ovariectomy (OVE) in veterinary medicine is elective sterilization in animals with a normal uterus. Usually, the technique used is ovariohysterectomy, but long-term studies have failed to show significant advantage of the ovariohysterectomy compared with ovariectomy alone unless the uterus has pathologic changes (Fransson, 2018).

The main argument against ovariectomy state that the uterus should be removed to prevent pyometra from occurring later in life. However, the incomplete uterine body removal which is often performed in ventral ovariohysterectomy creates no smaller risk. In a study with 72 dogs, no stump pyometras were described in dogs that underwent the ventral midline technique and in which proper ovarian removal had been performed (Janssens & Janssens, 1991).

Also, there is no evidence that conditions such as cystic endometrial hyperplasia or other conditions, develop in the ovariectomized bitch unless progestagens are administered, compared with ovariohysterectomy (Okkens, Kooistra, & Nickel, 1997).

A major advantage of OVE is that it can be performed through a smaller celiotomy and with less traction on the female genital tract. With respect to long-term urogenital problems, including endometritis/pyometra and urinary incontinence, it has been clearly established that they do not occur more frequently with either technique. Most evidence extracted from the literature report no benefit and thus no indication for removing the uterus during routine neutering in healthy bitches. Thus, reinforcing the idea that OVE should be the procedure of choice for canine gonadectomy (Goethem et al., 2006).

#### 2.3.3.4 Technique

The technique is performed using a ventral midline abdominal approach that starts at the umbilicus and extends caudally. The ovary is identified and the ovarian pedicle is ligated using traditional techniques and materials. Once ligated, the ovarian pedicle is severed. The uterine artery and vein are then ligated and severed at the proper ligament (cranial tip of the uterine horn), and the ovary removed. Closure is routine (Howe, 2006).

## 2.4 Laparoscopy

Laparoscopy is a technique to look into the abdominal cavity via a tiny incision using a (rigid) telescope, allowing visual exploration of the internal organs.(Schneider & Feussner, 2017)
It is also a minimally invasive surgical technique that achieves many of the same maneuvers as the traditional surgical procedure of laparotomy. However, laparoscopy is done by using the optical space produced by a gas that causes insufflation. Initial insufflation is done with the use of a Veress needle or a catheter placed through a minilaparotomy incision or by the placement of a trocar-cannula with the use of a Hasson technique. As soon as the peritoneal cavity is distended, the laparoscope is placed through the cannula and used to observe the placement of additional trocar-cannulae. With the use of these additional cannula, biopsy and surgical instruments are passed into the abdomen. An air-tight seal must be maintained by laparoscopic cannula sites to prevent loss of carbon dioxide and optical space (Rawlings, 2011).

### 2.4.1 Indications

Laparoscopic treatments, which have been in constant development, evidently expand the types and numbers of small animal procedures. Furthermore, the number of indications that can be treated with laparoscopy has extended are also shown on table 3, (Rawlings, 2011).
Virtually all of the organ biopsy specimens taken by traditional laparotomy can also be obtained by laparoscopy, examples of this are on table 3 (Rawlings, 2011).
Commonly performed laparoscopic or laparoscopic-assisted procedures in dogs and cats include liver, spleen, intestinal, and lymph node biopsies; feeding tube placement; ovariohysterectomy and ovariectomy (Buote, Kovak-McClaran, & Schold, 2011).
Additional applications of diagnostic laparoscopy include evaluation of abdominal trauma. This use is expanding in human medicine, along with operator experience can be quite accurate. In veterinary medicine, this represents a noninvasive method to evaluate blunt abdominal trauma. Injuries such as splenic and hepatic lacerations, diaphragmatic hernia, bladder rupture, renal rupture and abdominal hernia can be assessed. This often dictates the potential need for open abdominal surgery (Richter, 2001).

Table 3 Diagnostic indications for laparoscopy and treatments performed by laparoscopy or laparoscopic assistance (adapted from Rawlings, 2011)

| **Diagnostic Indications for Laparoscopy** | **Treatments Performed by Laparoscopy or Laparoscopic Assistanted** |
|---|---|
| Hepatic examination and biopsies | Laparoscopic incisional gastropexy (preventive or therapeutic) |
| Cholecystocentesis | Laparoscopic enterostomy tube placement |
| Renal examination and biopsies | Laparoscopic cryptorchid castration |
| Prostatic examination and biopsies | Laparoscopic ovariectomy/ovariohysterectomy |
| Pancreatic examination and biopsies | Laparoscopic cystopexy |
| Lymph node examination and biopsies | Laparoscopic cystoscopic calculi and polyp removal |
| Splenic examination and biopsies | Laparoscopic colopexy for recurrent rectal prolapse |
| Reproductive tract examination | Laparoscopic gastrostomy and enterotomy for foreign body removal |
| Examination and biopsy of masses | Laparoscopic attenuation of portosystemic shunts |
| Cancer staging by examination and biopsies | Laparoscopic-assisted resection of intestinal tumors |
| Intestinal exploration and full-thickness biopsy (laparoscopic Assistance) | Laparoscopic cholecystectomy |
| | Laparoscopic adrenalectomy |

### 2.4.2 Advantages

The advantages of minimally invasive surgery (MIS) have been found in studies of laparoscopic colectomy, appendectomy, gastric bypass, and splenectomy in human patients. At the moment, few of these reported advantages have been scientifically evaluated in veterinary patients. Also, several studies in human medicine have evaluated postoperative surgical site infection rate in procedures in which MIS is considered the reasonable standard of care. MIS have a decrease in pain and discomfort and a more rapid return to normal activity after surgery, with fewer wound-healing and other complications. It is usually correlated that the reported advantages of MIS in humans might also be realized in companion animals (Mayhew, Freeman, Kwan, & Brown, 2012).

Nonetheless there are some studies that report a reduction in pain and more rapid return to normal life in veterinary patients after MIS (Mayhew et al., 2012), such as, in procedures corresponding to laparoscopic ovariohysterectomy, ovariectomy (Culp, Mayhew, & Brown, 2009; Devitt, Cox, & Hailey, 2005).

It is generally accepted that the immune system is better preserved following laparoscopic than open surgery, what is demonstrated by the lower release of several biomarkers including interleukin 6 and C-reactive protein. This decreased of the immune response is most likely a consequence of a significantly smaller tissue injury (Targarona, Balague, Knook, & Trías, 2000).

The effect of insufflation gas is also considerable. It has been shown that air is actually more damaging to local cell-mediated immunity than $CO_2$, the most frequently used gas in laparoscopy. (Mayhew et al., 2012). In a study performed in a murine model, it was reported that laparotomy or air-insufflation laparoscopy impaired macrophage phagocytosis to a greater extent than did $CO_2$ laparoscopy (Watson, Redmond, McCarthy, Burke, & Bouchier-Hayes, 1995).

Also, images and movies can also be recorded during the procedure. These can be used to monitor disease severity and to communicate with the client and veterinary colleagues (Rawlings, 2011).

### 2.4.3 Contraindications

A traditional laparotomy procedure is frequently favored if the addition of endoscopy significantly complicates the procedure. An open laparotomy is usually required in the case of a major mass resection. Unstable cardiopulmonary or renal systems, endocrinopathies and neurologic problems can be contraindications for the same reason that they would be in traditional laparotomy.

The major contraindication for laparoscopy is a lack of equipment or experience on the part of the operator to perform the procedure. Training is required, and experience with multiple procedures reduces complications during laparoscopy. The primary missing examination tool is digital palpation, such as in the liver and spleen, during a laparotomy though this may be overrated (Rawlings, 2011).

In open surgery, instruments are easily sterilized by conventional methods (ethlylene oxide or autoclave). Though, for laparoscopic work the kit is mechanically more complex and so its complete sterilization can be more difficult. Several infectious complications, especially at the level of the abdominal wall, have been reported after laparoscopic cholecystectomy, perforated duodenal ulcer surgery and hysterectomy (Targarona et al., 2000).

Insufficient training and experience are one of the most important limitations/contraindications, given the long learning curve (Buote et al., 2011).

### 2.4.4 Equipment

#### 2.4.4.1 Imaging Chain

A basic video endoscopy imaging system consists of the following components: a light source, light-transmitting cable, endoscope, camera, and monitor; (figure 3) each component is essential and the quality of the image obtained is dependent of each element (Brandão & Chamness, 2015).

The light generated by the light source is transmitted by the optic fiber light cable, and farther down the telescope, by optics fiber to illuminate the anatomy being observed. The image is transmitted through a series of lenses from the distal end of the telescope to the eyepiece, where the chip in the video camera head senses the image and transmits it to the camera control unit (CCU), which processes the endoscopic image and transmits it to a monitor for viewing (Brandão & Chamness, 2015).

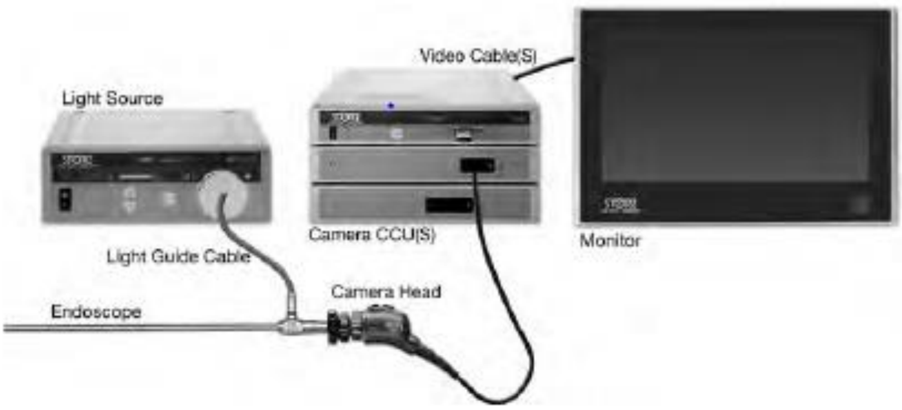


Figure 3 Basic endoscopic imaging chain, (2014 Photo Courtesy of Karl STORZ GmbH & Co.KG)

#### 2.4.4.2 Laparoscope (Telescope)

The telescope uses glass lenses to direct light by way of a fiberoptic bundle to illuminate the target area and the eyepiece. In conventional telescopes, a series of lenses are embedded in an air medium, whereas in the Hopkins rod lens telescopes (that are considered the gold standard, Schneider & Feussner, 2017) the lenses have been substituted with glass rods divided by small negative air lenses, see figure 4 (Van Lue & Van Lue, 2009).

In a rod lens system, air acts as a negative lens, within a glass medium, as opposed to the glass lenses within an air medium found in conventional telescopes. Rod lens telescopes convey significantly more light and have a wider field of view (Chamness, 2005).

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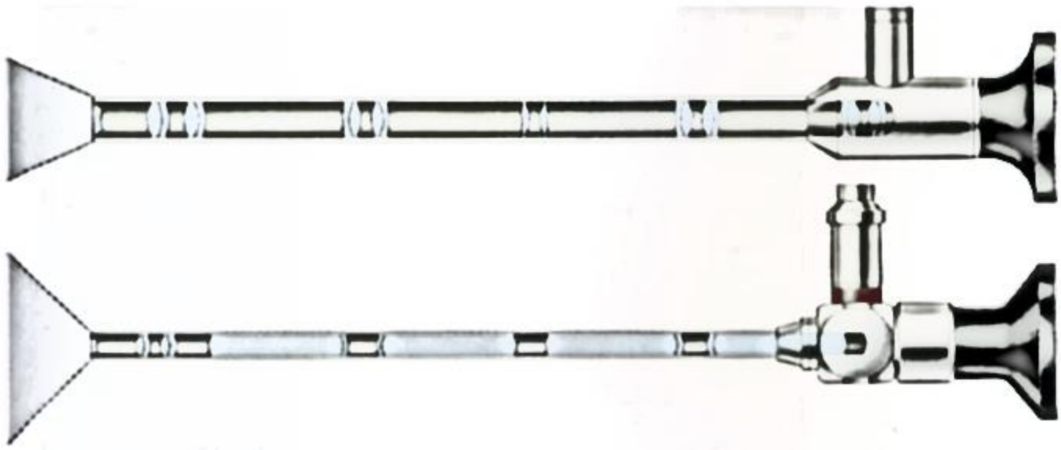


Figure 4 Traditional optical system (top figure) vs. Hopkins rod system (bottom figure) (adapted from Chamness, (2005)

#### 2.4.4.3 Light source

Light is conveyed from a remote light source through a fiberoptic light cable to the rigid fiberoptic laparoscope (telescope). The light source needs to be bright enough to illuminate a large cavity like the abdomen of a large deep chested dog. Currently, the Xenon light source is the most popular given that it offers excellent tissue color reproduction with light closely approximating that of pure sunlight (Brandão & Chamness, 2015).

#### 2.4.4.4 Endoscopy video cameras

The camera head encompasses either one or three semiconductors (CCDs), which sense the image and convert it to an electronic signal. Modern video cameras have a variety of features that make them lightweight, soakable, gas sterilizable, and, certain models are autoclavable. They may have automatic exposure control, a zoom lens, contrast enhancement capability, and buttons on the camera heads to control various settings or activate peripheral devices. The CCD is the “chip” referred to in single-chip vs. three-chip cameras (Chamness, 2005).

The optical quality of modern single-chip cameras is high, but the ones that make use of three-chip is better. Three-chip cameras have horizontal resolution and superior accuracy of color reproduction (Chamness, 2005), and have a chip for each of the primary colors of the image (red, green, and blue) and provide a superior image compared with one-chip cameras (Richter, 2001).

#### 2.4.4.5 Monitors

The final display for viewing the endoscopic image is provided by the video monitor and its connected via a cable, either directly from the camera processor or from any number of various recording devices that may be placed in between the camera processor and the monitor. The video chain should always terminate with the monitor (Chamness, 2008).

Optimal positioning of the screen during the operation is crucial, the monitor height should always be attuned to the eye level of the surgeon, and positioned in such a way as to minimize neck strain (Chamness, 2008).

#### 2.4.4.6 Insufflator

The insufflator is a pump that provides $CO_2$ into the abdomen, which is needed to achieve the artificial space that allows the surgeon to perform the surgery. It is designed to yield adequate pressure (ca. 15 mmHg) and to maintain it during the procedure even in the event of gas leaks, but, at the same time, it needs to avoid pressure peaks which would be harmful for the patients. Therefore, pressure and flow sensors are vital components of an insufflator. Insufflators are equipped with displays, that indicate the effective and the preselected intra-abdominal pressure (IAP) along with gas flow and the total amount of insufflated gas (Schneider & Feussner, 2017).

In the case of using a Veress needle approach, at the beginning of initiating insufflation, the pressure should be low, with a high flow rate on the insufflator display, hence reflecting the instillation of the $CO_2$ gas into the large potential space of the peritoneal cavity. If the pressure is initially high, the surgeon should check in the first place all stopcocks to guarantee that they are in the open position. If pressure still remains high, another possible reason is the Veress needle or cannula is not being in the desired tissue space (Van Lue & Van Lue, 2009).

#### 2.4.4.7 Operating table

The ideal table allows the surgeon to tilt the patient laterally in either direction as well as vary the degrees of head-up (known as reverse Trendelenburg position) or head-down (Trendelenburg position) positions. The table height will be lower during a laparoscopic procedure than during a conventional procedure given the long length of the instruments (Van Lue & Van Lue, 2009).

### 2.4.5 Instruments

Endoscopic instruments tend to be the same as used for traditional surgery with the exception that they are long and have a narrow shaft that is suitable for passing through the cannula. Reusable instruments can be properly cleaned and sterilized in a steam autoclave. (Rawlings, 2011)

#### 2.4.5.1 Cannula-Trocar assembly

The trocar is a sharp-pointed stylet that penetrates the abdominal wall. It is removed when the cannula enters the abdominal cavity, leaving the cannula in place which enables the laparoscope to be introduced later. (Richter, 2001).

When there is a need to penetrate the muscles and peritoneum a sharp trocar is used while the blunt trocars are used where there is no need to cut tissues. It is vital to avoid injury to internal structures such as the heart and lungs (Bennett, 2009).

To address the significant morbidity that can follow a trocar injury to a vascular structure or bowel, new features have been introduced such as trocars with optical viewing capability during insertion, use of a fascial- or tissue- separating blunt tip, threaded cannulas placed with a twisting motion, or combinations thereof, which are now widely used (Van Lue & Van Lue, 2009).

#### 2.4.5.2 Forceps

Laparoscopic forceps can be divided into three categories: grasping forceps, dissecting forceps, and biopsy forceps, and like in any open surgery, the kind of forceps used will depend on its intended use (Swanson & Millard, 2015).

The jaws of laparoscopic forceps can be traumatic or atraumatic; grasping forceps can also be fenestrated or closed, with varying strength that is proportional to their teeth size; dissection forceps can be bent or straight (Prisco, 2002). Given the loss of tactile feedback occurring in any laparoscopy procedure, even atraumatic forceps can damage tissues if too much force is applied, so one must be careful (Moore & Ragni, 2012).

#### 2.4.5.3 Scissors

Compared to open surgery, the use of scissors in minor access surgery is more limited, as one would expect. The skill required is much greater since they are potentially harmful. Scissors come in a variety of straight, curved, or hook blades. The edges can be serrated to prevent tissue slipping out of the blades. Curved scissors allow a better visual control during cutting and are generally preferred in laparoscopic surgery (Schneider & Feussner, 2017).

#### 2.4.5.4 Tissue Retractors

One of the most important disadvantages to overcome in the use of laparoscopic instrumentation is the loss of tactile feedback (Van Lue & Van Lue, 2009). Palpation probes are used to palpate organs and structures within a body cavity, and to move and retract out of the viewing field (Swanson & Millard, 2015). Ovariectomy hooks are used during laparoscopic ovariectomy and ovariohysterectomy to suspend the ovary against the body wall to ease ligation and transection of the ovarian pedicle. The small puncture that is created from the hook does not need to be closed (Swanson & Millard, 2015).

#### 2.4.5.5 Others

There are many other instruments used for additional maneuvers, and should be acquired depending on the procedure intended (Tapia-Araya, Martin-Portugués, & Sánchez-Margallo, 2015).

### 2.4.6 Electrosurgery

Electrosurgery is a valuable tool to make surgery much safer and faster. One must always take into account, the disruptive processes that can result from electric current running through tissue (Schneider & Feussner, 2017). In the monopolar system, current is generated in the cautery device to the active electrode, moving on throw the tissue, returning to the return electrode and back to the cautery (Prisco, 2002). The use of bipolar and ultrasonic sealing devices has resulted in more efficient and cost-effective surgery given that they limit the application of mechanical devices such as clips an and staples to larger vessels and more vascular tissues (Phillips et al., 2008). B. E. B. J. Van Goethem, Rosenveldt, & Kirpensteijn, (2003) also concluded that laparoscopic ovariectomy can be performed more rapidly when using bipolar instead of monopolar electrosurgery and with less risk of mesovarial haemorrhage. Although the advantages of bipolar based energy-based surgical devices, there are reports that certain ultrasonic energy-based surgical devices produce significantly less thermal damage. (Phillips et al., 2008).

### 2.4.7 Laparoscopic Surgery

#### 2.4.7.1 Anaesthesia

In small animals, laparoscopy procedures will generally require the use of general anesthesia and it is used for invasive or longer duration procedures and for patients with significant respiratory disease. General anesthesia allows patients to easily be ventilated and provides analgesia, good muscle relaxation, and a quiet surgical field. It will also allow to convert the surgery to a laparotomy in case of a major complication or unexpected finding. Each type of laparoscopic procedures have unique requirements, which must be considered when anesthetizing patients to prevent potential complications from occurring (Quandt, 1999). General anesthesia, using balanced anesthesia technique including several parenteral and inhalational agents with the use of muscle relaxants, showed a rapid recovery and cardiovascular stability (Gerges, Kanazi, & Jabbour-Khoury, 2006).

For abdominal laparoscopy, veterinary surgeons must be mindful of the main hemodynamic and respiratory consequences of laparoscopic procedures on the patient, such as increased IAP formed by the establishment of the pneumoperitoneum, the type of gas used and the position of the patient on the operating table for easy maneuvering of the surgeon (Dörfelt, Ambrisko, & Moens, 2012).

#### 2.4.7.2 Animal preparation

The urinary bladder should be expressed prior to MIS to minimize the risk of accidentally traumatizing it and to increase visualization. MIS is always performed under standard aseptic conditions just like any open procedure. The owner must always be prepared and aware for the possibility of needing to convert the surgery into an open procedure as a result of complications or an inability to accomplish the procedure through a MIS technique, hence the patient being clipped for a complete abdominal laparotomy. For an ovariohysterectomy, tipping the head down will improve visualization of structures in the caudal abdomen while for a liver biopsy, tipping the rear end down will displace viscera away from the liver improving visualization (Bennett, 2009).

Position of the patient depends on the procedure to be performed; dorsal recumbency is used in most cases, at least to place the first port and the telescope. Thermal support is also crucial, particularly in smaller patients (Sladakovic & Divers, 2016).

#### 2.4.7.3 Insufflation

In the typical anatomy of small animals, the mucosal surfaces are in close contact and the peritoneal space contains just a little fluid. In the case of the endoscope being placed into this space, the image obtained would be a diffuse pale red image resulting from the various organs and tissues. In order to have a proper image that enables the laparoscopic procedure, it is necessary to fill the peritoneal cavity with an inert gas and create a space to work – the pneumoperitoneum. In cats and small dogs, it is suggested to insufflate the abdomen to a maximum of 12 mmHg, and in larger dogs no higher than 14 mmHg. Once the operating cannulae is inserted, IAP may be lowered to 10 mmHg or below, as all that is required is a sufficient space to visualize the site of interest (Lhermette & Sobel, 2008).

In a recent study, the levels of pressure and influence of body fat, were studied, found that patients with a higher abdominal fat thickness would need a lower pneumoperitoneum pressure to maintain adequate laparoscopic working space, whereas patients with less abdominal fat thickness may need higher pressures. Thus the insufflator pressure could be tailored to the patient based on their body composition (Becker et al., 2016).

To attain a pneumoperitoneum there are two possible main techniques: a closed technique with the use of a Veress needle, and the open or Hasson technique performed through a full wall incision with a blunt trocar-cannula (Ferrão, 2016; Tapia-Araya et al., 2015).

Veress needle technique, uses as the name says, a Veress needle which consists of an outer sharp cutting tip with a spring-loaded blunt obturator within the needle that retracts into the needle once the needle as it passes through the tough body wall then advances past the sharp tip once inside avoiding injury to internal structures (Bennett, 2009). This is the most common method for insufflating the abdominal cavity. A skin puncture incision is performed in the selected abdominal area, and the abdominal wall is lifted and tensed upwards. The Veress needle is then inserted and directed caudally at a 50° angle from the skin, preferably towards the right caudal quadrant and away from the spleen. This insertion should be preferably carried out in the same site intended for the introduction of a trocar-cannula; the site is often caudal or cranial to the umbilicus. Usually the Veress needle insertion site corresponds to the second trocar-cannula (Tapia-Araya et al., 2015).

#### 2.4.7.3.1 Types of Gas

The ideal laparoscopic insufflation gas should be easily available, relatively inexpensive, colorless, highly soluble in plasma, and suitable to use for most patients and procedures. It also should be chemically stable, physiologically inert, and nonexplosive. There are several of types of gases whose use have been studied to be used in laparoscopic procedures, carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), helium (He), air, nitrogen ($N_2$), and argon (Ar) (Menes & Spivak, 2000).

#### 2.4.7.3.2 $CO_2$

Carbon dioxide ($CO_2$) is currently the insufflation gas of choice for laparoscopy. It satisfies most of the requirements for an ideal insufflation gas, being colorless, noninflammable, and rapidly excreted from the circulation (Neuhaus, Gupta, & Watson, 2001).

The hemoglobin carried by the red blood cells has a higher affinity for $CO_2$ than for other laparoscopic gases, adding a higher safety margin in the rare event of gas embolism. The high solubility of $CO_2$ in plasma is accountable for its recognized, yet overemphasized disadvantage: some degree of serum $CO_2$ elevation and a decrease in serum pH. In fact, severe hypercarbia ($pCO_2$ > 55 mm Hg) rarely seen, except in patients with depressed cardiopulmonary function. Mild hypercarbia has little or no hemodynamic effect and is well tolerated by almost all patients. Yet, with the rapid expansion of laparoscopic procedures and the change in patient demography, the potential for severe hypercarbia in some cases should be kept in mind (Menes & Spivak, 2000). Warmed and humidified $CO_2$, can also be used with minimal additional equipment and cost, which had been reported to improve temperature control (Dean et al., 2017).

#### 2.4.7.4 Complications

Intra-operative complications of laparoscopic surgery described in veterinary medicine range from 2% (Tweet & Monnet, 2005) to 35% (Buote et al., 2011), and are usually a consequence of the introduction of a Veress needle or access trocar-cannula units, or improper instrument and tissue handling. They include perforation or laceration of viscera, haemorrhage and subcutaneous emphysema, as can be seen on table 4 (Tapia-Araya et al., 2015).

An elective conversion is defined as a case that is converted to a laparotomy in the absence of a complication. McClaran & Buote, (2009) reported a 23% emergent or elective conversion rate, where an elective conversion is defined as a case that is converted to a laparotomy in the absence of a complication and emergent conversion is defined as a case that must be converted due to the development of a complication that cannot be adequately managed using laparoscopy.

Complications of laparoscopy can be minimized with proper planning and operator experience, but even experienced laparoscopic surgeons must be aware of these potential complications, therefor proper advanced training is essential before performing laparoscopy (Richter, 2001).

Table 4 Potential complications with laparoscopy adapted from McClaran & Buote, (2009)

| Intraoperative | Post-operative |
|---|---|
| Excessive hemorrhage Penetration | Incisional (subcutaneous emphysema, seroma, dehiscence, hernia, infection) |
| Anesthetic complication | Peritonitis |
| Equipment malfunction | Anemia (requiring transfusions) |
| Pulmonary complication (air embolus) | Hypotension requiring treatment Pulmonary |
| Penetration of hollow viscus | Pulmonary complication (air embolus) |
| | Port site metastasis |
| | Adhesion formation |

##### 2.4.7.4.1 Pneumoperitoneum

The pneumoperitoneum, usually created with the use of $CO_2$, necessarily raises intra-abdominal pressure, which can have significant cardiovascular, respiratory, and neurologic effects (Gerges et al., 2006).

##### 2.4.7.4.2 $CO_2$

The insufflation of $CO_2$ to deliberately create a pneumoperitoneum may cause the following complications: hypercapnia, cardiac arrythmias, depression of cardiac output, pulmonary impairment, gas embolism, gastric reflux, and increased intracranial pressure. The absorption of carbon dioxide into the blood can contribute to hypercapnia which enhances hypertension, tachycardia, cardiac arrhythmias, vasodilation, and myocardial depression. The pneumoperitoneum and hypercapnia may enhance sympathetic tone, leading to an increase in plasma catecholamines which may produce vasoconstriction, elevate central venous pressure and increase cardiac chronotropy, inotropic and sympathetically mediated arrhythmias (Quandt, 1999).

#### 2.4.7.4.2.1 Cardiovascular effects

Peritoneal stretch at pneumoperitoneum induction can stimulate a vagally-mediated bradycardia. This can be alleviated with release of pressure and ensuring that IAP does not exceed 16 mmHg. An increase in IAP causes venous return to initially increase, however, further rises causes a decrease in cardiac output. Compression of the abdominal aorta, production of neurohumoral factors and activation of the renin–angiotensin–aldosterone axis causes a raised systemic vascular resistance and has a depressive effect on myocardial contractility. The rise in systemic vascular resistance is usually greater than the reduction in cardiac output hence mean arterial pressure is usually maintained or even raised but it can be labile, especially in hypovolemic patients, and put vulnerable patient groups at risk (Oti, Mahendran, & Sabir, 2016).

Patients with normal cardiovascular function are able to tolerate well these variations in preload and afterload yet those with cardiovascular disease, anaemia, or hypovolemia require meticulous attention to volume loading, positioning, and insufflation pressures. Even so many cases of cardiovascular collapse during laparoscopy occurs in healthy patients, because of, namely, vasovagal reflex response to peritoneal stimulation from trocars or insufflation (Gerges et al., 2006).

#### 2.4.7.4.2.2 Respiratory effects

Creation of a pneumoperitoneum with an IAP of 15 mmHg reduces respiratory system compliance, and increase peak inspiratory and mean airway pressures, yet they quickly returned to normal values after deflation (Rauh, Hemmerling, Rist, & Jacobi, 2001).

Elevated IAP reduces diaphragmatic excursion and shifts the diaphragm cranially, resulting in the early closure of smaller airways that lead to intraoperative atelectasis with a decrease in functional residual capacity. In patients with significant pulmonary dysfunction, pre-operative pulmonary function testing including arterial blood gas analysis should be a must, and intraoperative radial artery cannula should be placed. If refractory hypoxemia, hypercapnia, or high airway pressures occur during the laparoscopy, the pneumoperitoneum should be released followed by slow reinsufflation using lower IAPs (Gerges et al., 2006).

###### 2.4.7.4.2.3 Neurological changes

Increases in intra-abdominal pressure are associated with increases in intracranial pressure and decreases in cerebral perfusion pressure even at low levels of IAP. This can also happen whenever hypercapnia, increased systemic vascular resistance, head-down positioning, are present. Because of this phenomenon, it is inadvisable to perform laparoscopic surgery on patients with reduced intracranial compliance unless absolutely necessary (Deeren, Dits, & Malbrain, 2005).

#### 2.4.7.5 Gonadectomy using laparoscopy

As discussed previously there are several techniques to achieve gonadectomy of the female dog, Below, are described two techniques: laparoscopic OVH and laparoscopic OVE. Both of these procedures, can be performed in several ways, mainly varying the number of portals used. As with normal OVH and OVE, laparoscopic OVH and laparoscopic OVE are very similar in terms of short and long term outcomes, mainly varying the time to be performed, with less surgical time for the second one (Corriveau et al., 2017).

In female dogs, laparoscopic sterilization provides a greatly improved view of the surgical field because of the enhanced illumination and magnification afforded by the instrumentation, which may decrease the risk of intraoperative complications such as haemorrhage or incomplete removal of ovarian tissue. Studies have shown that LapOVH is associated with less pain and surgical stress, compared with open OVH (Davidson et al., 2004), and that LapOVE is associated with a shorter recovery time than open OVE when post-operative activity levels are compared (Culp et al., 2009).

##### 2.4.7.5.1 LapOVE

There are several techniques described to perform a Lap OVE, however there has been a general trend towards reducing the number of portals in order to reduce the related surgical trauma (Katić & Dupré, 2017). A study by Dupré and colleagues (Dupre et al., 2009), compared single and dual portal (telescope with working channel) techniques using a 5 mm vessel-sealing device, no significant difference was found for the respective surgical times. Another study, done by Case, Marvel, Boscan, & Monnet,(2011), compared the use of one, two and three portal techniques, where the two portal technique had less surgical time than one portal technique, and less total pain score than the three portal technique. Though, it is an important detail to note that they used vessel-sealing devices of different shaft diameters, different seal and cut lengths, all of the procedures analyzed, and the sample size was limited to a total of 18 dogs, dividing into 3 groups.

Recent studies have tried a one port approach, known as single incision laparoscopic surgery (SILS). Single-Laparoscopic port multiple access devices, accommodate two to three instruments, plus a telescope and an insufflation cannula, and are inserted through a single, ventral, 2 to 3 cm long midline incision. Laparoscopic ovariectomy is then performed similarly to how it is performed in the three-port technique (Manassero & Viateau, 2018).

The following technique described is one that uses two portals given that is the number of portals used to perform the LapOVE in the study of this dissertation.

#### 2.4.7.5.1.1 Technique

A skin incision, approximately 12 mm long, is made 2 cm caudal to the umbilicus. The first trocar (caudal trocar) is inserted using a blind technique. The laparoscope is inserted and a thorough inspection of the abdominal cavity is performed. After removal of the Verres needle, a 5 mm trocar-canulla is placed cranial to the umbilicus and slightly paramedian while being observed through the laparoscope to avoid entering the falciform ligament, the dog is then placed in right lateral recumbency (Dupre et al., 2009). A recent study reported that the 45º table rotation provided the best ovary visualization, regardless of body side or observer experience (Liehmann, Mag, & Dupré, 2017). Subsequently, the laparoscope is changed to the cranial cannula and grasping forceps into the caudal cannula, the ovary is suspended to the lateral abdominal wall by use a laparoscopic ovariectomy hook. The grasper is replaced with a vessel-sealing device and the ovarian pedicle, suspensory and proper ligaments are sealed and transected. After that, the vessel-sealing device is exchanged with a grasper and the ovary is removed through the cannula or the abdominal wall. After re-establishing the pneumoperitoneum, and with the dog repositioned in left lateral recumbency the right ovariectomy is performed and the portals closed. In the end the abdominal cavity is inspected again, followed by routine closure (Dupre et al., 2009).

#### 2.4.7.5.2 LapOVH

The technique below is a three-median-portal laparoscopy-assisted technique. Similar types of this technique have also been used for treatment of canine pyometra (Adamovich-Rippe et al., 2013; Corriveau et al., 2017).

#### 2.4.7.5.2.1 Technique

The animal is placed in a 15-degree Trendelenburg position by elevating its caudal end. A pneumoperitoneum is established by a closed or open (Hasson) technique. A working cannula is inserted on the midline approximately 3 cm caudal to the umbilicus to introduce the laparoscope. Two additional midline cannulas are placed under direct laparoscopic visualization at 3 to 5 cm cranial to the umbilicus and 3 to 5 cm cranial to the pubis in large-breed dogs (Fransson, 2018).

A blunt probe is inserted in the most caudal portal, and the spleen and colon are retracted away from the left ovary. Tilting the patient to the right helps visualization. After the ovary has been identified, grasping forceps replace the blunt probe, which are used to elevate the ovary. A bipolar sealing device is introduced in the most cranial portal and used to seal and transect the suspensory ligament and surrounding structures. After the ovarian pedicle is transected it should be observed for haemorrhage. The procedure is repeated on the right side. With the ovary and uterus held away from the portal site, the portal incision is extended with a scalpel blade to 15 mm or larger, depending on the size of ovaries, so that the uterine horns and ovaries can be exteriorized. After the uterus has been exteriorized, conventional ligatures are placed around the uterine body before it is transected. The caudal incision is covered with moist gauze, and the abdomen is reinsufflated and inspected for haemorrhage. Portal sites are closed with simple interrupted sutures of 3-0 to 2-0 monofilament absorbable suture in the rectus fascia and buried 4-0 absorbable suture in the subcutaneous tissue and skin (Fransson, 2018).

#### 2.4.7.5.3 Challenges and complications to both procedures

Challenges to both procedures are related with longer surgical times and the existence of an association between obesity and difficulty accessing ovaries. There has also been a connection between number of heat cycles and the occurrence of intraoperative bleeding in dogs however using appropriate vessel-sealing equipment allows the procedures to be performed safely. Removal of samples can be problematic if the necessary steps are not taken, including enlarging the port incision or placement of samples into sterile retrieval bags. Because single-port devices are generally placed through larger incisions exteriorization of reproductive organs is generally facilitated with their use (Buote, 2015).

If the structures are transected too close to the abdominal wall due to improper use of cautery and transabdominal suspension sutures, it can cause an increase of the likelihood of collateral thermal injury, particularly in the hands of an inexperienced laparoscopic surgeon (Devitt et al., 2005)

Regardless of ligation method, the stated incidence of pedicle hemorrhage has been reported in the range of 3% to 30% with most hemorrhage being minor (Buote, 2015).

One of the most common, if not the most common intraoperative complications is insertional trauma to intra-abdominal organs, most commonly the spleen. Splenic trauma with the initial trocar or Veress needle placement will result in bleeding into the abdominal cavity and has been reported in 5% to 18.7% of cases (Buote, 2015).

Potential post-operative complications include incisional problems including seroma, hematoma at the hook or suspension suture site, port site infection, retained ovarian tissue, intermittent vaginal hemorrhage, herniation of omentum through an incision site, and ongoing bleeding from a pedicle. An overall post-operative complication rate of 3.9% to 31% has been reported (Buote, 2015).

#### 2.4.7.6 Learning Curve

The primary constraint for the initial acquisition of the surgery skill appears to be developing the necessary perceptual-motor coordination to carry out the procedures successfully (Ericsson, 2004)

The basic skills required for laparoscopic surgery include visual and spatial abilities, ambidexterity, hand–eye coordination, instrument targeting accuracy, depth perception (Rosser, Rosser, & Savalgi, 1998).

The biggest challenges and differences from standard surgery include the use of long instruments, which magnifies any tremor and limits tactile sensation. More important is the normal binocular vision that becomes monocular hence the associated depth perception is lost. Magnification may be an advantage due it comes with a reduced field of view, and any instrument activity outside the view becomes a liability (Fransson, Millard, & Claude, 2015).

Certain laparoscopic skills can be acquired through the use of simulators; however, refinement of such skills for application in a live animal remains an important step in the learning process (Nylund, Drury, Weir, & Monnet, 2017).

A study suggested that veterinary medical students, with assistance from an instructor, may be taught to perform laparoscopic ovariectomies with performance equivalent to that for students performing open ovariectomies (Levi et al., 2015).

#### 2.4.7.7 Future of laparoscopy surgery

One of the biggest advances in MIS in the last decade is in the field of robotic surgery. Robotics combined with computer science has been able to augment a surgeon’s skills to achieve greatly improved accuracy and precision in complex surgery. Improving technology in optics and computer science has presented virtual reality (VR) and three dimensional (3D) to operating rooms which in return, allow for the development of patient-specific models allowing planning and practice of complex surgery on VR platform before performing the actual surgery. Robotic surgery has evolved immensely since the initial operating room version Zeus (Computer Motion). Newer models of surgical robots, Da Vinci (Intuitive Surgical), feature compact mobile platforms, multiple operating arms, and superior surgeon's console equipped with surgeon-piloted stereotactic 3D immersive and ergonomic handles intuitive to human hand movements providing improved dexterity. The current platform enables remote access enabling telesurgery, without the need for the surgeon to be present physically in the operating theatre (Siddaiah-Subramanya, Tiang, & Nyandowe, 2017).

## 2.5 Pain

Merskey & Bogduk, (1994) in conjunction with the International Association for the Study of Pain (IASP) define pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage. The inability to communicate verbally does not negate the possibility that an individual is experiencing pain and needs appropriate pain-relieving treatment. Accordingly, pain is the experience associated with actual or potential tissue damage (Merskey & Bogduk, 1994). The ability to experience pain is universally shared by all mammals, including companion animals, and veterinary surgeons have an obligation to mitigate the suffering (Mathews et al., 2014). There are varying types of pain in humans and animals such as neuropathic (e.g., post-amputation pain), maladaptive, dysfunctional, nociceptive, and inflammatory pain (surgical tissue damage). Furthermore, pain may be of short duration (post-operative pain that resolves) or long term; superficial or deep, and somatic or visceral (e.g., inflammatory bowel syndrome) in origin. The mechanisms and manifestations of pain are complex; and unlike humans, animals cannot be comforted by the knowledge that pain will subside or improve (Sharkey, 2013).

Despite advances in the recognition and treatment of pain, there remains a gap between its occurrence and its successful management; the inability to accurately diagnose pain and limitations in, and/or comfort with, the analgesic modalities available remain root causes (Mathews et al., 2014). Recent surveys of peri-operative analgesic provision in small animals suggested that the use of analgesic drugs in small animal veterinary practice is sub-optimal, (Hugonnard, Leblond, Keroack, Cadoré, & Troncy, 2004; Williams, Lascelles, & Robson, 2005).

Difficulties in being able to recognize pain were cited as one of the major causes for withholding analgesics in some studies, with the main reason stating that they did not feel confident in their abilities to recognize and assess pain in animals (Hugonnard et al., 2004; Williams et al., 2005).

### 2.5.1 Surgical Stress

The stress response is the name given to the hormonal and metabolic changes which follow injury or trauma, in this case, caused by surgery. This is part of the systemic reaction to injury which encompasses a wide range of endocrinological, immunological and haematological effects. The stress response to surgery is characterized by increased secretion of pituitary hormones and activation of the sympathetic nervous system (Desborough, 2000), such as adrenocorticotrophic hormone (ACTH), cortisol, glucagon, cAMP, vasopressin, growth hormone, renin and a concomitant decrease in insulin (Benson et al., 2000). Even though these functions are beneficial in the acute survival situation, this response may, in fact, have negative effects on homeostasis and tissue healing (Moldal, Kjelgaard-Hansen, Peeters, Nødtvedt, & Kirpensteijn, 2018).

The surgical stress response is thought to be proportional to the degree of tissue trauma, the more tissue trauma, the more pain, given that pain is proportional to increasing levels of circulating cytokines (Kristiansson, Saraste, Soop, Sundqvist, & Thörne, 1999), which is a result from the surgical procedure, making it crucial to choose the ones that minimize the negative impact of surgery on the body (Moldal et al., 2018). Such as minimally invasive surgical techniques, including laparoscopically assisted procedures, that reduce the effects of tissue injury (Buunen et al., 2004).

An important factor to take into account is that the systemic administration of analgesics can decrease the stress response, and are most effective when administered pre-emptively (Benson et al., 2000). And that opioids suppress hypothalamic and pituitary hormone secretion. As in the case of morphine which can suppress the release of corticotrophin and, consequently, cortisol in normal and stress conditions (Buunen et al., 2004).

The dependence of both the endocrine response to injury and the perception of pain on similar intact afferent neural pathways has led to the notion that pain may be quantified in a more or less objective fashion by measurement of the magnitude of the neuroendocrine response (Marcovich, Williams, Seifman, & Wolf, 2002). Parameters that can be used to measure this include C-reactive protein, iron, glucose (Moldal et al., 2018) and plasma cortisol (Marcovich et al., 2002). More specific parameters to take into account in laparoscopic surgery, given that they increase in response to the stress of peritoneal distention are cortisol, prolactin, and glucose (Quandt, 1999).

Post-operative pain in animals can result in a prolonged hospital stay being detrimental to recovery because it can cause a decrease in food intake, exacerbate protein catabolism, depress respiratory function, cause cardiac dysrhythmias and central hypersensitivity to noxious stimuli, and lead to the development of chronic pain (Katz, Jackson, Kavanagh, & Sandler, 1996; Mastrocinque & Fantoni, 2003; Mathews, 2000).

Because of all this, it is of crucial importance to be able to assess pain in these patients through the use of objective measures and more subjective ones, such as pain scores (Mathews, 2000). Equally important is the choice of surgical procedures that minimize the negative impact of surgery on the body.

### 2.5.2 Glucose

The stress response to surgery is characterized by increased secretion of pituitary hormones and activation of the sympathetic nervous system and has many effects in the different system. In the pancreas, glucagon is released and insulin secretion may be diminished (Desborough, 2000), which causes an elevation of glucose after anaesthesia and surgery in dogs (Benson et al., 2000).

Insulin is the key anabolic hormone; it is synthesized and secreted by the β cells of the pancreas. It is released after food intake when blood glucose and amino acid concentrations increase. Insulin promotes the uptake of glucose into muscle and adipose tissue and the conversion of glucose into glycogen and triglycerides. It also stimulates the formation of glycogen from glucose in the liver. Protein catabolism and lipolysis are inhibited by insulin. Insulin concentrations may decrease after the induction of anaesthesia, and during surgery, there is a failure of insulin secretion to match the catabolic, hyperglycemic response. This may be caused partly by α-adrenergic inhibition of β cell secretion. In addition, there is a failure of the usual cellular response to insulin, the so called "insulin resistance", which occurs in the perioperative period. Glucagon is produced in the α cells of the pancreas. This hormone promotes hepatic glycogenolysis. It also increases gluconeogenesis from amino acids in the liver and has lipolytic activity. Although plasma glucagon concentrations increase transiently after major surgery, this does not make a major contribution to the hyperglycemic response (Buunen et al., 2004).

To summarize it, the pathophysiology behind post-operative hyperglycemia is partly induction of a hyperglycemic response by cortisol and growth hormone and partly insulin resistance and inhibition of insulin secretion, all induced by the neuroendocrine and metabolic stress response to surgery (Moldal et al., 2018).

### 2.5.3 Pain Scores

Evidence-based pain management is dependent upon the ability to detect pain in dogs, and if affected, distinguish change in their mobility, daily activities, and normal behaviors via validated, sensitive pain assessment tools (PATs) (Sharkey, 2013).

Some animals experience residual pain following a surgery or injury, whereas other animals seem to return quickly to normal function with no obvious residual pain. Responses to surgery and injury or to therapy are unique to each individual, and the differences reflect genetic variation in such factors as the number, distribution, and morphology of opioid receptors (Hellyer et al., 2007; Kim, Mittal, Iadarola, & Dionne, 2006; Landau, 2006).

In this regard, validated pain scales offer reliable methods for veterinarians/ owners to assess pain and quantify changes in pain intensity. Due to the subjective and observational nature of many PATs, validated and reliable pain scales are essential to assure the usefulness of the measure to indicate pain or predict a dog's function or quality of life. Validated PATs offer the ability to repeatedly measure pain outcomes in the individual patient and across groups. The use of validated PATs can provide the basis by which the effectiveness of pain therapies and new animal analgesics could be determined (Sharkey, 2013).

Pain measurement tools should possess the key properties of validity, reliability, and sensitivity to change. Pain is an abstract construct so there is not a gold standard for measurement and given that the goal is to measure the effective component of pain, that becomes a real challenge. This is further compounded by the use of an observer to rate the dog's pain. Few of the scales available for use in dogs have been fully validated (Mathews et al., 2014).

Until recently, the methods used to assess pain in animals were the scales used in human beings; the simple descriptive scale (SDS), the numerical rating scale (NRS), and the visual analogue scale (VAS). However, these scales have been shown to be unreliable in the assessment of acute pain in dogs in a hospital setting; moreover, they measure only one dimension of the pain experience, namely its intensity, whereas multidimensional or composite rating scales also take into account the sensory and affective qualities of pain (Murrell, Psatha, Scott, Reid, & Hellebrekers, 2008).

When using these scales, the observer's judgment can be affected by factors such as age, gender, personal health, and clinical experience, thus introducing a degree of inter-observer variability and limiting the reliability of the scale.  However, when used consistently, these are effective as part of a protocol to evaluate pain as described above. Composite scales include the Glasgow Composite Measure Pain Scale and its short form (CMPS-SF) which is validated for use in measuring acute pain, is a clinical decision-making tool when used in conjunction with clinical judgement. Intervention level scores have been described (i.e. the score at which analgesia should be administered), thus it can be used to indicate the need for analgesic treatment (Mathews et al., 2014).

#### 2.5.3.1 Glasgow Composite Measure Pain Scale

The development of the Glasgow Composite Measure Pain Scale (CMPS) by Holton, Pawson, Nolan, Reid, & Scott, (2001) was prompted by the need for a valid, reliable and statistically useful measure of pain in animals, and the further application of a scaling model to convert the prototype into an interval level scale (Morton, Reid, Scott, Holton, & Nolan, 2005) gave scope for varied and detailed statistical analyses of pain score results and opportunities for more effective monitoring of acute pain and analgesic efficacy in the clinical research setting. However, such advantages come at the expense of simplicity and are costly in terms of the time required to complete the questionnaire hence the creation of the short form, to simplify the scale where possible, ensuring that it can be completed in as short a time as possible, and defining an intervention level for analgesic administration. The CMPS, is a behaviour-based composite scale to assess acute pain in dogs (Holton et al 2001). It takes the form of a structured questionnaire completed by an observer following a standard protocol which includes assessment of spontaneous and evoked behaviours, interactions with the animal, and clinical observations. The questionnaire consists of seven behavioural categories: posture, activity, vocalization, attention to wound or painful area, demeanour, mobility, and response to touch. In each category are grouped a number of words or expressions (items) from which the observer chooses that one in each category which best describes the dog's behaviour. With a total score of 24 and a score $\geq$6/24 indicating the need for additional analgesia (Reid et al., 2007).

The use of the CMPS-SF has been validated by Murrell, Psatha, Scott, Reid, & Hellebrekers, (2008) and the scale was shown to be a reliable clinical tool for identifying different pain intensities as well as changes in pain score over time in a population of dogs undergoing a variety of surgical procedures (Kim et al., 2012).

Also, one of the reasons for this study to use this composite pain scoring system has to do with the fact, that the hospital where this study was conducted was already using it and has the main tool in evaluating pain, and therefore, the staff has already accustomed and proficient in using it in case any doubts appeared to the author.

## II. Study Case

### 1. Objectives

The main objective of this study was focused on comparing several aspects that entail the surgical procedures of OVH and LapOVE, from the day the procedures are performed to the post-operative check-up, to evaluate both techniques. On that basis, the following parameters were compared: surgical times; glucose; temperature; pain scores and complications.

### 2. Experimental design

The study was perfomed using two groups of animals, female dogs, with the objective of perfoming gonadectomy. In one of the groups a convencional OVH was done and in the other gonadectomy was perfomed using a 2-port LapOVE. In both of them several parameters were recorded: surgical times; glucose; temperature; pain scores and complications during the procedures.

### 3. Materials and methods

#### 3.1 Materials

##### 3.1.1 Animals

Patients would be assigned to either the OVH group or the LapOVE, the decision of the surgical procedure done in each patient was made by their owners who were aware of the risks that entail each procedure. The inclusion criteria for a patient to be in this study was to have over 5kg given that the hospital did not do laparoscopic surgery under that weight.

##### 3.1.2 Surgical Material

A conventional surgical kit with: forceps, scissors, scalpel and needle holder was used for both procedures, adding specific instruments for the laparoscopy procedure which can be found on table 5. The same type of anaesthetic machine was used for both cases. The surgical set up for the LapOVE can be seen on figure 5

Figure 5 Surgical set up for LapOVE (Original)

Table 5 Specific Laparoscopic equipment

| Material | | Product used |
|---|---|---|
| **Equipment** | Camera | Karl Storz telecam c-mount one chip camera head |
| | Power Source | Veterinary Video Camera III |
| | Monitor | 17" Neovo Medical Grade LCD Monitor |
| | Light Source | Advantage LED Light Source |
| | Insufflator | Advantage 15 Ltr Automatic Insufflator (figure 6) |
| | $CO_2$ | $CO_2$ Cannister |
| | Electrocautery | Advantage VetSEAL Vessel Sealing Unit (figure 6) |
| **Instruments** | Bipolar | VetSeal 10mm Thermocut Handpiece |
| | Telescope | 5mm 0 Degree Laparoscopy Glass Rod Telescope |
| | Trocar-cannula | Laparoscopic Magnetic 10.5mm Trocar Sheath-Threaded |
| | | Laparoscopic Magnetic 5.5mm Trocar Sheath-Threaded |
| | Trocar Tip | Advantage 10.5mm Laparoscopic Pyramidal Tip Trocar |
| | | Advantage 5.5mm Laparoscopic Pyramidal Tip Trocar |
| | Palpation Probe | Laparoscopic 5mm Palpation Probe |
| | Forceps | Laparoscopic 5mm Babcock Grasping Forceps |
| | Veress Needle | Advantage Laparoscopic Veress Needle 2.5x 120mm |

The laparoscopic tower components were the monitor, insuflator, Co2 cannister and the light source, figure 7.

Figure 6 Electrocautery and bipolar (With authorization from Freelance Surgical Veterinary Divison)

Figure 7 Laparoscopic tower (original)

## 3.2 Methods

The patients had to be in a kennel for at least one hour to acclimate to the kennel. All information was recorded on a monitoring document which can be seen on appendix 1. Both procedures were done by the same surgeon.

### 3.2.1 Patient preparation

Owners were advised to not feed their animals the night before, which meant approximately 12 hours of fast before surgery. The patients were admitted to the hospital in the morning between eight and nine, and placed in a kennel. A 20 G x 1.25 in. or 22G x 1 in. intravenous catheter was placed in the cephalic vein of the right or left anterior member, according to the size of the patient. The catheter was used for intravenous drugs and fluids if necessary. Under anaesthesia the ventral abdomen was clipped, extending just caudal to the rib cage and cranial to the pubis. In the case of the LapOVE the clipping area was extended laterally to the lumbar muscles, as can be seen in figure 8. Also, in the case of the LapOVE the bladder was expressed. Afterward, the area clipped is scrub with chlorhexidine 4% in a 1:1 dilution with water.

Figure 8 Clipping area for LapOVE (original)

### 3.2.2 Anaesthetic Protocol

All dogs in both procedures were pre-medicated with methadone (0.3mg/kg) and medetomidine (0.01mg/kg) intramuscularly and meloxicam (0.2 mg/kg) has also administrated, subcutaneously at the same time. No antibiotics were used. Induction was done with propofol (2 mg/kg) intravenous and the patient was intubated after and kept under maintenance with isoflurane and oxygen in an appropriate concentration. Monitorization was done by checking all vital parameters every five minutes, in combination with a pulse oximeter (Edan h100b) and a multiparameter monitor (CARDELL Veterinary, Monitor 9500 HD).

### 3.2.3 Patient Position and surgical field preparation

After the patient has been prepared, he is carried to the surgical theatre. In both cases, once he is placed on the operative table, he is again scrubbed with chlorhexidine 4%.

#### 3.2.3.1 LapOVE

The procedure takes place in the laparoscopy surgical theatre as shown in figure 9. The patient is positioned in dorsal recumbency, and two sandbags are placed laterally to keep the patient in a stable position, as shown in figure 10. Once the surgeon is ready, four extra-large drapes are placed on the patient in a diamond shape, all cables are then set up, and all of the laparoscopic equipment assembled.

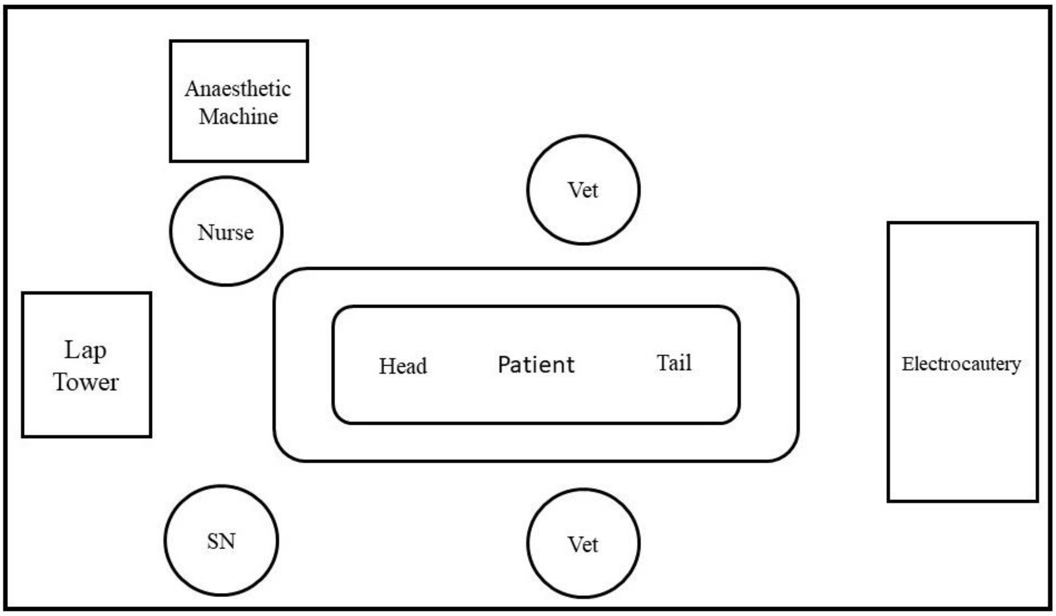



Figure 9 Surgical theatre and staff disposition (original)

Vet – Veterinary surgeon;
SN - Second veterinary nurse;
Lap tower – Laparoscopic tower

Figure 10 Patient position (original)

#### 3.2.3.2 OVH

The procedure takes place in the soft tissue surgical theatre as shown in figure 11, once the surgeon is ready, a drape is placed on the patient, the size of which depends on the size of the patient.

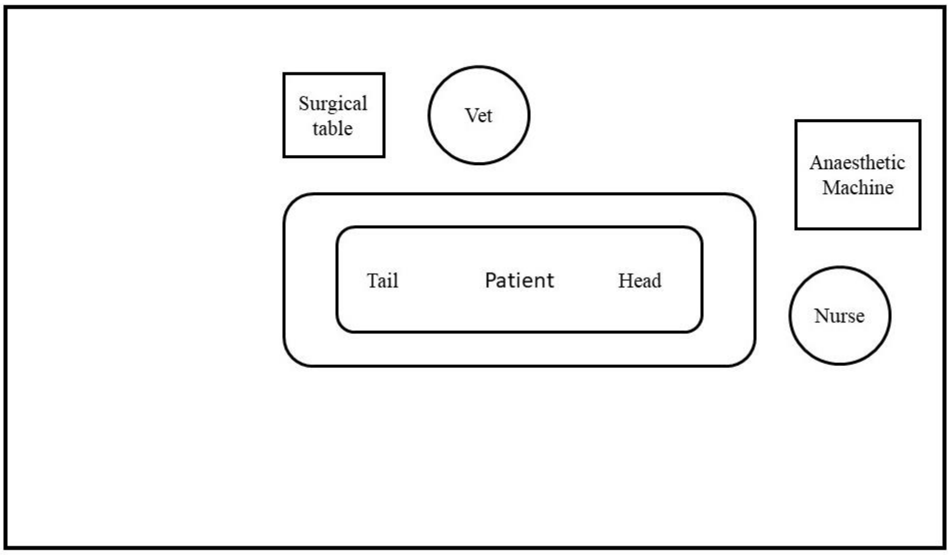



Figure 11 Soft tissue surgical theatre (original)

### 3.2.4 Surgical procedure - LapOVE

Figure 12 shows the set up before the first incision is done.

Figure 12 Set up before the first incision is made (original)

#### 3.2.4.1 Pneumoperitoneum

The first step is establishing pneumoperitoneum, this is done with a first incision on the skin two to three cm cranially to the umbilicus with an 11 blade. The Veress needle is inserted and directed caudally towards the right caudal quadrant to avoid the spleen. When the needle is in place the insufflation is turned on, and the intra-abdominal pressure should start going up slowly until it reaches 10mmHg, figure 13. If pressure immediately rises to 10mmHg, a possible reason is the Veress needle not being in the desired tissue space.

Figure 13 Veress needle and CO2 tube in place

#### 3.2.4.2 Trocar – cannula position

An incision is made two cm caudally to the umbilicus, with an 11 blade, and a 5.5mm trocar is placed, this is where the laparoscope is going to go throw. The abdominal cavity is observed to see if there was any puncture of a vital structure. After that, the $CO_2$ cable is switched to the 5.5mm cannula and the Veress needle is removed followed by a 10.5mm trocar that is placed where the Veress needle was while being observed through the laparoscope to avoid entering the falciform ligament or damaging any structure (figure 14). Another full inspection of the abdominal cavity is done. The $CO_2$ cable is then attached to this cannula.

Figure 14 Both trocar's positioned

#### 3.2.4.3 Surgery

After the port placement, the patient is rotated to the left towards the side of the surgeon, to move the duodenum and other intestines that are often overlying the right ovary. The ovary is visualised just caudal and lateral to the kidney and grasped with Babcock forceps that are introduced in the cranial port. It is then held up against the abdominal wall and the Babcock forceps are laid down to retain the ovary in an elevated position. The site of contact with the abdominal wall is determined by palpation on the external abdominal wall while observing the peritoneum through the endoscope. Once the site is determined, an ovariectomy hook (Karl Storz) is placed through the abdominal wall to hold the ovary in place (figure 15). The weight of the handle of the hook maintains position just by laying the handle down on the patient.The Babcock's can then be removed and replaced with a bipolar cutting device (VetSEAL). The ovarian ligament, pedicle and uterine attachments are transacted and cauterised to free the ovary. Dissection should be as close to the ovary as possible to reduce the amount of fat surrounding the ovary once it is dissected free, which in turn facilitates the removal of the ovary from the abdomen (figure 16). Once the ovary is dissected free, (figure 17) the uterine horn and remains of the pedicle are inspected for haemorrhage and the bipolar device is removed from the abdomen and replaced by the Babcock's forceps. The ovary is grasped, being careful to avoid just grasping fat, and the ovariectomy hook is then removed allowing the ovary to be retracted to the mouth of the cannula. The laparoscope is withdrawn into the caudal cannula to prevent iatrogenic damage as the patient is rotated back into dorsal recumbency.

Figure 15 Ovary being held by the spay hook (original)

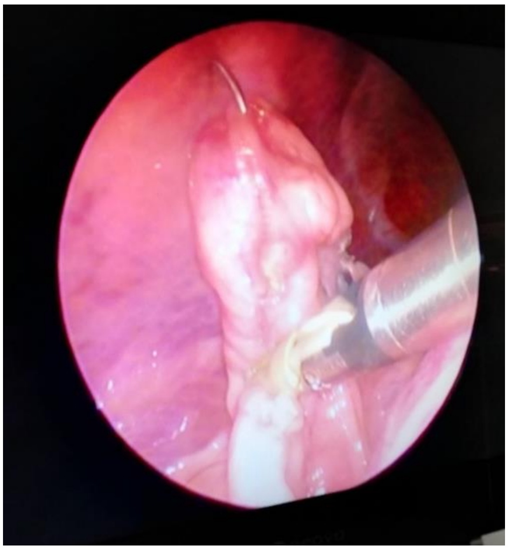


Figure 16 Advantage VetSeal sealing and cutting the surrounding tissues (original)

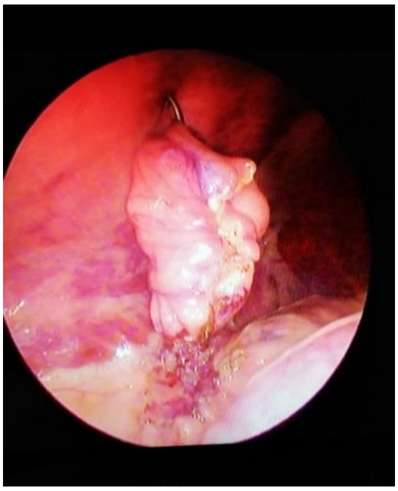


Figure 17 Ovary ready to be removed (original)

The ovary is removed from the abdomen either throw the lumen of the cannula or if it is too large, by removal of the cannula and direct traction through the body wall. It is usually best to gently remove the cannula and apply a gentle back and forth twisting motion to exteriorise the ovary enough to allow it to be grasped with artery forceps (figure 18). These are then used to carefully tease the ovary out.

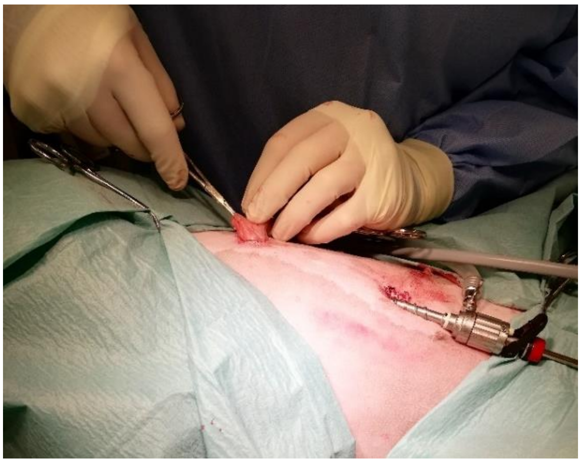


Figure 18 Ovary being removed with artery

Once removed and examined, the cannula can then be replaced and pneumoperitoneum is re-establishing, the procedure is repeated on the other ovary. The patient is tilted to the right since the spleen might be overlying the kidney and ovary, and the surgeon swaps sides. Once the ovary has been removed, both of the ovaries are again observed to make sure all of the structure was removed (figure 19) afterward the abdominal cavity is desufflated and closure routine is followed with a synthetic absorbable suture (figure 20)

Figure 19 Both ovaries once removed

Figure 20 Aspect of the wound after closure

### 3.2.5 Surgical procedure - OVH

Depending on the size of the dog, an incision is made in the midline of the abdominal caudally to the umbilicus. Once the ovary is identified the suspensory ligament is broken, a three-clamp technique is used and the ovarian pedicle is ligated using polydioxanone. The same is done for the other side, after which the uterine body is also ligated using an encircling ligature with the same suture material. Following removal of the ovaries and uterus, the incision is closed in layers, including the body wall, subcutaneous tissue, and skin, this last two with a monofilament absorbable suture (figure 21).

Figure 21 Aspect of the wound after surgery

### 3.2.6 Surgical time

Surgical time was divided into the following categories: Preparation, from the moment the patient was intubated until the first incision; Surgery, the time between the first incision and final stitch; and total procedure, from the time the patient was intubated until it was extubated.

### 3.2.7 Temperature

Oesophageal temperature was measured with the CARDELL Veterinary, Monitor 9500 HD, at the time of the first incision (T1) and at end of surgery (T2).

### 3.2.8 Glucose

Glucose was measured before the patient was premedicated (T1) and one hour after extubation (T2). This was done by measuring blood glucose obtain from the marginal ear vein with a glucometer, Zoetis alphatrack 2, with a normal range of 4.1–7.9 mmol/L (IDEXX Laboratories, 2015)

### 3.2.9 Pain scores

Pain scores were evaluated one, two and three hours after extubation (T1, T2, and T3 respectively). This was done always by the same person, the author of this dissertation, with the CMPS-SF.

### 3.2.10 Complications

Complications were divided into intraoperative and post-operative. The intraoperative complications were subdivided into technical incidents and procedure related. The post-operative group was subdivided into minor wound complications and gastrointestinal signs

### 3.2.11 Post-operative

After the surgery and stopping the isoflurane, oxygen was still administrated for a short while, after which they were disconnected from this and extubated when the laryngeal reflex was detected. They were kept in the kennel until they were discharged in the afternoon and were fed after the glucose was measured. Follow up for the OVH was three days and seven days after surgery, they were sent home with a buster collar and exercise restriction which could be increased if appropriate in the first post-operative check. For the LapOVE procedure the first post-operative check has ten days after, they were also sent home with a buster collar but without any restrictions, they could go back to their normal routine as soon as they were home. In both types of procedures, oral meloxicam (0.01mg/kg) was prescribed to be given with food once a day.

## 3.3 Statistical analysis

Data was analysed using Microsoft® Excel 2016, R© for Windows 10 (version 3.6.0), and the lme4 package. R© is free software environment for statistical computing and graphics.
General descriptive statistics were used for both quantitative and qualitative variables. Numerical variables were expressed using median, and range (minimum to maximum value). Quantile comparison plots were elaborated to see the probability distribution of the temperature and glucose. Linear mixed models were used in order to analyse the relationship between glucose and procedure over time and another for temperature and procedure over time. As fixed effects, we had temperature in the first one and glucose on the second one, and as random effects, we had intercepts for time and procedure. P-values with a confidence level of 95% were obtained by the Anova (Car library).

# 4. Results

## 4.1 Populational sample

This study was composed of 24 cases, OVH group has 10 cases and the LapOVE group with 14 cases. The age and weight of both groups can be found on table 6. The groups were not normally distributed.

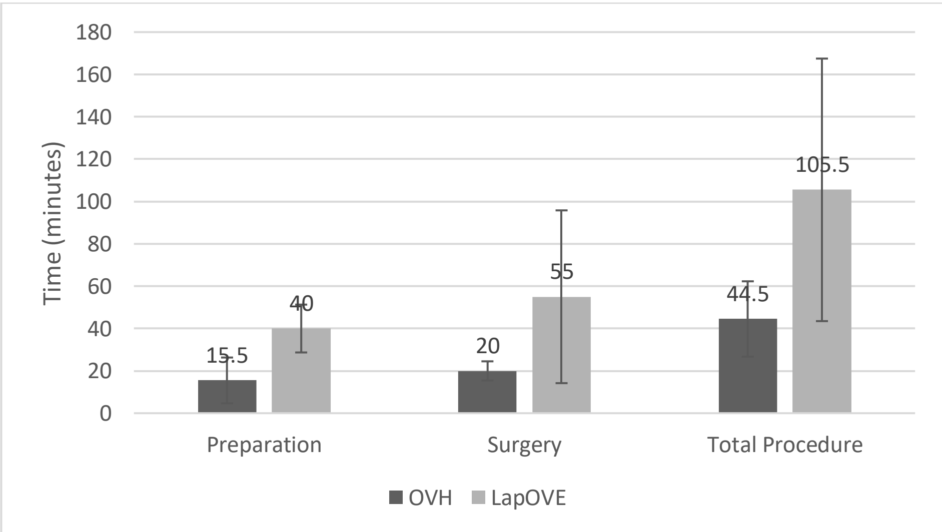
Table 6 Age and weight of the animals of both study groups

| *Group* | *Median of age (in months)* | *Weight (kg)* | *Number of patients* |
|---|---|---|---|
| *OVH* | 14 ± 22.3 (IQR) | 8.6 ± 5.3 (IQR) | 10 |
| *LapOVE* | 14 ± 19.00 (IQR) | 20.0 ± 9.2 (IQR) | 14 |

## 4.2 Surgical Time

Three patients undergoing LapOVE, had an extra procedure done, flushing of the right eye duct. The median for preparing the patient for LapOVE was 40 minutes while OVH 15.5 minutes. The median time of surgery for OVH was 20 minutes and LapOVE was 55 minutes. In the OVH group the fastest surgery was 17 minutes and the longest 44 minutes. For the LapOVE group it was 37 minutes and 108 minutes respectively. In total the procedure took considerable more time in the LapOVE group than the OVH group, graph 1.

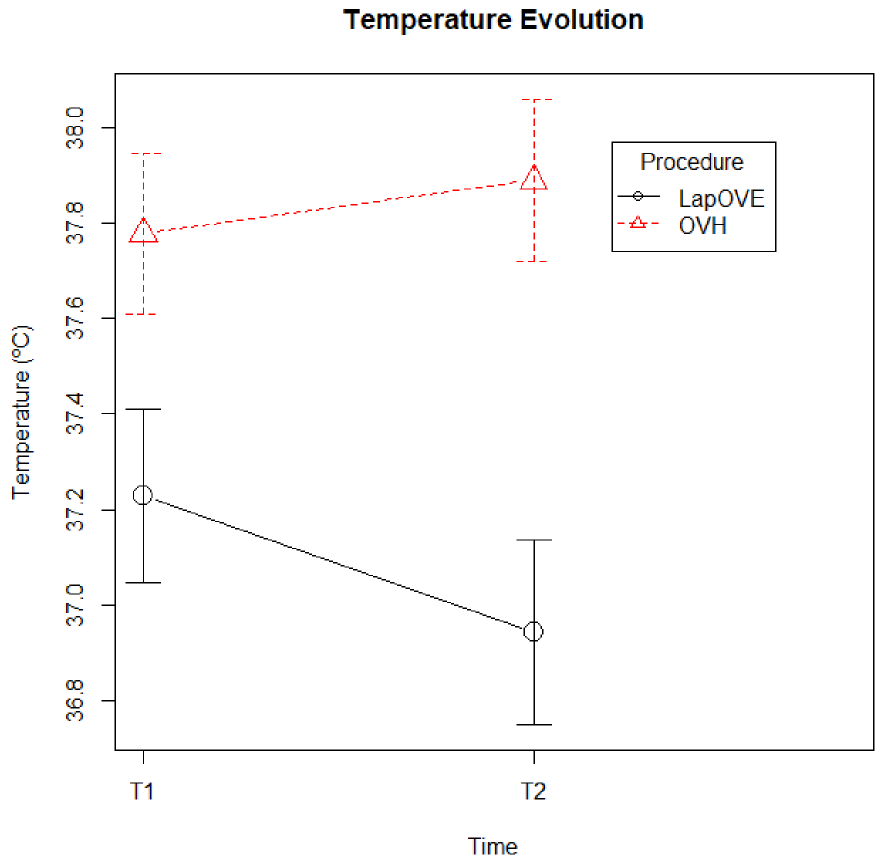
**Graph 1** Surgical times of the different steps according to the procedure with error bars of the interquartile range




## 4.3 Temperature

As observed in graph 2, the temperature raised on the OVH group, while on the LapOVE it steadily decreased. The mean of difference of temperature in both groups show that the OVH group raised 0.1±0.1 ºC and the LapOVE decreased 0.3±0.3 ºC.

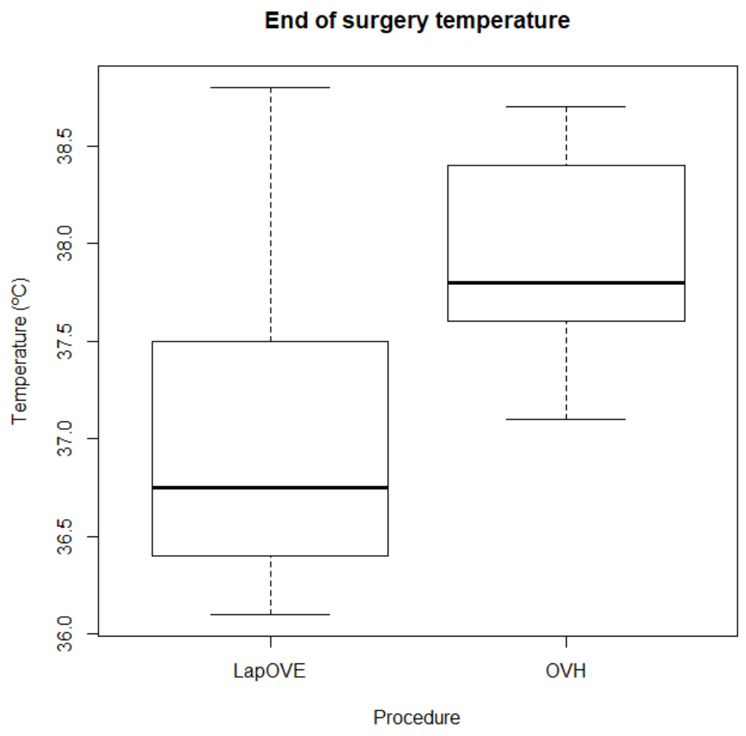
**Graph 2** Plot of means of temperature evolution according to the procedure with the error bars of the standard deviation




T1 – Before first incision
T2 – After end of surgery

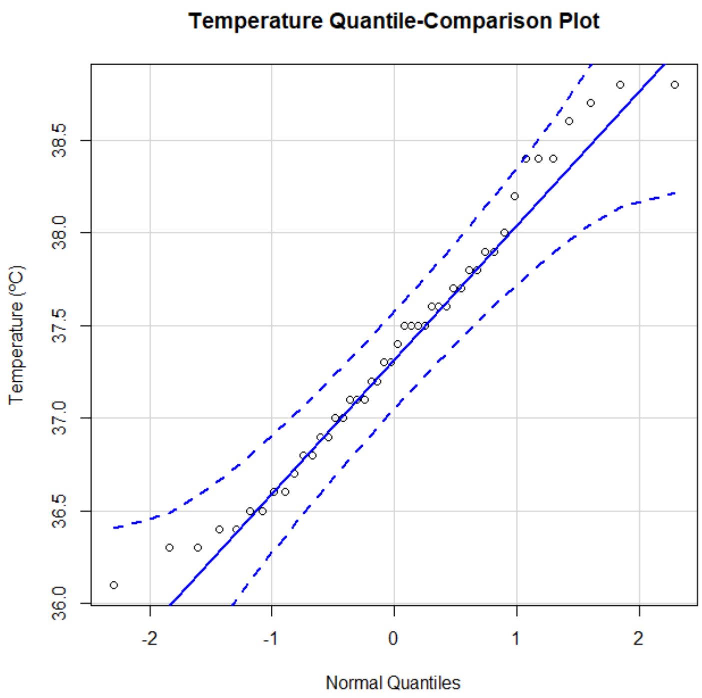
Graph 3, shows the temperature at the end of the surgery for both procedures we conclude the IQR for the LapOVE is 1.0ºC, with a lower quantile of 36.4ºC and the upper quantile with 37.4ºC . In the OVH procedure the IQR is 0.8ºC with a lower quantile of 37.6ºC and the upper quantile with 38.4ºC.

**Graph 3** Boxplot of the end of surgery temperature by procedure




In graph 4, most points fall near the line, although there are some deviations. The solid blue line represents a perfect distribution fit and the dashed blue lines are the confidence intervals of the perfect distribution fit. We found a significant effect of the procedures over time on temperature levels (P <0.0003).

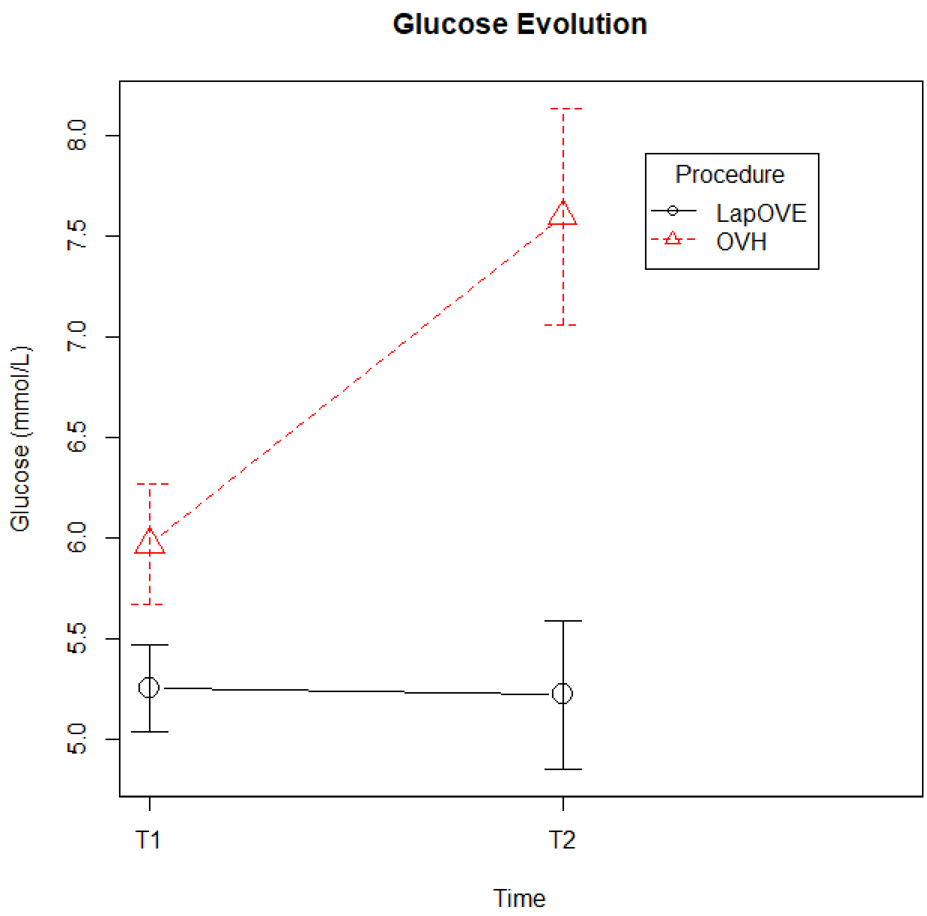
**Graph 4** Quantile-Comparison Plot of the temperature



### 4.4 Glucose

As observed on graph 5, the glucose raised on the OVH group 1.6±2.1 mmol/L, while on the LapOVE it decreased. 0.03±1.4 mmol/L

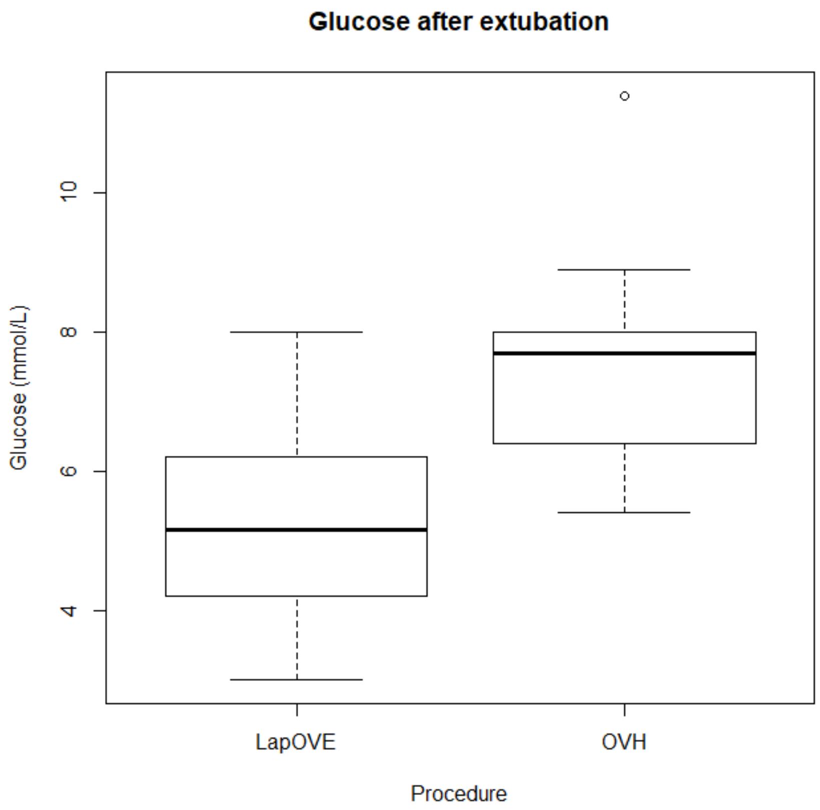
**Graph 5** Plot of means of the glucose evolution difference according to the procedure with the error bars of the standard deviation




T1 – Before surgery
T2 – One hour after extubation

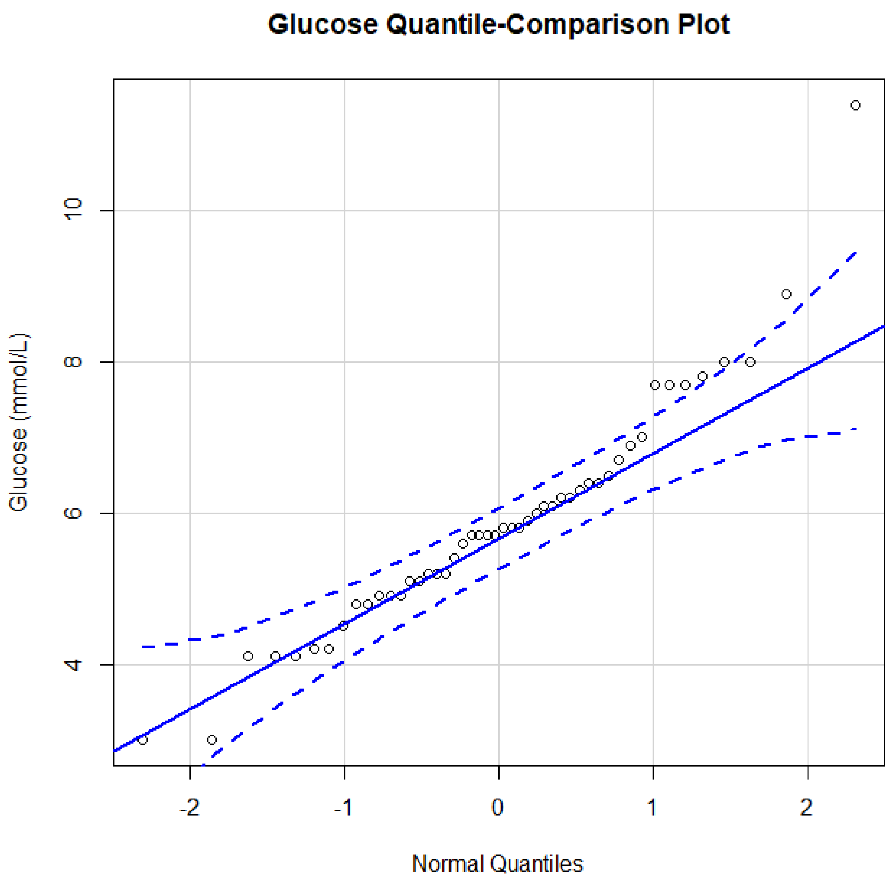
In graph 6 representing the level of glucose one hour after extubation the IQR for the LapOVE is 1.9 mmol/L, with a lower quantile of 4.4 mmol/L and the upper quantile with 6.2 mmol/L and in the OVH procedure the IQR is 1.5 mmol/L with a lower quantile of 6.5 mmol/L and the upper quantile with 8.0 mmol/L.

**Graph 6** Boxplot of glucose after extubation by procedure




By observing graph 7 most of the points fall near the line although there are some deviations and outliers. The solid blue line represents a perfect distribution fit and the dashed blue lines are the confidence intervals of the perfect distribution fit. We found a significant effect of the procedures over time on glucose levels (P <0.016).

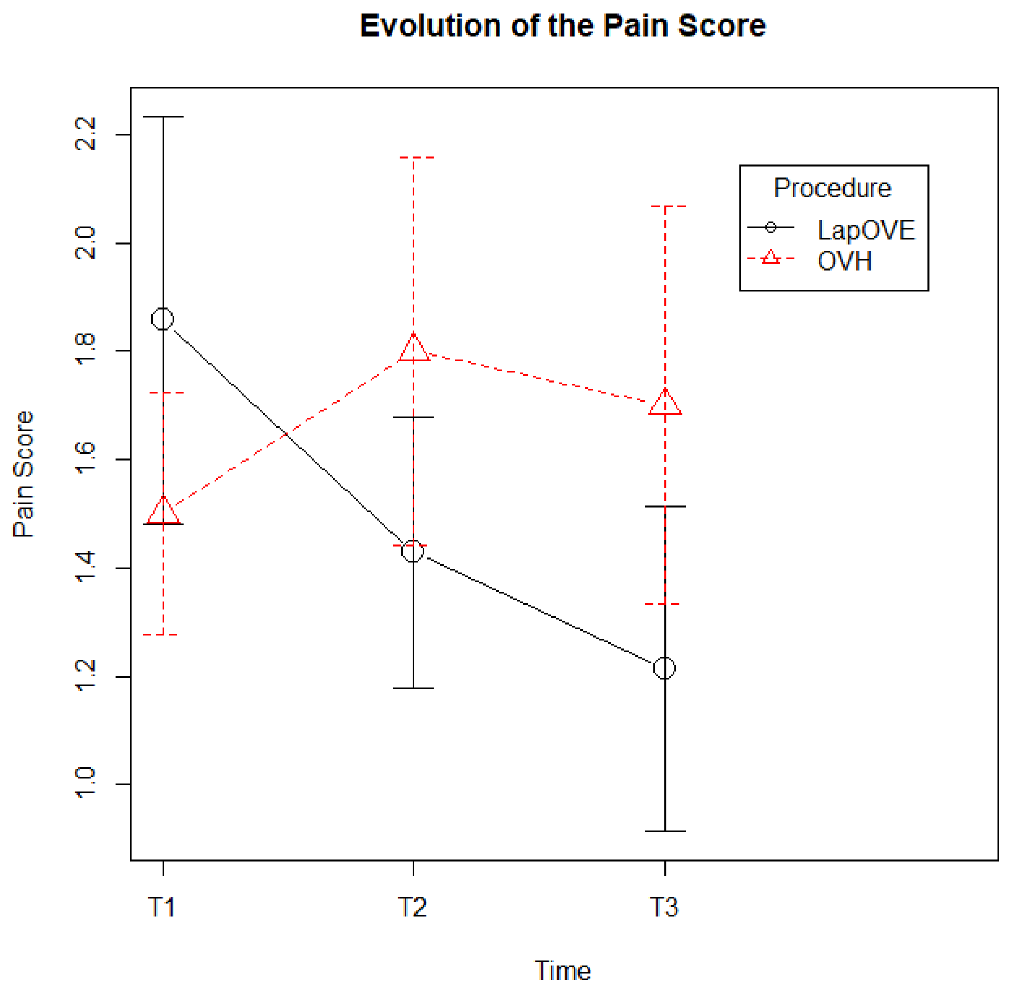
**Graph 7** Quantile-Comparison plot of glucose



## 4.5 Surgical Pain

In order to see if there was any difference in the pain scores after surgery between procedures, a plot of means of the pain score was done as seen on graph 8.

**Graph 8** Plot of means of the evolution of the pain score




T1 – One hour after extubation
T2 – Two hours after extubation
T3 - Three hours after extubation

The LapOVE group scores a higher pain score on the first hour after extubation, but it decreases steadily. The OVH group has a better score in the first hour, increasing on the second hour, and decreasing after. Performing a Wilcoxon rank sum test we come to the conclusion that there is not any significant difference in pain scores between the procedures in any given time T1 (P<0.64), T2 (P<0.44) and T3 (P<0.22).

## 4.6 Complications

**Graph 9** Complications intraoperative and post-operative of both procedures


The instrumentation problems occurred in the LapOVE technique in three patients (21%). The first one was the $CO_2$ cannister running out and having to be switched. The second one, had to do with the blade of the Advantage VetSEAL being blunt and causing a longer time to seal and cut the structures. The last one was a piece that got dropped on the floor and the surgeon had to wait for it to be autoclaved. Although these problems could have been avoided with better preparation and attention, they still caused a delay. In terms of procedure complications from the OVH technique, pedicle haemorrhage occurred in two patients (22%) due to the ligature placement, with no further complications. With the LapOVE, there were complications reported in three patients (21%), in one patient there was a lot of difficulty in introducing the Veress needle and ensuring with was placed in the abdominal cavity. Another had an ovarian which was bigger than the incision made by the trochanter and had to be taken by pieces, eventually the instruments had to be placed back in place to retrieve what had also fallen in the abdominal cavity; Lastly one of the patients had an intestine adherence to the abdominal wall given that it had undergone an exploratory laparotomy in the past. When the Veress needle was introduced it puncture the intestine. Regarding post-operations complications in both cases, we had minor wound complications, which were swelling, rash, or inflammation, four patients in the LapOVE group (29%) and one patient in the OVH group (11%). Gastrointestinal (GI) signs were either vomiting, diarrhea or both and occurred in 4 patients of both procedures (17%)

# 5. Discussion

## 5.1 Surgical time

In our study, all the surgical procedure steps were longer for LapOVE than for OVH. The preparation phase involved a lot more steps for the LapOVE group. A lot of that time was used setting up all of the equipment to do the procedure, besides having to clip and scrub a larger surgical field. The surgical procedure had a median of 55 minutes for the LapOVE group and 20 in the OVH group. Something to consider is the flaws related to the equipment and the fact that three patients had an extra procedure done in the LapOVE. The author also arrived at the conclusion that some patients would benefit from more adequate size trocar-cannulas since the same size ones were used for patients with either 5kg or 30 kg. This was quite evident in the cases where there were difficulties removing the ovaries from the abdominal cavity in larger dogs.

The mean surgical time reported for OVH ranges from 18.6 minutes, with a mean duration of anesthesia of 44.0 minutes, Devitt et al., (2005), to 69 minutes (Davidson et al., 2004).

For the LapOVE Case et al.,(2011) reported a mean surgical time of 18.2 minutes using a 2-port procedure similar to Dupre et al., (2009) reporting 19.1 minutes and Culp et al., (2009) 30 minutes, Corriveau et al., (2017) reported 50 minutes with a total of anesthesia time of 125 minutes. However, in this report not all LapOVE were done using a 2-port technique. In a study where students received training in laparoscopic ovariectomy using a 2-port technique, the mean surgical time was reported to be 129 minutes (Levi et al., 2015).

## 5.2 Temperature

In both procedures, measures were taken to ensure the maintenance of normothermia, which included using blankets and bubble wrapping their feet.

We observed that the temperature in the LapOVE dropped steadily. The mean has a decrease of 0.3±0.3 ºC while the OVH group it raised 0.1±0.1 ºC. There was a significant effect of the procedure in the difference of temperatures at the beginning and end of the procedure. This was expected as laparoscopic procedures are a known risk factor for developing perioperative hypothermia given the prolonged surgical time and increased heat loss via exposure to $CO_2$ insufflation during pneumoperitoneum (Noll et al., 2018). Hypothermia during anaesthesia is common among surgical patients. The core temperature typically drops during the first hour of surgery. This drop in temperature is mainly attributed to the initial core heat redistribution to the peripheral tissues from the core caused by anaesthetic-induced vasodilation (vasodilation results largely from impairment of central thermo-regulatory control rather than from direct peripheral effects of anaesthetics) (Sessler, 2016).

Despite the efforts mention above to try and keep normothermia, OVH benefits from the fact that it is a shorter procedure and it is easier to use more measures to keep normothermia, for instance, more blankets, on the other hand in the LapOVE group the clip area is larger which contributes more to the loss of heat.

### 5.3 Glucose

In our study before the surgery the LapOVE group presented a median glucose of 5.15 ± 0.95 (IQR) mmol/L, and 5.15± 1.9 (IQR) mmol/L one hour after extubation. OVH preoperative had a median glucose 5.8 ± 0.65 (IQR) and 7.7±1.5 (IQR) mmol/L one hour after extubation, it showed increased levels when compared with the LapOVE group.

In order to try and explain this, several theories were proposed. In this study, we administrated medetomidine, which has been proven to obtund the surgical stress response by preventing the catecholamine response induced by surgery (Benson et al., 2000) and could, therefore, affect the glucose concentration. One could assume that since both OVH and LapOVE groups were administered medetomidine, this effect would have been shown in the mean blood glucose of both groups. Considering that an increase in glucose is induced by the neuroendocrine and metabolic stress response to surgery (Moldal et al., 2018) and that the use of minimally invasive surgical techniques, including laparoscopically assisted procedures, reduces the effects of tissue injury (Buunen et al., 2004), it would be likely that the decrease in glucose is caused by the less surgical stress that is associated with LapOVE. However, Guedes & Rude (2013), also reported that the pre-anesthetic administration of medetomidine significantly suppressed insulin secretion and increased plasma glucose concentration in healthy dogs undergoing anaesthesia and surgery.

The most likely theory has to do with the time these patients spent under anaesthesia being much longer in the LapOVE group. Meaning that when we measured the glucose, in association with the time they were starved, we missed the spike in glucose and it was already returning to normal.

Devitt et al., (2005) compared glucose levels in both OVH and laparoscopic-assisted ovariohysterectomy (LAOVH). In the OVH group, this parameter remained significantly increased up to 6 hours after extubation, and only for 1 hour in the LAOHV group. Preoperatively the LAOHV group presented a mean glucose of 4.7 mmol/L, and 5.3 mmol/L one hour after extubation, decreasing from there. OVH preoperative had a mean glucose 4.1 mmol/L and 5.4 mmol/L one hour after extubation also decreasing onwards, however, it also showed increased levels when compared with the LAOHV group.

A recent study Moldal et al., (2018) found as well that in patients who were subjected to OVH had immediately before the first incision a mean glucose of 5.9 mmol/L and just before the end of surgery, 6.4 mmol/L.

This would suggest that patients undergoing laparoscopic procedures have a reduced increase in glucose following the procedure. On the other hand, a study comparing post-operative pain between ovariohysterectomy by harmonic scalpel assisted laparoscopy and OVH found no differences in glucose variation (Hancock et al., 2005).

### 5.4 Pain scores

The complete assessment of pain for these procedures would require no analgesic or anti-inflammatory drug administration, which would not be appropriate or ethical.

In our study, we found that the patients of the OVH tend to have a lower pain score in the first hour after extubation, and increasing in the second hour. The opposite occurred with the LapOVE group. However, despite the differences, no significant differences were found between procedures in any given time and no rescue therapy was needed. Ideally the observer, in this case the author of this dissertation, should not be able to identify the procedure the patient was submitted. The author knew beforehand that and even if he did not, the procedure could still be identified just by looking at the incision line. However, and despite its disadvantage's the CMPS-SF proved to be quite useful in helping evaluation pain in the patient.

Davidson et al., (2004) compared pain scores between LAOVH and OVH using objective (University of Melbourne Pain Scale - UMPS) and subjective parameters. They reported significantly lower pain scores with LAOVH at one or more time periods after surgery. Suggesting lower scores for some pain descriptors in LAOVH dogs may be a less painful surgical procedure than OVH in dogs. Nonetheless, OVH scores were never significantly lower in any category, having no significant differences in pain scores between groups for most descriptors. The lack of significant differences in pain scores may have been because they were low at all times for most dogs.

A study comparing Harmonic scalpel-assisted laparoscopy (HALO) surgery to OVH found using physiologic data, abdominal nociceptive threshold scores and UMPS concluded that dogs appeared to be in less pain with HALO than OVH, and that OVH had higher UMPS scores in at all post-operative time intervals. After 72 hours of surgery, differences in pain scores between groups were no longer apparent (Hancock et al., 2005).

Case et al., (2011), compared the severity of post-operative pain in dogs undergoing laparoscopic ovariectomy with one, two, or three instrument cannulas, where owner-assessed post-operative comfort was also evaluated. They would indicate their pet's comfort level on a scale from 1 to 10, with 1 equalling the worst pain and 10 equalling normal comfort. Out of 17 owners, 7 (41.2%) and 12 (70.1%) reported no signs of discomfort (meaning a comfort score of 10) 24 and 48 hours after surgery, respectively. In the case of the group where 2 portal LapOVE was performed, median owner-assigned comfort scores were, 10.0 (range, 8 to 10), 24 hours after surgery and 10.0 (range, 9 to 10), 48 hours after surgery. (Case et al., 2011)

### 5.5 Complications

Intraoperative complications directly associated with LapOVE and ovariohysterectomy in recent reports have included haemorrhage from the reproductive tract pedicles, organ laceration, and incisional problems such as swelling, redness, discharge, and dehiscence (Culp et al., 2009). One patient had an intestinal perforation, however, this came as a result of an abnormal position of the intestine, given that it was adherent to the ventral abdominal wall where the Veress needle is usually inserted, as a result of previous surgery. The other patient had a larger ovarian than the trocar incision. Bits of the ovarian had to be retrieved from the abdominal cavity that were separated while attempting to extract the ovarian. The last case came as a result of the difficulty placing the Veress needle in the abdominal cavity causing in the process a subcutaneous emphysema. Minor bleeding encountered in the LapOVE dogs required no intervention to achieve haemostasis. A study by Verdaasdonk, Stassen, Van Der Elst, Karsten, & Dankelman, (2007) reported that in 87% (26/30 of laparoscopic procedures), found that one or more incidents with technical equipment or instruments occurred. These incidents concerned mainly problems with technical equipment. In half of the cases, the equipment was malfunctioning, and in 20% of those, the cause of the problem was unclear. Some of those issues took a considerable amount of operating time to resolve.

In our OVH complications, pedicle haemorrhage occurred in two cases however it was resolved without any further complications. This is in accordance with Berzon, (1979) that reported haemorrhage as the most common complication in dogs where OVH was performed occurring in (20.2%), 76 out of 377 dogs.

Post-operative complications for both OVH and LapOVE included swelling and redness of the suture line occurring in four patients of the LapOVE group (29%) and one patient in the OVH group (11%). This kind of wound complications have been reported in a study Goethem et al., (2003), to happen up to 3.9% of cases (12 of 309 patients), undergoing LapOVE, that got resolved without medical or surgical intervention. OVH wound inflammation accounted for 5% of complications (7 out of 141 patients) and in all those, the swelling, inflammation and discharge was resolving or had resolved by the time their sutures were removed and no further treatment was considered necessary (Burrow et al., 2005).

Wound complications for both LapOVE and OVH can be caused subsequent to swelling, irritation of the suture line or arise from self-inflicted trauma, which consists of excessive licking of the suture line or actual chewing out or removal of the skin sutures. It is not a major complication although it can cause delayed healing of the suture line. Hence the importance of using the buster collar at home and more importantly keeping it on.

There were also 4 cases in total of GI signs, although no specific reason was found at the check-ups. There are several causes that can cause vomiting and/or diarrhea, one of which is the use of meloxicam, which has reported side effects of gastrointestinal signs (Zeidler et al., 2002). For this reason, owners were advised to discontinue the use of meloxicam. After this, there were no reports of further gastrointestinal symptoms.

For post-op checks, animals submitted to OVH had to check in three and seven days after surgery and had their exercise restricted until the check-up. As for the LapOVE group they came back ten days after surgery and there were no restrictions on physical activity.

Culp et al., (2009) found in their study that dogs submitted to LapOVE had a 25% decrease in total activity counts after surgery, whereas dogs undergoing ovariectomy had a 62% decrease in total activity counts after surgery (95% CI: 48–76%).

## 6. Conclusion

The results obtained from this dissertation were correlated in some aspects with what was reported in previous studies however it differed in some aspects. For instance, although surgical times are expected to be longer in LapOVE than OVH they were quite longer than the expected time reported. The difference in temperature at the beginning and end of surgery differed between procedures, with OVH having less impact on the patient. The procedure chosen had a significant effect on glucose where it seemed to represent less operative pain in the LapOVE. Regarding post-operative pain, although a very slight difference existed in the first three hours after the patients were extubated, there were no major differences in the end between the two procedures, and even when the pain score in the OVH group was superior to the LapOVE there did not seem to exist any significant differences. In neither case, rescue therapy was needed. The only major difference seemed to be the total activity at home, where LapOVE patients were able to return to their normal life straight away. There were more intraoperative and post-operative complications in the LapOVE group and also all technical incidents happened in patients of this group. Also, more minor wound complications existed in the LapOVE however it is difficult to assess if this is caused because of the surgical technique or by the owners removing the buster collar at home before they were advised to do so, the same problem also happened in the OVH group. Unfortunately, there were issues with the population sample of this study. In order to be significantly statistical more cases would be necessary, with a normally distributed population in terms of weight and age, and without any extra procedures as it happened in three of our cases or previous conditions, such as past surgery's. In this author opinion, taking into account all of data collected and personal experience, the differences found between the two procedures, there is not enough evidence to support performing LapOVE over a conventional OVH. Although all the advantages that are inherent to laparoscopic procedures, they did not outweigh significantly the disadvantages that are associated with the surgical procedure for OVH. This is not to say LapOVE should not be recommended over a standard OVH, given that there are differences in terms of activity following the days after surgery, it is a decision made by the owners and in most cases the owners had already decided they wanted gonadectomy performed by laparoscopic before the options were presented to them. This author also finds it would have been interesting to have done an inquiry to owners for the days following surgery and to use more objective pain parameters, such as cortisol, c-reactive protein, or even to be able to record more glucose values in the hours following surgery. However, for economic reasons such was not possible. As for the CMPS-SF the author found it to be quite useful in assisting to evaluate pain in the patients.

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# 8. APPENDIX

## 8.1 Appendix 1

Anaesthetic Monitoring Chart

| | | | |
|---|---|---|---|
| Date: | CN: | | |
| Owner Name: | | Animal Name: | |
| Breed: | Age: | Pre GA bloods ☐ | Risk 1 2 3 4 5 6 |
| Sex: | | Procedure | |
| Weight: | BCS: 1 2 3 4 5 | | |

**Premeds:**

| Drug | Dose | Route | Time | Repeat? |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |

**Induction:**

| | | |
|---|---|---|
| IV catheter? (Y?N): | Fluids? (Y/N): | Rate: |
| Agent: | | |
| Dose: | | |
| Admit time: | Surgery Start: | Surgery end: |
| Intubation: | Extubation: | Surgery time: |

| | 30m, before pre-med | 1h after ext. | 2h after ext. | 3 h after ext. | 4 h after ext. | 5 h after ext. | First appointment |
|---|---|---|---|---|---|---|---|
| **Time** | | | | | | | |
| **Glucose** | | | | | | | |
| **Pain Score** | | | | | | | |
| **Heart rate** | | | | | | | |
| **Resp. Rate** | | | | | | | |
| **Temperature** | | | | | | | |
| **CRT** | | | | | | | |
| **MM** | | | | | | | |

| Complication during surgery(s): | Description |
|---|---|
| 1. | |
| 2. | |

| Notes after 1st appointment | Description |
|---|---|
| | |

## 8.2 Appendix 2

### SHORT FORM OF THE GLASGOW COMPOSITE PAIN SCALE

**Dog's name** ______________________________

**Hospital Number** __________ **Date** / / **Time**

**Surgery** Yes/No (delete as appropriate)

**Procedure or Condition**___________________________________________

_______________________________________________________________

*In the sections below please circle the appropriate score in each list and sum these to give the total score.*

**A. Look at dog in Kennel**

*Is the dog?*

| (i) | | (ii) | |
|---|---|---|---|
| Quiet | 0 | Ignoring any wound or painful area | 0 |
| Crying or whimpering | 1 | Looking at wound or painful area | 1 |
| Groaning | 2 | Licking wound or painful area | 2 |
| Screaming | 3 | Rubbing wound or painful area | 3 |
| | | Chewing wound or painful area | 4 |

In the case of spinal, pelvic or multiple limb fractures, or where assistance is required to aid locomotion do not carry out section **B** and proceed to **C**
*Please tick if this is the case* ☐ then proceed to C.

**B. Put lead on dog and lead out of the kennel.**

*When the dog rises/walks is it?*

| (iii) | |
|---|---|
| Normal | 0 |
| Lame | 1 |
| Slow or reluctant | 2 |
| Stiff | 3 |
| It refuses to move | 4 |

**C. If it has a wound or painful area including abdomen, apply gentle pressure 2 inches round the site.**

*Does it?*

| *(iv)* | |
|---|---|
| Do nothing | 0 |
| Look round | 1 |
| Flinch | 2 |
| Growl or guard area | 3 |
| Snap | 4 |
| Cry | 5 |

**D. Overall**

*Is the dog?*

| *(v)* | |
|---|---|
| Happy and content or happy and bouncy | 0 |
| Quiet | 1 |
| Indifferent or non-responsive to surroundings | 2 |
| Nervous or anxious or fearful | 3 |
| Depressed or non-responsive to stimulation | 4 |

*Is the dog?*

| *(vi)* | |
|---|---|
| Comfortable | 0 |
| Unsettled | 1 |
| Restless | 2 |
| Hunched or tense | 3 |
| Rigid | 4 |



**Total Score (i+ii+iii+iv+v+vi) = ______**

## Appendix 2 (continuation)

Short Form of the Glasgow Composite Pain Scale (SF-GCPS) with assessment record sheet, to be used by dog owners

**Date:** **If Total Score is greater than 5 (4 when not carrying out section B) give analgesics**

| Time: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | | | | | | | | | | | | | | | | | | | | | | | | |
| A2 | | | | | | | | | | | | | | | | | | | | | | | | |
| B1 | | | | | | | | | | | | | | | | | | | | | | | | |
| C1 | | | | | | | | | | | | | | | | | | | | | | | | |
| D1 | | | | | | | | | | | | | | | | | | | | | | | | |
| D2 | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | | | | | | | | | | | | |

Notes:

**Date:** **If Total Score is greater than 5 (4 when not carrying out section B) give analgesics**

| Time: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | | | | | | | | | | | | | | | | | | | | | | | | |
| A2 | | | | | | | | | | | | | | | | | | | | | | | | |
| B1 | | | | | | | | | | | | | | | | | | | | | | | | |
| C1 | | | | | | | | | | | | | | | | | | | | | | | | |
| D1 | | | | | | | | | | | | | | | | | | | | | | | | |
| D2 | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | | | | | | | | | | | | |

Notes:

**Date:** **If Total Score is greater than 5 (4 when not carrying out section B) give analgesics**

| Time: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | | | | | | | | | | | | | | | | | | | | | | | | |
| A2 | | | | | | | | | | | | | | | | | | | | | | | | |
| B1 | | | | | | | | | | | | | | | | | | | | | | | | |
| C1 | | | | | | | | | | | | | | | | | | | | | | | | |
| D1 | | | | | | | | | | | | | | | | | | | | | | | | |
| D2 | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | | | | | | | | | | | | |

Notes:

**Date:** **If Total Score is greater than 5 (4 when not carrying out section B) give analgesics**

| Time: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | | | | | | | | | | | | | | | | | | | | | | | | |
| A2 | | | | | | | | | | | | | | | | | | | | | | | | |
| B1 | | | | | | | | | | | | | | | | | | | | | | | | |
| C1 | | | | | | | | | | | | | | | | | | | | | | | | |
| D1 | | | | | | | | | | | | | | | | | | | | | | | | |
| D2 | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | | | | | | | | | | | | |

Notes: