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# Retrospective study of infection rate in canine mastectomies without associated antibiotic prophylaxis

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# Retrospective study of infection rate in canine mastectomies without associated antibiotic prophylaxis

## Retrospektiv studie av infektionsgrad vid mastektomier hos hund utan profylaktisk antibiotikabehandling

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## SUMMARY

Peri-operative antibiotics are often used by both veterinarians and physicians to prevent and treat surgical site infections (SSI). According to international guidelines, antibiotic prophylaxis is only required when it has been proven to be clinically necessary. Surgeries with no indication for prophylactic treatment with antibiotics include routine procedures such as cutaneous and superficial soft tissue surgeries and clean abdominal procedures.

The risk for developing SSI depends not only on external factors such as contamination of the surgical area but also on the patient's health status and possible concurrent diseases such as e.g. diabetes.

Mammary tumours are the most common type of tumour to afflict female dogs. Thus, mastectomy is a common procedure and, in most cases, the gold standard for treatment. Depending on the size, location and invasiveness of the tumour, or tumours, different surgical approaches are available.

Mastectomy is usually a clean surgery. However, it can be a large reconstructive surgery due to the necessity to remove extensive amounts of tissue to achieve safety margins. Therefore, this procedure can have an increased risk for complications.

According to the literature, SSI rates in clean surgeries range between 0-6%. In the majority of the studies referred to, patients submitted for clean surgical procedures receive pre-operative antibiotics. This makes comparison of SSI rates unreliable. Moreover, to the best of the authors knowledge, there are no prior studies supporting the use of antibiotics in canine mastectomy.

This study included 65 separate surgeries, performed on 59 female dogs. This resulted in 95 separate surgical wounds. The surgeries ranged from lumpectomies to radical mastectomies. Information concerning post-operative complications (i.e. SSI) were obtained from medical records.

Patients treated with pre-operative antibiotics and/or cortocosteroids were excluded (n=7). Complications reported were divided into; seroma, infection, suture reaction, dehiscensce/wound rupture and other.

The total incidence of complications was 20% (n=19/95), whereas SSI rates was 7.4% (n=7/95). These results were similar to previously observed rates in studies analysing SSI rates in clean, surgical procedures receiving pre-operative antibiotics. In conclusion, this study provides no support for the use of perioperative antibiotics in mastectomy in otherwise healthy dogs.

## SAMMANFATTNING

Peri-operativ antibiotika används ofta av både veterinärer och läkare för att förhindra och behandla post-operativa sårinfektioner (SSI). Enligt internationella riktlinjer, skall antibiotika endast användas i ett profylaktiskt syfte när det är bevisat att det är kliniskt nödvändigt. Operationer utan indikation för profylaktisk antibiotikaterapi inkluderar rutiningrepp så som hud- och ytliga mjukdelsoperationer samt rena bukingrepp.

Risken att utveckla SSI grundar sig inte endast i påverkan från yttre faktorer såsom exempelvis kontamination av det kirurgiska området. Risken beror även på patientens hälsostatus och eventuella samtidiga sjukdomar såsom exempelvis diabetes.

Juvertumörer är den vanligaste tumörformen som drabbar tikar. På grund av detta är även mastektomi en vanlig operation, och i de flesta fall, den rekommenderade behandlingen. Beroende på storlek, lokalisation och eventuell infiltration av omliggande vävnader finns olika kirurgiska tillvägagångssätt.

Mastektomi är ett ingrepp vilket klassas som rent. Det kan dock inkludera omfattande rekonstruktion då det kan vara nödvändigt att avlägsna avsevärda mängder vävnad för att uppnå rena marginaler. Därmed ökar risken för komplicerad sårläkning.

Enligt literaturen är förekomsten av SSI, vid rena operationer, mellan 0-6%. I majoriteten av de studier som refereras till, har patienter som fått ren kirurgi utförd behandlats med pre-operativ antibiotika. Detta gör jämförelser med studier som denna, där det inte används, otillförlitliga. Vidare så saknas det, till författarens kännedom, tidigare studier som stödjer användningen av antibiotika vid mastektomier hos hundar.

I denna studie inkluderades 65 separata operationer utförda på 59 tikar. Detta resulterade i 95 separata kirurgiska sår. Operationerna varierade från lumpektomier till radikala mastektomier. Information gällande post-operativa komplikationer (d.v.s. SSI) erhölls från patientjournaler.

Inga patienter som blivit behandlade med pre-operativ antibiotika inkluderades. Komplikationer som rapporterades delades in i; serom, infektion, suturreaktion, sårruptur/öppning och övriga.

Den totala förekomsten av komplikationer var 20% (n=19/95), och förekomsten av SSI var 7.4% (n=7/95).

Dessa resultat liknar tidigare observerade resultat gällande förekomst av SSI i studier där patienter blivit behandlade med pre-operativ antibiotika vid kirurgiska ingrepp klassade som rena.

Sammanfattningsvis, visar denna studie inget stöd för profylaktisk antibiotikanavändning vid mastektomier på för övrigt friska hundar finns.

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# INTRODUCTION

## Background

Antimicrobial prophylaxis is commonly used by veterinarians, and physicians, for various surgical procedures to treat and prevent surgical site infection (SSI). SSI remain an important cause for post-operative morbidity (Nelson, 2011). Increasing antimicrobial resistance is a major, worldwide public health challenge that requires strict policies and guidelines concerning the use of antibiotics.

According to international guidelines, antibiotic prophylaxis is only recommended when it has been proven to be clinically necessary. Surgeries with no indication for antibiotic prophylaxis include routine procedures such as cutaneous and superficial soft tissue procedures and clean abdominal procedures (Scottish Intercollegiate Guidelines Network, 2014). The risk of developing SSI largely depends on the extent of wound contamination with exogenous bacteria (Mangram *et al.* 1999; Sveriges veterinärförbund, 2009). Efficient pre-operative preparation of the patient's skin preparation and the used surgical technique can reduce the number of wound contaminants (Mangram *et al* 1999; Sveriges veterinärförbund, 2009; Windahl *et al.* 2015). In most cases mastectomy is the current gold standard of therapy for mammary tumours in dogs (Bartels *et al.*, 1978; Novosad *et al*., 2003; Kudnig *et al.*, 2012). The dimensions of the surgical excision are based on the size and location of the primary tumour and lymphatic drainage (Kudnig *et al.*, 2012). Mastectomy is classified as a skin and reconstructive procedure. Peri-operative antimicrobial therapy is commonly used, due to frequent surgical complications including SSI during skin and reconstructive surgery (Field et al., 2015; Montinaro et al., 2015*)*. However, there are no studies supporting its benefits in mastectomies. To the best of the author's knowledge, there are no prior publications establishing guidelines for the use of antibiotics in canine mastectomy.

In neither Swedish or international guidelines for the use of antibiotics are there clear guidelines for the use of antibiotics in connection to mastectomy described (Sveriges veterinärförbund, 2009; Spohr *et al*., 2009; Scottish Intercollegiate Guidelines Network, 2014).

The author sought to determine whether antibiotic prophylaxis affected rates of SSI in canine mastectomy.

## LITERATURE REVIEW

### Reconstructive surgery

Mastectomies can lead to large skin defects that require reconstruction. Techniques used in reconstructive surgery can include: skin stretching, skin recruitment, free skin grafts, microvascular free tissue transfer and a variety of skin flaps (Nevill *et al.*, 2010). When compared with humans, the higher mobility and elasticity of dog's skin can facilitate performing reconstructive surgery (Hunt *et al.*, 2001). But since mammary tumour removal can include the removal of large areas of tissue, the risk for complications should be heeded (Table 1 and Table 2) (De Carvalho Vasconcellos *et al.*, 2005; Field *et al.*, 2015; Montinaro *et al.*, 2015; Horta *et al.*, 2015). The goal of reconstructive surgery is to achieve wound healing and reestablishment of normal function of the skin (Amsellem, 2011).

When performing reconstructive surgery to cover an area, the surrounding skin is detached (undermined) from underlying tissues in order to be able to stretch the skin so that it can cover the defect (Szentimrey, 1998; Hunt *et al.* 2001; Amsellem, 2011). By undermining the skin, the surgeon is left with varying amounts of dead space (Amsellem, 2011). This may be corrected during surgery (through e.g. use of walking sutures) and can reduce the risk for complications (Remedios, 1999).

Table 1. *Incidence of complications in reconstructive surgery (including wounds classified as clean, clean-contaminated, contaminated and dirty) (adapted and summarized from: Field et al., 2015; Montinaro et al., 2015)*

| Complication | Incidence (%) |
|---|---|
| Dehiscence | 18-50 |
| Swelling of skin flap (axial pattern) | 43 |
| Necrosis | 18-46 |
| Infection | 12 |
| Discharge | 14 |
| Seroma | 23 |

Table 2. *Post-operative complication rates (regional(n=18) and radical mastectomy (n=18) 10 days after surgery) (Adapted from: Horta et al, 2015)*

| Complication | Regional (%) | Radical (%) |
|---|---|---|
| Posterior limb edema | 22 | 11 |
| Hematoma | 66 | 50 |
| Dehiscence | 11 | 22 |
| Subcutanoeus emphysema | 11 | 5,5 |
| **Infection** | **22** | **50** |
| Seroma | 5,5 | 0 |

## *Complications in reconstructive surgery*

### *Seroma*

Seroma is the accumulation of serosanguineous fluids within a dead space (Amsellem, 2011). This accumulation of fluids is formed by vascular leakage which is caused by the post-operative inflammation and also due to capillary bleeding (Amsellem, 2011). To minimise the risk of seroma formation, gentle tissue handling, fastidious haemostasis and closure of dead space is of importance (Remedios, 1999). In general, seromas are not painful (Remedios, 1999). They can often be differentiated from abscesses by clinical examination but if needed, a bacteriological culture can be of assistance (Amsellem, 2011).

Aspiration is usually not recommended as treatment of seromas due to an increased risk of abscess formation through contamination (Pavletic, 2010). Although, in case of large seromas, aspiration may be necessary along with compression, but the risk of relapse is rather high (Pavletic, 2010). Treatment for seromas also include drainage, which can be achieved by removing solitary sutures to open up the wound, or inserting a drain (Amsellem, 2011).

### *Hematoma*

Hematoma is a localized collection of blood outside the blood vessels (Amsellem, 2011). This is often the result of incomplete haemostasis (Amsellem, 2011). Hematomas, as well as seromas, can increase tension in the wound (Amsellem, 2011). Thus, they can increase the risk of wound rupture or dehiscence (Amsellem, 2011). Furthermore, the increased tension and pressure exerted by hematomas, can reduce the blood supply in the tissue which may increase the risk of necrosis (Hillelson *et al.*, 1980).

### *Contamination of adjacent tissues with neoplastic cells*

When removing tumours, such as mammary gland tumours, the risk of contamination of adjacent tissues by neoplastic cells should be considered (Amsellem, 2011). If it is not possible to remove the entire tumour, or tumours, with safety margins, there is an underlying risk for contamination (Amsellem, 2011). One technique of reconstructive surgery, related to tumour removal, includes removing the tumour in a two staged process (Amsellem, 2011). First, the tumour is removed and the wound is bandaged while the tumour is examined histopathologically and after this further excised to the extent necessary (Liptak *et al.*, 2009).

Another technique includes immediate reconstruction after the tumour has been removed (Seguin *et al.*, 2005). When using this technique, gloves, instruments and drapes should be changed once the tumour is removed to prevent contamination (Seguin *et al.*, 2005).

### *Wound tension*

Tension in a wound creates a risk for wound rupture, or dehiscence, which is a common complication after reconstructive surgery (Amsellem, 2011). Tension in the wound can also cause tissue constriction which results in lymphatic and venous compression and consequently ischemia and necrosis (Lascelles *et al.*, 2003; Amsellem, 2011). If, and when, swelling of tissue is seen, immediate intervention is necessary (Pavletic, 2010). To relieve the pressure that has built up, sutures can be removed (Pavletic, 2010). Alternatively, another incision, parallel to the original incision can be made (Pavletic, 2010). This is of particular importance in the distal

extremities where tissue tension can lead to a tourniquet effect which ultimately can lead to total occlusion of lymphatic and venous drainage (Lascelles *et al.*, 2003).

### *Skin flap necrosis*

A variety of skin flaps can be used during reconstructive surgery (Nevill, 2010). Depending on their blood supply skin flaps can be classified as either axial pattern (APF) or sub dermal flaps (Pavletic, 2002). Necrosis in a skin flap is commonly associated with a lack of blood supply and usually involves the tip (Amsellem, 2011). This type of necrosis is referred to as distal flap necrosis (Pavletic, 2002).

When using a flap to cover an area, the skin used should be undermined below the cutaneous trunci muscle or under the deep subcutaneous tissue (Pavletic, 1982). This is done to preserve the sub dermal plexus that supplies the skin with blood (Pavletic, 1982). Stretching skin beyond its physical limits of blood supply and inadequate post-operative care may lead to necrosis and other complications as described above (Pavletic, 1982).

### *Wound healing and post-operative care*

A wound goes through several stages in the process of healing (Campbell, 2015). Initially it goes through the inflammatory/debridement phase (Campbell, 2015). During this first stage, the white blood cells (WBCs) performs an autolytic debridement of the wound (Campbell, 2015). Secondly, it goes through the proliferative/healing phase (Campbell, 2015). This phase consists of two separate, but simuoultaneus, processes: epithelialization and wound contraction (Campbell, 2015). The third, and last stage, is remodeling/maturation during which wound repair consists of remodeling and strengthening of collagen (Tobias *et al*., 2012; Campbell, 2015).

Removing mammary tumours is considered a clean surgery where the wound is closed with sutures to heal primarily. Wounds that are intended to heal primarily should have their edges well approximated and in direct contact (Yao *et al.*, 2013). During the first phases of wound healing, the tensile strength in the wound is very limited (Yao *et al.*, 2013). The wound is kept together by the sutures, as remodeling of collagen fibres have not yet occured (Yao *et al.*, 2013). Because of the limited tensile strength, excessive movement in the surgical area should be avoided (Franz *et al.*, 2008).

Cleaning of a post-operative wound is occasionally necessary to remove debris, exudate or devitalised tissue that otherwise may delay healing (Velnar *et al.*, 2009). When cleaning, caution should be taken to avoid inflicting trauma to the wound (Yao *et al.*, 2013). It is also important to remember that cleaning itself may interfere with healing (Yao *et al.*, 2013). Therefore, excessive cleaning may delay healing (Yao *et al.*, 2013).

In primary wound healing, dressing of the wound is optional. If a dressing is used it should promote wound healing, be able to remove exudate and be a barrier against contamination (Yao *et al.*, 2013). Dressings should be left untouched for the first 48 hours and only removed if necessary. If so, an aseptic, non-touch technique should be used (National Institute for Health and Care Exellence, 2008).

If a wound can not, or should not, be closed to heal by primary healing, it may be left open to heal by secondary healing. The majority of open wounds profit from healing in a moist environment (Campbell, 2015). A moist environment can support the normal cell function

during the different stages of the healing process (Campbell, 2015). To achieve moist environments, clinicians have a wide variety of moisture-retentive dressings (MRDs) to chose from (Campbell, 2015). MRDs can work synergistically with in particular open wounds to support microscopically precise debridement and repair and at the same time contribute to a faster, and healthier, healing process (Campbell, 2015). The choice of MRD is based on the needs of the wounds itself, as wounds can range from clean, surgical wounds to dirty, traumatic wounds (Campbell, 2015). The choice made, can be based on the need for debridement, the need for granulation or epithelialization and the amount of exudate the wound is expected to produce (Campbell, 2015).

During the initial phase (inflammatory/debridement phase), the MRD chosen should support the debridement performed by the WBCs and also support the cytokines that signal for other cells involved in the healing process (Campbell, 2015). Apart from this, the dressing should also be able to absorb the exudate produced by the wound and generated by the debridement to maintain a healthy environment (Campbell, 2015).

The MRD used during the proliferative/healing phase should support the growth and function of fibroblasts, endothelial and epithelial cells as these cells are responsible for granulation, epithelialization and contraction (Campbell, 2015). At this stage the MRD should also support growth factors and be able to absorb exudate and add moisture back to the wound (Campbell, 2006; Junker *et al.*, 2013; Maynet *et al.*, 2014).

## Surgical site infections

SSI can occur anywhere in the surgical area (Tobias *et al*., 2012). Standard criteria to divide SSI into incisional or organ/space infections have been developed (Horan *et al*., 1992). Incisional infections can be further subdivided into superficial or deep depending on if the infection is limited only to the skin and subcutanoeus tissues, or if it extends further and also involves deeper tissues such as the muscular fascia and muscular layers (Horan *et al*., 1992). Organ/space infections can occur anywhere in the body other than the skin, fascia or muscle that is involved in the surgical procedure (Horan *et al*., 1992). SSI is a relatively common occurrence in both human and veterinary medicine (Mangram *et al.*, 1999; Nelson., 2011; Verwilghen *et al.*, 2015). In veterinary medicine SSI afflict between 0%-26.8% (Table 3) of all patients that undergo surgery (Vasseur *et al*., 1985; 1988; Eugster *et al.*, 2004; Fossum, 2009; Nelson, 2009a; 2011b; Tobias *et al.*, 2012). Although, there are vast differences in the type of surgery performed (Nelson, 2009).

Non-sterile sources are the main origin for contaminants causing SSI (Fossum, 2002). These contaminants often include the bacterial flora that normally inhabits the skin (Falk-Brynhildsen *et al.*, 2013). Such bacteria include e.g.; *Staphylococcus spp*., *Escherichia Coli*, *Pasteurella spp.* and *Bacteroides spp.* (Sveriges veterinärförbund, 2009). Examples of non-sterile sources may be neglected surgical equipment, patients own surfaces and fluids (e.g. skin, gastrointestinal tract) (Sveriges veterinärförbund, 2009). Even though the skin is prepared with a sterile wash, it is not possible to remove every single bacterium from the skin (Falk-Brynhildsen *et al.*, 2013). These remaining bacteria can then be transferred to the surgical wound through the surgeon's hands or instruments to cause a cross contamination and thus cause an infection (Falk-Brynhildsen *et al.*, 2013).

A bacterial infection is defined as having more than $10^5$ bacteria per gram of tissue (Robson *et al.*, 1968; Fossum, 2002). Surgical wounds may be classified by the degree of contamination in order to predict the probability that a SSI will occur. Wounds can be classified by four different categories of contamination; a) clean, b) clean-contaminated, c) contaminated, d) dirty (Fossum., 2002; Sveriges veterinärförbund, 2009). Clean wounds include non-inflammatory, operative wounds that does not involve the respiratory-, gastrointestinal-, genitourinary- or the oropharyngeal tracts (Fossum, 2002). If one or more of the above tracts are included, the wound is classified as clean-contaminated wound. Therefore, clean-contaminated wounds are performed under controlled surgical conditions, and also comprises the placement of drains in clean wounds (Fossum, 2002; Sveriges veterinärförbund, 2009).
Clean wounds have an SSI rate between 0-6% (Berzon, 1979; Vasseur *et al*., 1985; 1988; Eugster *et al.*, 2004; Nelson, 2009; 2011; Fossum, 2009; Tobias *et al.*, 2012). The rates increase when associated with severe traumas such as bone fractures (Fossum, 2002; Sveriges veterinärförbund, 2009). Contaminated wounds occur when the surgical asepsis is compromised by any contaminated fluid (e.g. spills of gastrointestinal content), but purulent discharge is not present (Fossum, 2002; Sveriges veterinärförbund, 2009). Wounds are classified as dirty, when purulent discharge, necrotic tissue or foreign bodies are present (Fossum, 2002; Sveriges veterinärförbund, 2009).

Table 3. *Incidence of SSI (apated and summarized from: Berzon, 1979; Vasseur et al., 1985; 1988; Eugster et al., 2004; Fossum, 2009; Nelson, 2009a; 2011b; Tobias et al., 2012)*

| Wound classification | SSI Incidence (%) |
|---|---|
| Clean | 0-6 |
| Clean-contaminated | 3.5- 9.3 |
| Contaminated | 4.6-26.8 |
| Dirty | 6.7-18.1 |

### *Risk factors for the development of SSI*

The development of SSI depends on external (e.g. bacterial strain) and intrinsic factors (e.g. immunological status, comorbidities and affected tissues). In addition to the surgical site conditions other factors such as hematoma, necrotic tissue and local infections can also influence the patient's ability to withstand SSI. The reason being that these factors can inhibit the normal response from the host (Fossum, 2002; Sveriges veterinärförbund, 2009).
Although the surgical technique may be immaculate, the outcome or possibility of complications also depend on the patient's status. Physical condition, nutritional status, concurrent diseases or metabolic disorders and immunosuppressive medication all play a role in the development of SSI (Fossum, 2002). Furthermore, the possibility to keep the surgical wound in stillness to avoid tension, and also compliance from the owner concerning post-operative care are important factors.
Duration of surgery and anaesthesia are also contributing factors in the development of SSI. Higher complications rates (i.e. SSI) are observed in surgeries that lasts longer than 90 minutes and when anaesthesia lasts longer than 120 minutes (Vasseur *et al.*, 1988; Eugster *et al.*, 2004; Muraro *et al.*, 2014).

Implants of different sorts may also be a risk factor (Arciola *et al.*, 2012). Eventhough surgical asepsis is practiced, implants can be colonized by bacteria (Arciola *et al.*, 2012). Implant surfaces can also function as a substrate for the development biofilm (Arciola et al., 2012). Bacteria embedded in biofilm are able to withstand the patient's immune response and antibiotics (Arciola *et al.*, 2012)

The risk of hypothermia and hypovolemia during surgery should also be minimised since these factors can contribute to the development of post-operative complications (Sveriges veterinärförbund, 2009). Hypothermia and hypovolemia can impair peripheral circulation, thus reduce the resilience against possible infections (Heinzelmann *et al.*, 2002; Sveriges veterinärförbund, 2009; Nelson, 2011). Therefore, patients should be carefully monitored concerning body temperature and also treated with intravenous fluids when necessary (Sveriges veterinärförbund, 2009).

The surgeon's technique regarding tissue handling is important as traumatized tissue supports bacterial growth (Nelson, 2011).

Patients older than 10 years of age have an increased risk of developing SSI because of a possibly impaired immune response (Fossum, 2002). Also patients younger than one year of age may be predisposed because of an immature immune response (Fossum, 2002).

## *Prevention of SSI*

### *Asepsis*

The ultimate goal of aseptic technique is to avoid infections during surgery. Aseptic technique is defined as "the methods and practices that prevent cross contamination in surgery" (Fossum, 2002). There are a number of routines and preparations commonly used to avoid the occurrence of SSI. These routines include e.g. surgical hand wash (Widmer *et al.*, 2010), preparation of the area of surgery (Noorani *et al.*, 2010), sutures treated with antiseptic substances (Edmiston *et al.*, 2006), surgical gloves (Hayes *et al.*, 2014), protective gowns, surgical caps and mouth guards (Rutala *et al.*, 2001), check lists (Weiser *et al.*, 2010), surgical drapes of different kinds (Rutala *et al.*, 2001) and also recommendations concerning the premises where the surgery is carried out (Sveriges veterinärförbund, 2009).

### *Antibiotics*

#### Prophylactic use of antibiotics

Antibiotics used prophylactically require a sufficient concentration at the surgical area when the procedure commences in order to inhibit the growth of potential pathogens (Fossum, 2002). Nevertheless, antibiotics should not be used to compensate poor surgical preparations or a faulty technique (Sveriges veterinärförbund, 2009). Antibiotics used for prophylactic treatment should be administered at least 30 minutes, but not more than 60 minutes before the initial incision (Sveriges veterinärförbund, 2009). The antibiotics, in this case, should be administered intravenously because subcutaneous or intramuscular administration does not give steady serum concentrations to the same extent as intravenously administration (Sveriges veterinärförbund, 2009). If the half-life (T½) is known, administration should be repeated after two T½ (Sveriges veterinärförbund, 2009). The optimal length for prophylactic treatment with

antibiotics has not been defined, but should cease at the end of surgery (Sveriges veterinärförbund, 2009).
The type of antibiotic chosen for pre-operative therapy, should have a narrow spectrum of activity, it should be able to penetrate the area of incision and also be aimed at the bacteria that is expected to cause a possible infection (Sveriges veterinärförbund, 2009).
Antibiotics recommended for prophylactic use during soft tissue and orthopaedic surgeries are penicillin (bensylpenicillin sodium, ampicillin, amoxicillin and cloxacillin) or 1st generations cephalosporins (cephalotin) (Sveriges veterinärförbund, 2009).

### Therapeutic use of antibiotics

Generally, antibiotics are required to treat SSI. For this reason, the proper selection of antibiotic is of importance to avoid bacterial resistance (Fossum, 2002; Sveriges veterinärförbund, 2009). The choice of substance is preferably made by results of a bacterial culture (Sveriges veterinärförbund, 2009). Nevertheless, specific tissue affinity and minimal side effects should be considered (Fossum, 2002; Sveriges veterinärförbund, 2009). In addition to antibiotics, other options of treatment can be used, such as drains, lavage, removal of necrotic tissue and infected implants (Fossum, 2002).

#### *Antiseptics*

Antiseptics are biocides or products that can destroy or inhibit the growth of microrganisms in or on living tissue (McDonnell *et al.*, 1999). Antiseptics differ from antibiotics by the ability of antibiotics to travel through the lymphatic system to destroy bacteria, and from disinfectants as the latter are used to destroy microorganisms found on non-living objects (McDonnell *et al.*, 1999). For an antiseptic to function satisfyingly it should meet numerous criteria. These criteria can differ depending on if they are meant to be used on healthy or, in anyway, compromised skin. For instance, the efficiency of antiseptics can be judged by their spectrum of effect or their antiseptic efficiency (Lachapelle *et al.*, 2013). Furthermore, they can be classified by their time of action and skin interaction (Lachapelle *et al.*, 2013). Antiseptics generally have a broad spectrum of antimicrobial activity, thus their use in connection to infections could reduce the usage of antibiotics and therefore minimize the risk of development of bacterial resistance (Lachapelle *et al.*, 2013).

### Povidone iodine (PVP-I)

Povidone iodine (PVP-I) is an iodine union which is efficient against both gram negative and gram positive bacteria, spores, fungi, protozoa and viruses (Lachapelle *et al.*, 2013). PVP-I mechanism of action is through a slow release of idodine from the union, which leads to ionization of lipids and oxidation of cytoplasm and cell membranes without affecting the tissue of the patient (Lachapelle *et al.*, 2013).
PVP-I has the broadest antimicrobial spectrum of all available antiseptics (Lachapelle *et al.*, 2013). It also has a fast and long lasting effect and at the same time it is very well tolerated by the skin but may cause allergic reactions (Lachapelle *et al.*, 2013). PVP-I is not associated with selection of resistant strains of bacteria (Lachapelle *et al.*, 2013). In contrast to this, bacterial resistance for example chlorhexidine, silver and triclosan has been reported (Lachapelle *et al.*, 2013).

### Triclosan

Triclosan is an antiseptic which at very high concentrations has a bactericidal effect (Braoudaki *et al.*, 2004). In contrast to most other antiseptics, it is very specific in its mechanism of action (Braoudaki *et al.*, 2004). Triclosan binds to an enzyme that is coded for in the *Fabl*-gene and through a series of processes inhibits the synthesis of fatty acids that are needed for the reproduction of bacteria (Braoudaki *et al.*, 2004).
The *Fabl*-gene is also the target for many narrow spectrum antibiotics (Braoudaki *et al.*, 2004). Because of this, it has been debated if the usage of triclosan can lead to the development of antibiotic resistance against the types of antibiotics that targets the same gene among these bacteria (Braoudaki *et al.*, 2004). In a study it was shown that exposure to triclosan was linked to a high risk of development of resistance and cross-resistance among *Staphylococcus aureus* and *Escherichia coli* (Westgate *et al.*, 2016).

### Chlorhexidine

Chlorhexidine is considered to be a safe and well tolerated antiseptic, which has proven to be effective in reducing infections in both surgical and nonsurgical patients (George *et al.*, 2016). It is effective against gram negative and gram positive bacteria, facultative anaerobes, some lipid-enveloped viruses as well as yeasts (Abbas *et al.*, 2016; George *et al.*, 2016). Chlorhexidin acts by altering the osmotic equilibrium in bacteria through binding to the cell wall (Milestone *et al.*, 2010). Chlorhexidine also have a residual effect with a high level of antimicrobial activity for up to several hours after application and it has a strong affinity for skin and mucous membranes (George *et al.*, 2016).
The widespread use of chlorhexidine as an antiseptic agent does, however, raise concerns for resistance (Abbas *et al.*, 2016). In *Methicillin-resistant Staphylococcus aureus* (*MRSA*) and *Klebsiella spp*. multidrug efflux systems have been identified to cause resistance against chlorhexidine (Abbas *et al.*, 2016).
In a study, the efficiency of a number of antiseptics was compared at different concentrations (Koburger *et al.*, 2010). In said study triclosan, PVP-I, octenidine, polyhexanide and chlorhexidine was compared. The results showed that if a longer period of contact is possible (>24h) the efficiency of the different substances ranked as follows:

*Polyhexanide = octenidine > chlorhexidine > triclosan > PVP-I* (Koburger *et al.*, 2010).

If a more rapid effect was desired, which is desired in pre-operative wash, the substances ranked as follows;

*Octenidine = PVP-I >> polyhexanide > chlorhexidine > triclosan* (Koburger *et al.*, 2010).

According to the same study, PVP-I reached an acceptable antimicrobial activity after a contact time of 1 minute (Koburger *et al.*, 2010). In contrast to this, chlorhexidine reached the same level of antimicrobial activity as PVP-I after 10 minutes (Koburger *et al.*, 2010).
A study analysed the optimal time that PVP-I should be left to dry prior to surgery to be as efficient as possible (Yasuda *et al.*, 2015). The results showed that PVP-I was as most effective,

in minimizing the incidence of SSI, if it was allowed to dry for 10 minutes before the initial incision was made (Yasuda *et al.*, 2015).
Chlorhexidine solutions are often alcohol based and the drying time may vary. Generally, a drying time of 3 minutes is recommended for alcohol based solutions before the area is covered by surgical drapes (Cowles *et al.*, 2014). Although, the drying time may differ when used in veterinary medicine. This is because animals often have more hair than humans which can affect the time it takes for alcohol based, chlorhexidine solutions to dry (Cowles *et al.*, 2014).

### *Surgical drapes*

Self-adherent surgical drapes were introduced in human medicine about 50 years ago (Falk-Brynhildsen *et al.*, 2013). Since then, they have been improved by being impregnated by various antiseptics such as PVP-I and triclosan. The purpose of these drapes is to reduce the number of SSI through minimizing the possibility of cross-contamination of the surgical wound. Several studies, including both animals and humans, have been carried out to analyse the functionality of these drapes. In a study, the results showed that the occurrence of SSI in surgeries, where an untreated adhesive drape was used to cover the surgical area, was in fact higher than the surgeries where no drape was used at all (Owen *et al.*, 2009). Similar results were presented in a review article (Webster *et al.*, 2013). According to Webster *et al.* (2013), the rates of SSI, after surgeries where an adhesive drape treated with PVP-I was used, was no different than the surgeries where no drape was used at all (Webster *et al.*, 2013).

### *Antimicrobial dressings*

The purpose of an antibacterial dressing is to lessen the bacterial burden of the wound (Mosti *et al.*, 2015). The dressing should have a broad spectrum of effect at the same time as it should not damage the healthy skin or prolong wound healing (Mosti *et al.*, 2015). Dressings can be treated with antiseptics that possess bactericidal effects or with hydrophobic substances (Mosti *et al.*, 2015). As the bacteria causing SSI are often hydrophobic in nature, these bacteria bind to the hydrophobic dressing (Mosti *et al.*, 2015; Stanirowski *et al.*, 2016). When the dressing is changed, the bacterias bound to the dressing is removed from the wound along with it (Mosti *et al.*, 2015; Stanirowski *et al.*, 2016).
Dressings treated with hydrophobic substances have the advantage of not releasing any antimicrobial substances (Stanirowski *et al.*, 2016). Hence, the risk of cytotoxicity and sensitization is non existing (Stanirowski *et al.*, 2016). Moreover, the risk of development of resistance among bacteria is eliminated, which is a cause for concern when using dressings treated with e.g. silver or triclosan (Braoudaki *et al.*, 2004; Stanirowski *et al.*, 2016). Along with minimal risks, hydrophobic dressings may also accelerate wound healing since they can stimulate fibroblast proliferation and migration (Cutting *et al.*, 2015; Stanirowski *et al.*, 2016).

## Canine mammary tumors

Mammary tumours are the most common type of tumour found in female dogs (Morris *et al.*, 2001; Henry *et al.*, 2010). However, the term *mammary tumour* does include a wide range of different histological types (Table 4) (Bostock, 1986). Approximately 50% of the tumours that occur in the mammary glands are malignant (Morris *et al.*, 2001). About half of the malign tumours are prone to metastasize (Henry *et al.*, 2010). Although mammary tumours can occur in all breeds, there are some with a genetic predisposition, such as spaniels, miniature poodles, german sheperds, malteese, yorkshire terriers and dachshunds (Henry *et al.*, 2010). Large breeds are more prone to develop malignant tumours than small breeds (Itoh *et al.*, 2005; Henry *et al.*, 2010; Komazawa *et al.*, 2016). The majority of mammary tumours occur in animals over 10 years of age (Morris *et al.*, 2001). The development of mammary tumours is linked to oestrogen and progesterone levels (Morris *et al.*, 2001). Therefore, the risk of developing mammary tumours increase with the number of oestrus cycles gone through (Morris *et al.*, 2001). Thus, it is well accepted that spaying female dogs before their second oestrus is protective against the development of malignant mammary tumours (Schneider *et al.*, 1969; Murphy, 2008; Henry *et al.*, 2010; Scmidt *et al.*, 2015).

The mammary gland is formed by epithelial ducts and alveoli located along stromal connective tissue. Around each and everyone of these alveoli there are myoepithelial cells (Morris *et al.*, 2001). Tumours that originate from the epithelial tissue are described as simple (epithelial elements only) or complex (mixed elements) (Morris *et al.*, 2001). Benign tumours (e.g. lipoma) and malign tumours (e.g. mastocytoma) can also develop in the mammary tissue without being classified strictly as mammary tumours (Morris *et al.*, 2001).

Benign mammary tumours are classified as: a) simple adenomas, b) complex adenomas or, c) benign mesenchymal tumours (Morris *et al.*, 2001). These benign tumours are minimally invasive and do not metastasize. However, excision of benign nodules from mammary tissue does not exclude the possibility of new benign tumours developing in the same gland at a later stage (Morris *et al.*, 2001). Carcinomas make up about 90% of the malign tumours found in mammary tissue (Morris *et al.*, 2001). The remaining 10% is made up of sarcomas and mixed malignant tumours (Morris *et al.*, 2001). Carcinomas can vary from well circumscribed, small nodules to ulcerated, diffuse and inflamed (Morris *et al.*, 2001). They can also be infiltrative masses that extend down into the inguinal region and down the hind-limbs (Morris *et al.*, 2001). Malignant tumours can behave like benign tumours or in a more aggressive way (Morris *et al.*, 2001). Once a tumour is removed and analysed to be malignant, the most important trait is if it shows signs of local invasion (Morris *et al.*, 2001). If this is the case, these tumours tend to invade local lymph nodes and lungs rapidly (Morris *et al.*, 2001). Although lymph nodes and lungs are the most common locations for metastasis, it does not exclude the risk of metastasis to abdominal organs (Morris *et al.*, 2001).

Table 4. *Frequency of histological types of mammary tumours in dogs (adapted from: Bostock, 1986)*

| Tumour type | Relative frequency/ incidence (%) |
|---|---|
| *Benign* | 51.0 |
| Benign mixed tumours/ fibroadenomas, complex adenomas | 45.5 |
| Simple adenomas | 5.0 |
| Benign mesenchymal tumours | 0.5 |
| *Malignant* | 49.0 |
| Solid carcinomas | 16.9 |
| Tubular carcinomas | 15.4 |
| Papillary carcinomas | 8.6 |
| Anaplastic carcinomas | 4.0 |
| (Total carcinomas) | 44.9 |
| Sarcomas | 3.1 |
| Carcinosarcomas/ malignant mixed tumours | 1.0 |

### *Methods of treatment*

Mastectomy is the gold standard of treatment for mammary gland tumours in dogs (Bartels *et al.*, 1978; Novosad *et al.*, 2003; Henry *et al.*, 2010; Kudnig *et al.*, 2012). Nonetheless, there are some exceptions such as inflammatory carcinomas (where surgery is contraindicated) or if metastasis in other organs are present, where chemotherapeutics may be indicated (Henry *et al.*, 2010; Kudnig *et al.*, 2012). No chemotherapeutic protocol has been shown to improve the survival time for dogs with mammary tumours (Henry *et al.*, 2010). Different chemotherapeutic agents have been used (e.g. paclitaxel, 5-FU, doxorubicin, carboplatine) but neither have been proven to be better than the other (Henry *et al.*, 2010). Neither radiation therapy or immunotherapy have been explored well enough to show their importance in the treatment of mammary tumours in dogs (Henry *et al.*, 2010).

The choice of surgical approach depends on the size of the tumour, or tumours, and also localisation and invasiveness into underlying and/or surrounding tissue (Kudnig *et al.*, 2012).

Lumpectomy, (also known as nodulectomy), is a type of surgery performed on well circumscribed masses that are superficial and has a size smaller than 1 cm (Morris *et al.*, 2001; Kudnig *et al.*, 2012). Lumpectomy includes removing the nodule and a margin of about 1 cm of the skin that is surrounding the tumour (Kudnig *et al.*, 2012). This technique involves removing only the tumour rather than removing the entire gland itself (Kudnig *et al.*, 2012).

Mastectomy (also known as mammectomy) includes the removal of an entire gland (Kudnig *et al.*, 2012). This technique applies to tumours larger than 1 cm or if the tumour is invading the surrounding tissue (Kudnig *et al.*, 2012). When this technique is chosen as the surgical approach, it is recommended that the gland is removed with a margin of 1-2 cm and also dissected down to the abdominal fascia (Kudnig *et al.*, 2012). If the tumour is adherent to the

abdominal fascia, the part that is adherent to the tumour should also be removed (Kudnig *et al.*, 2012).

The cranial thoracic, caudal thoracic and cranial abdominal gland (glands no. 1, 2 and 3) and the cranial abdominal, caudal abdominal and inguinal gland (glands no. 3, 4 and 5) have a large extent of lymphatic connections (Fig. 1) (Morris *et al.*, 2001; Tobias *et al.*, 2012). When one larger or several tumours are located in any one of these glands, the recommendation is to perform a regional mastectomy (Morris *et al.*, 2001; Kudnig *et al.*, 2012). A regional mastectomy implies the removal of all of the glands that share lymphatic connections (Kudnig *et al.*, 2012). The inguinal lymph nodes also have a close connection to gland number 5 and is usually removed along with the removal of this gland (Kudnig *et al.*, 2012). The axillar lymph node, on the other hand, is somewhat difficult to reach and is seldom involved (Kudnig *et al.*, 2012). For this reason, the axillar lymph node is often only removed if it shows signs of enlargement or if it shows cytological signs of metastasis (Kudnig *et al.*, 2012).

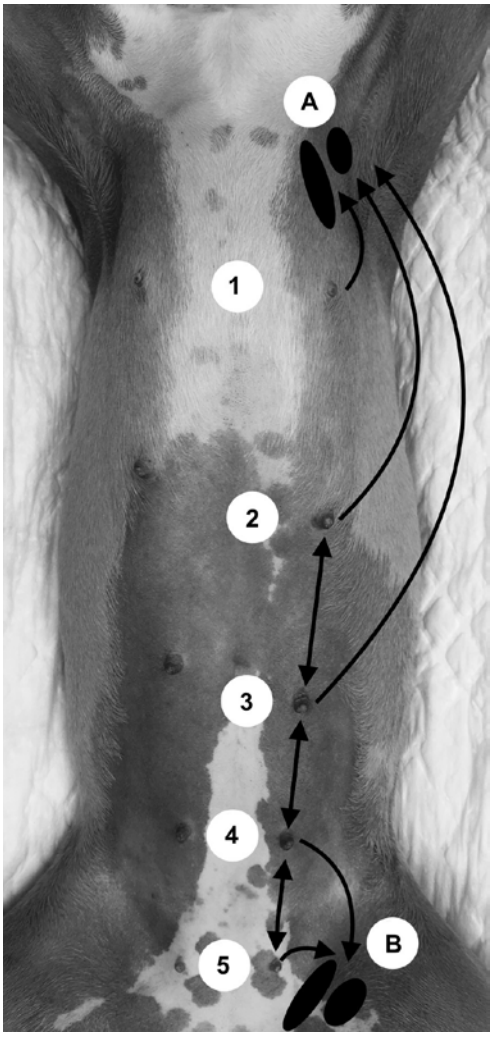


**Fig. 1. Lymphatic drainage of canine mammary glands**
**A.** *Axillary lymph nodes* **B.** *Inguinal lymph nodes* **1.** *Cranial thoracic gland* (gland 1) **2.** *Caudal thoracic gland* (gland 2) **3.** *Cranial abdominal gland* (gland 3) **4.** *Caudal abdominal gland* (gland 4) **5.** *Inguinal gland* (gland 5)
Picture: Private.
Schematic adapted from: Harvey *et al.*, (1998)

A radical mastectomy entails removing an entire chain of glands on one side (unilateral) or both sides (bilateral) (Kudnig *et al.*, 2012). This type of radical surgery is performed on dogs with extensive disease (Kudnig *et al.*, 2012). If removal of both sides is indicated this should be done during two separate surgeries with at least 3-6 weeks in between them (Kudnig *et al.*, 2012). An elliptical incision is made along both sides of the chain witch a 1-2 cm margin (Kudnig *et al.*, 2012). Like mastectomies and regional mastectomies, dissection down to the abdominal muscle fascia is performed and if the tumours are adherent to the fascia, this part of the fascia is also removed (Kudnig *et al.*, 2012).

Mammary gland 1-3 generally drains cranially and gland 4-5 generally drains caudally (Harvey *et al.*, 1998; Henry *et al.*, 2010). Although gland 3 and 4 may drain to either side (Harvey *et al.*, 1998; Henry *et al.*, 2010). In many cases there are also lymphatic communication between adjacent glands (Morris *et al.*, 2001). Because of the lymphatic communication, glands adjacent to glands that contain tumours, and also entire chains of mammary glands in the individuals that suffer tumours in the third gland, sometimes need to be removed. Although this might be theoretically correct, there are no studies that support that this does affect the final outcome of future health in the dog (Morris *et al.*, 2001).

## MATERIAL AND METHODS

Relevant data were collected from patient's record database (at the University Animal Hospital, Uppsala, Sweden) in which a search was made for female dogs diagnosed with mammary tumors. Dogs that underwent surgery from July, 2013, to September, 2016 were evaluated. The chosen interval was set to be able to study one month post-operatively to evaluate post-operative complications and also to be as current as possible. The study group consisted of female dogs that were subjected to surgery to remove mammary tumours. Patients in the study group were confined to individuals between the ages of 3 to 10, weighing between 10 to 30 kg. Individuals with concurrent diseases or disorders such as lung metastasis, diabetes mellitus or various skin conditions were excluded from the study. Individuals that were treated with peri-operative antibiotics and/or glucocorticoids were also excluded.

The surgical approach chosen for each individual patient was noted as well as the number of glands removed. The surgical wounds included in this study ranged from lumpectomies to radical mastectomies. They were all observed as separate wounds, without consideration given to the surgical approach or number of glands excised. If more than one wound was created in the same patient during the same surgery they were observed as separate wounds.

### Surgery

In the case of lumpectomies, an incision was made over the tumour which was then excised with blunt and sharp dissection. In the case of more extensive surgery, an elliptical incision was made around the mammary glands to be excised and subcutaneously dissected with sharp and blunt dissection until the abdominal muscle fascia was exposed, and if necessary partially removed due to adherence to the tumour/tumours.

Major blood vessels, including superficial epigastric vessels, were ligated with a 2-0 or a 3-0 absorbable suture. Whenever the inguinal mammary gland was removed PDS or Monocryl (2-0 or 3-0) was also used to advance the skin toward the centre of the defect with a walking suture and a subcuticular continuous suture. Simple interrupted or continuous sutures with a 3-0 or 2-0 monofilament (nylon) suture were use to appose skin. The time of anaesthesia was defined from the time of induction to the time of extubation.

### Description of Data

Data collected from the medical records included: incidence of complications (Table 6), breed (Attachement 1), age at time of surgery/surgeries (Attachment 2), weight, surgical approach/portion of mammary gland chain removed (Table 5) and pathologic analysis of the lesions that were removed (Attachment 3). In addition, evaluation of wound healing and the bacteriological cultures taken from the wounds with a suspected infection was studied along with the type of antibiotic used for treatment (Table 7).

The type of pre-medication protocol was noted (Attachment 4), the type of suture material used in the subcutaneous and the cutaneous tissues (Attachment 5), if patients were treated with local anaesthesia or not (Attachement 6) and the substances used for post-operative pain relief (Attachment 7).

## Anaesthesia

In all of the surgeries, anaesthesia was induced by propofol and maintained with isoflurane in an inhalant anaesthesia machine.

All the data collected from the patient records, concerning complications during wound healing was evaluated by a senior surgeon to distinguish SSI from other complications during wound healing.

## RESULTS

A total of 65 surgeries (ranging from lumpectomies to radical mastectomies) were performed on 59 dogs resulting in 95 separate wounds.

In total (of the patients that were included in this study) nine patients were treated with antibiotics post-operatively due to suspicion of SSI. Two patients were diagnosed with a SSI post-operatively at an external clinic. These clinics were contacted with the owner's permission. In one case there was an infection due to both *haemolytic E. coli* and *Staphylococcus pseudointermedius* and in the other case no culture was taken (Table 7).

The nine patients with a suspected SSI, at the University Animal Hospital, had a bacteriological culture test including evaluation of antibiotic resistance analysed. Two of these cultures showed no growth, hence no infection was present. However, one infection was due to *β-hemolytic streptococci*, another due to *Staphylococcus pseudointermedius*, two due to both *β-hemolytic streptococci* and *pseudointermedius*, one due to *Staphylococcus pseudointermedius* and one due to *Staphylococcus aureus*. None of the cultures showed signs of antimicrobial multiresistance (Table 7).

Out of the nine patients treated with antibiotics, seven recieved amoxicillin and two recieved clindamycin.

Seven patients were excluded because of pre-operative medication. Out of these seven patients, five was treated with ampicillin and two were treated with prednisolone.

Complications reported were divided into: seroma, infection, suture reaction, dehiscence/ wound rupture and other. The total complication rate in surgical wounds due to removal of mammary tumours was 20% and the infection rate was 7.4%.

Table 5. *Total incidence (%) of complications in wounds divided by surgical approach*

| Complication | Lumpectomy | Regional mastectomy | | | | Radical mastectomy |
|---|---|---|---|---|---|---|
| | | 1 gland | 2 glands | 3 glands | 4 glands | |
| Seroma | 0 | 0 | 16.6 | 18.2 | 0 | 0 |
| Infection | 2.5 | 0 | 8.3 | 18.2 | 20 | 22.2 |
| Suture reaction | 0 | 5.5 | 0 | 9.1 | 0 | 0 |
| Dehiscence/ wound rupture | 0 | 0 | 8.3 | 18.2 | 20 | 11 |
| Other | 0 | 0 | 0 | 18.2 | 0 | 0 |
| Number of wounds | 40 | 18 | 12 | 11 | 5 | 9 |

Table 6. *Total incidence (%) of complications in total amount of wounds (n=95)*

| Complication | Incidence (%) |
|---|---|
| Seroma | 4.2 |
| Infection | 7.4 |
| Suture reaction | 2.1 |
| Dehiscence/ wound rupture | 4.2 |
| Other | 2.1 |

Table 7. *Bacterial cultures from suspected SSI and choice of antibiotic*

| Bacterial Culture | Antibiotic | |
|---|---|---|
| | Amoxicillin | Clindamycin |
| β-haemolytic Strept. | 1 | |
| Staph. pseudointermedius | 1 | |
| β-haemolytic Strept. & Staph. pseudointermedius | 2 | |
| Staph. aureus | 1 | |
| Haemolytic E. coli & Staph. pseudointermedius | 1 | |
| No growth | 1 | 1 |
| N/a | | 1 |

## DISCUSSION

This is the first study analysing the need for treatment with antibiotics in connection to mastectomies that has been reported. Since mammary tumours are the most common tumour in female dogs, it is also a surgery that is commonly performed. Therefore, guidelines concerning the use of peri-operative antibiotics in connection to this procedure should be considered to be of great importance.

Rather than sorting by amount of patients, sorting was done by amount of wounds created during surgery. The reason being that several individuals had multiple tumours surgically removed that was situated in glands not adjacent to one another. This resulted in several cases with more than one wound created in the same animal during the same surgery.

Antibiotics should only be used when indicated or necessary. In these cases, the choice of antibiotic should, when possible, be based on a bacterial culture and resistance. Another factor that should be taken into consideration is that if the use of antibiotics is indicated, the substance should also have a minimal negative impact on the patient (Weese, 2008). Negative side effects of antibiotic treatment include e.g. diarrhea which, if severe, may affect the patient's immune response in a negative way.

If antibiotics are not used cautiously, the inevitable side effect is the progressive development of multiresistant bacteria (van den Bogaard *et al.*, 2000). The worst case scenario includes the total unability to treat bacterial infections with antibiotics. Because of this, the author considers this study to be of importance. Similar studies analysing the need for antibiotics in connection to other common surgeries, procedures and conditions, without clear regimens for the use of antibiotics are equally important.

In a study by Turk *et al.* (2015), the fact that procedure-specific studies are important is discussed. The authors argue that analysing risk factors for SSI for a diverse surgical population can limit the possibility to make conclusions (Turk *et al.*, 2015). The risk is that procedure-specific factors associated with SSI may be overlooked (Turk *et al.*, 2015).

The unnecessary use of antibiotics in veterinary medicine does not only affect animals. The development of resistance is not confined to clonal spread of resistant strains (van den Bogaard *et al.*, 2000). Resistance can also be spread through the transfer of genes between animal and human bacteria (van den Bogaard *et al.*, 2000). Although the threat of development of multiresistant bacteria is increasing due to over use of antibiotics it is still extensively misused. For the safety of public health, the selection and spread of resistant bacteria from animals must be controlled (van den Bogaard *et al.*, 2000). This can only be achieved by reducing the amount of antibiotics used (van den Bogaard *et al.*, 2000).

One study suggested that wound classification should be considered for all surgical techniques to be able to determine appropriate pre-operative, intra-operative and post-operative care (Weese, 2008).

Apart from the correct choice of antibiotics, the time of treatment is also of importance. As stated earlier, pre-operative antibiotics should be administered intravenously not less than 30 minutes but not more than 60 minutes before surgery. One study showed that administration of antibiotics after surgery did not differ in preventing SSI compared to no peri-operative antibiotics at all (Stone et al., 1976).

When comparing the results concerning post-operative complications, specifically SSI, that afflicted the dogs included in this study to complications and SSI in animals included in other studies there were limitations. The guidelines for the use of antibiotics in Sweden are more restrictive than in many other countries where prophylactic antibiotics are used as a standard even in surgeries considered as clean. Because of this, comparison of SSI rates may be misguiding since the surgeries are performed during different conditions.

At the same time as comparisons may be limited, the results when comparing the incidence of SSI becomes interesting.

None of the patients included in this study recieved pre-operative antibiotics. The incidence of SSI was 7.4% (n=7/95). This is similar, or in some cases even lower, than several of the studies analysing the rates of SSI in clean, soft tissue, surgeries that included reconstruction and where patients recieved prophylactic antibiotics, sometimes broad spectrum (Muraro *et al*., 2014).

Studies have shown that the use of prophylactic antibiotics did not influence the incidence of SSI in clean surgeries performed by experienced surgeons (Vasseur *et al*., 1985; 1988).

According to Swedish guidelines, pre-operative antibiotics should only be administered in surgeries that are considered to be in the risk zone of developing a SSI (Sveriges veterinärförbund, 2009). Pre-operative antibiotics may also be used when, if an SSI would occur, the consequences of this is considered to be disastrous (Sveriges veterinärförbund, 2009).

A study reported that the incidence of SSI was twice as high in surgeries that lasted 90 minutes when compared to surgeries that lasted 60 minutes (Brown *et al*., 1997). According to the model used in another study which intended to predict SSI, the risk increased 1.01 times per minute of surgery. This corresponded to a doubling of the risk of developing SSI per 70 minutes of surgery (Eugster *et al*., 2004).

In a study including 377 dogs that underwent elective ovariohysterectomy (OHE) without pre-operative antibiotics, the incidence of SSI (and suture abscesses) were 6% (23 dogs) (Berzon, 1979). OHE is one of the most common elective procedures carried out on female dogs and is not an indication for prophylactic use of antibiotics (Berzon, 1979; Sveriges veterinärförbund, 2009; Adin, 2011). Eventhough mastectomy is a reconstructive surgery and OHE is not, the two procedures share similarities in the surgical approach. They both include incisions in the same area of the body and the post-operative care is somewhat similar.

OHE guidelines do not recommend the use of pre-operative antibiotics. Since OHE infection rates reported from Berzon (1979), and mastectomies, without treatment of prophylactic antibiotics, are similar they should be instituted similar pre-operative guidelines for the use of antibiotics.

Mastectomy is considered as a clean surgery. Eventhough there are obvious risk factors for the development of SSI, such as large amount of dead space, wound tension and risk for necrosis, it should not be classified as a surgery in which prophylactic antibiotics are necessary in an otherwise healthy dog. Instead, in surgeries, such as mastectomy, where one is aware of the possible risk factors, extra care should be given to preparation, technique and duration of the surgery. The major limitation of this study lies in the retrospective evaluation of the clinical reports concerning wounds and distinguishing SSI from other complications concerning wound healing. The (relative) size of the wounds and effect thereof was not analysed. The different conditions in the home environment for each of the patients and compliance from the owner are also inherent limitations to this study.

## CONCLUSIONS

The results from this study, indicates that the rate of SSI in mastectomies is not higher than the rates in other clean surgeries. This study presents no evidence that supports prophylactic use of antibiotics in mastectomies.

Antibiotics should never compensate for a faulty preparation or surgical technique. Since the use of antibiotics in clean surgeries have been studied in numerous studies, and been proven not to reduce the rates of SSI, they should only be used if clearly indicated.

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## ATTACHEMENTS

### Attachement 1

*Complications divided by breed*

| Breed | Complication | | | | | Total |
|---|---|---|---|---|---|---|
| | Seroma | Infection | Suture reaction | Wound rupture/ Dehiscence | Other | |
| Airedale terrier | 1 | | | | | 1 |
| American cocker spaniel | | | | | | 1 |
| Bavarian mountain scenthound | | | | | | 1 |
| Havanese | | | | | | 1 |
| Mixed breed | | 2 | | | | 11 |
| Border collie | 1 | | | | | 2 |
| Border terrier | | | | | | 1 |
| English cocker spaniel | | | | 1 | | 3 |
| Danish-swedish farmdog | | | | | | 1 |
| Dobermann | 1 | | | 1 | | 1 |
| English bulldog | | | | | 1 | 1 |
| English setter | | 1 | | | | 1 |
| English springer spaniel | | | | | | 2 |
| Finnish lapphund | | | | | | 1 |
| Flat coated retriever | | | | | | 1 |
| Golden retriever | | | 1 | | | 2 |
| Swedish elkhound | 1 | | | 1 | | 1 |
| German short-haired pointingdog | | | | | | 2 |
| Labrador retriever | | 1 | | | | 5 |
| Lagotto romagnolo | | | | | | 2 |
| Münsterlander | | 1 | | | | 1 |
| Nova scotia duck tolling retriever | | | | | | 3 |
| Spanish waterdog | | | | | | 1 |
| Pumi | | | | | | 1 |
| Schnauzer | | | | | | 1 |
| German shepherd | | | | | | 3 |
| Siberian husky | | | | | | 1 |
| Staffordshire bull terrier | | | | | 1 | 1 |
| Standard poodle | | | | | | 2 |
| Swedish lapphund | | | | | | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Tibetan terrier | 1 | 1 | | | 1 |
| Welsh springer spaniel | 1 | | 1 | | 2 |

## Attachement 2

*Complications divided by age at time of surgery*

| Age | Complication | | | | | Surgeries performed at age |
|---|---|---|---|---|---|---|
| | Seroma | Infection | Suture reaction | Wound rupture/ Dehiscence | Other | |
| 3-<4 | | | | | | 1 |
| 4-<5 | 1 | | 1 | 1 | 1 | 6 |
| 5-<6 | | | | | | 4 |
| 6-<7 | | | | | 1 | 9 |
| 7-<8 | 2 | 2 | | 1 | | 10 |
| 8-<9 | 1 | 3 | 1 | 1 | | 19 |
| 9-10 | | 2 | | 1 | | 16 |

## Attachement 3

*Complications divided by tumour type*

| Tumour type | Complication | | | | | Total amount of tumours |
|---|---|---|---|---|---|---|
| | Seroma | Infection | Suture reaction | Wound rupture/ dehiscence | Other | |
| Adenoma | | 2 | 1 | 1 | | 23 |
| Carcinoma | 1 | 2 | | 2 | | 9 |
| Mixed adenoma/ carcinoma | | 1 | | | | 6 |
| Unknown benign | | | | | | 5 |
| Unknown malign | 1 | 1 | | 1 | | 4 |
| Other | | | 1 | | | 4 |
| n/a | 2 | 1 | | | 2 | 14 |

## Attachement 4

*Complications divided by type of pre medication (when generic name of substance was given this is noted, when substance name was given this is noted)*

| Pre medication | Complication | | | | | Total amount of pre med.* protocol |
|---|---|---|---|---|---|---|
| | Seroma | Infection | Suture reaction | Wound ruptue/ dehiscence | Other | |
| Acepromazine, Butorphanol | | | | | | 1 |
| Acepromazine, Carprofen, Methadone | 1 | 2 | | 2 | | 23 |
| Acepromazine, Carprofen, Methadone, Medetomidine | | | 1 | | | 1 |
| Acepromazine, Medetomidine | | 1 | | | | 1 |
| Acepromazine, Meloxicom, Methadone | 1 | | | | | 6 |
| Acepromazine, Methadone | 1 | | | | | 8 |
| Glycopyrrolate, Acepromazine, Carprofen, Methadone | | | | | | 1 |
| Medetomidine, Butorphanol | | | | | | 1 |
| Medetomidine, Butorphanol, Carprofen | | | | | | 2 |
| Medetomidine, Methadone | | | | | | 2 |
| Medetomidine, Methadone, Carprofen | | 2 | | | | 5 |
| Medetomidine, Methadone, Glycopyrrolate | | | | | 1 | 1 |
| Medetomidine, Methadone, Norocarp | | | | | | 1 |
| Buprenorfine, Methadone, Carprofen | | | | | | 1 |
| Plegicil, Methadone | | | | | | 3 |
| Plegicil, Norocarp, Methadone | | | | | | 1 |
| Robinul, Plegicil, Methadone | | | | | 1 | 1 |
| Robinul, Plegicil, Norocarp, Methadone | | | | | | 2 |

* Pre medication

| | | | | | |
|---|---|---|---|---|---|
| Sedator, Norocarp, Methadone | | 1 | 1 | | 1 |
| Unknown | 1 | 1 | | 2 | 3 |

## Attachement 5

*Complications divided by suture material (sut. mat.) used in sub cutis (s.c.) and cutis (c.)*

| Suture material (s.c.; c.) | Complication | | | | | Amount of surgeries where sut. mat. used |
|---|---|---|---|---|---|---|
| | Seroma | Infection | Suture reaction | Wound rupture/ Dehiscence | Other | |
| Ethilon (size n/a) | | | | | | 1 |
| Monocryl 3-0; Ethilon 3-0 | 2 | 1 | | 2 | 1 | 13 |
| Monocryl 3-0; Monocryl 3-0 | | | | | | 13 |
| Monocryls 3-0; Monocryl 3-0 (+ Tegaderm) | | 1 | | | | 1 |
| Monocryl 4-0; Monocryl 4-0 | | | | | | 3 |
| PDS 2-0; Ethilon 3-0 | | 1 | | 1 | 1 | 5 |
| PDS 2-0, Monocryl 3-0; Ethilon 3-0 | 1 | 2 | | | | 10 |
| PDS 2-0, Monocryl 3-0; Monocryl 3-0 | | | | | | 1 |
| PDS 3-0; Ethilon 3-0 | 1 | 1 | 1 | | | 5 |
| PDS 3-0; Monocryl 3-0 | | | | | | 1 |
| PDS 3-0, Monocryl 3-0; Ethilon 3-0 | | 1 | 1 | 1 | | 6 |
| PDS 3-0, Monocryl 3-0; Ethilon 3-0 (+Tegaderm) | | | | | | 2 |
| PDS 3-0, Monocryl 4-0; Monocryl 4-0 | | | | | | 1 |
| PDS 2-0, Monocryl 3-0, Ethilon (size n/a) | | | | | | 1 |
| Vicryl 3-0; Ethilon 3-0 | | | | | | 1 |

## Attachement 6

*Complications divided by the use (and substance) of local anaesthesia (when generic name of substance was given this is noted, when substance name was given this is noted)*

| Substance | Complication | | | | | Total |
|---|---|---|---|---|---|---|
| | Seroma | Infection | Suture reaction | Wound rupture/ dehiscence | Other | |
| Lidocaine + Bupivacaine | | 1 | | | | 5 |
| Marcaine | | | | | | 1 |
| Marcaine + Lidocaine | 1 | | | | | 2 |
| Xylocaine | | | | | | 1 |
| Xylocaine + Marcaine | | | | | | 1 |
| None | 3 | 6 | 2 | 4 | 2 | 55 |

## Attachement 7

*Complications divided by substances used for post-operative (post op.) pain relief (when generic name of substance was given this is noted, when substance name was given this is noted)*

| Post op. | Complication | | | | | Total amount of post op. protocol |
|---|---|---|---|---|---|---|
| | Seroma | Infection | Suture reaction | Wound rupture/ dehiscence | Other | |
| Carprofen | | | | | | 1 |
| Durogesic patch | | | | | 1 | 2 |
| Durogesic patch & Norocarp | | | | | | 3 |
| Durogesic patch & Metacam | | 1 | | 1 | | 6 |
| Durogesic patch & Rimadyl | 1 | 2 | | 1 | | 6 |
| Marcain drain & Durogesic patch | | 1 | | | | 1 |
| Metacam | 1 | 2 | | | | 11 |
| Methadone | | | | | | 1 |
| Norocarp | | 1 | 1 | 1 | 1 | 14 |
| Rimadyl | 1 | | 1 | | | 11 |
| Temgesic & Norocarp | | | | | | 1 |
| Tramadol | | | | | | 1 |
| Unknown NSAID | | | | | | 1 |
| n/a | 1 | | | 1 | | 6 |