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**PREPUBERTAL GONADECTOMY IN MALE CATS: A
RETROSPECTIVE INTERNET-BASED SURVEY ON THE
SAFETY OF CASTRATION AT A YOUNG AGE**

PREPUBERTAALNE GONADEKTOOMIA ISASTEL
KASSIDEL: RETROSPEKTIIVNE INTERNETIKÜSITLUSEL
PÕHINEV NOORTE KASSIDE KASTREERIMISE OHUTUSE
UURING

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ABSTRACT

Estonian University of Life Sciences Fr. R. Kreutzwaldi 1, Tartu 51006		Abstract of Final Thesis	
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<p>Prepubertal gonadectomy (PPG) of kittens is proven to be a suitable method for feral cat population control, removal of unwanted sexual behaviour like spraying and aggression and for avoidance of unwanted litters. There are several concerns on the possible negative effects on PPG including anaesthesia, surgery and complications. The aim of this study was to evaluate the safety of PPG. Microsoft excel was used for statistical analysis. The information about 6646 purebred kittens who had gone through PPG before 27 weeks of age was obtained from the online retrospective survey. Database included cats from the different breeds and –age groups when the surgery was performed, collected in 2019. The complications were seen in 30 (0.5%) kittens for the PPG and 60 (0.9%) of kittens developed feline infectious peritonitis (FIP). Since there were few complications it is mostly safe to use the PPG for purebred kittens under 27 weeks of age. The safety of this procedure is strongly related to the veterinarian’s experience and skills. There was no clear link between the complications and FIP connected to the PPG. Considering the data of this study, the breed population might not be in all the cases large enough to be adjustable for representing the breed outside this study.</p>			
Keywords: Purebred cats, prepubertal gonadectomy, castration complications, feline infectious peritonitis			

LÜHIKOKKUVÕTE

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<p>Prepubertaalne kastreerimine (<i>prepubertal gonadectomy</i>, PPG) on tõhus meetod kodutute kasside populatsiooni arvukuse piiramiseks, soovimatu sugulise käitumise nagu territooriumi märgistamine ja agressioon vältimiseks ning soovimatute pesakondade sünni vältimiseks. Anesteesia, kirurgia ning komplikatsioonid on mõned põhjused, mis tekitavad inimestes hetkel kahtlusi PPG kasutamiseks. Käesoleva uuringu eesmärk on hinnata PPG turvalisust. Uuringus kasutatav andmebaas on kogutud 2019. aastal internetipõhise retrospektiivse küsimustiku abil ja hõlmab endas 6646 kassi andmeid, kes olid kastreeritud enne 27. Elunädalat. Statistilise analüüsi teostamiseks kasutati programmi Microsoft Excelit. PPG tõttu esines komplikatsioone 30 (0.5%) kassil ning 60 (0.9%) kassil arenes kahe aasta jooksul välja kasside nakkuslik peritoniit (<i>feline infectious peritonitis</i>, FIP). Vähene komplikatsioonide arv näitab, et PPG on enamasti turvaline valik noorte kasside kastreerimiseks ja PPG komplikatsioonide esinemine on suurel määral seotud loomaarsti kogemuste ja oskustega selle protseduuri läbi viimisel. Antud uuringust ei selgunud, et PPG võiks mõjutada FIPi esinemist. Arvestades väikest komplikatsioonide esinemist ja vähest vastuste arvu mõne tõu kohta, ei olnud võimalik anda usaldusväärset hinnangut PPG riskiteguritest tõugude lõikes.</p>			
Märksõnad: Tõukassid, prepubertaalne kastreerimine, kastreerimisel esinevad komplikatsioonid, kasside nakkuslik peritoniit			

TABLE OF CONTENTS

Contents

ABSTRACT	2
LÜHIKOKKUVÕTE	3
TABLE OF CONTENTS.....	4
INTRODUCTION	6
1. LITERATURE OVERVIEW.....	9
1.1. The Cat.....	9
1.2. Feline gonadectomy	10
1.2.1. Feline gonadectomy	10
1.2.2. Gonadectomy compared to non-surgical sterilization	11
1.3. Suggested time for the appropriate age to castrate cats.....	12
1.3.1. Suggested time for castrating cats set by institutions.....	12
1.3.2. Opinion of veterinarians regarding the appropriate age of feline castration.....	13
1.4. Prepubertal gonadectomy.....	13
1.4.1. Benefits of the prepubertal gonadectomy.....	13
1.4.2. Negative aspects of prepubertal gonadectomy	16
1.5. Clinical considerations for prepubertal gonadectomy	17
1.5.1. Anaesthesia	17
1.5.2. Surgery.....	20
2. MATERIALS AND METHODS.....	21
2.1. The data collection	21
2.2. Questionnaire	21
2.3. Statistical analysis.....	22
3. RESULTS AND DISCUSSION	23
3.1. The dataset	24
3.1.1. The age of the kittens at the time of PPG	25
3.2. Factors affecting the safety of PPG	27
3.2.1. Complications.....	27
3.3. Feline infectious peritonitis	34
3.3.1. The death	36
3.3.2. The vaccination status	36
3.3.3. Collar and suit.....	37
3.3.4. Attitude of the breeders regarding PPG	37

CONCLUSIONS	38
REFERENCES	40
ÜLDKOKKUVÕTE	46
APPENDICIES.....	47
Appendix 1. Questionnaire for cat breeders	48
Appendix 2. Non-exclusive licence for depositing the final thesis and opening it for the public and the supervisor's (supervisors') confirmation for allowing the thesis for the defence	50

INTRODUCTION

The domestic cat has lived alongside humans for approximately 10 000 years. In these years, a wild animal used only for pest control has spread all over the world and has moved from grain storages to our beds. The number of cats has increased dramatically and the population is out of control in some areas, also endangering wild and protected species (Jessup, 2004). Castration in cats is important to avoid unwanted breeding, spreading of diseases and to reduce unwanted sexual behaviour like marking the territory and aggression (Yates *et al.*, 2019). The appropriate age of castration has been under question in regulating institutions, animal owners and veterinarians for a long time because of the possible safety risks. There are several aspects for concern in castration: anaesthesia, surgery, complications, post-castration obesity and possible urinary tract problems (Spain, *et al.*, 2004; Ohlund *et al.*, 2018). It has been suggested that the best and possibly safest method for controlling stray cat population, avoiding unwanted breeding and reducing unwanted sexual behaviour is to castrate cats before the onset of puberty meaning perform prepubertal gonadectomy (PPG) (Root Kustritz, 2017). The age for PPG varies in the literature but the mutual agreement for this is that it is performed before 23 weeks of life (Howe, *et al.*, 2000; Farnworth, *et al.*, 2013). Still, there are many people who do not recommend this procedure or are afraid of it.

The thesis briefly describes the surgical methods of sterilizing cats and compares them to non-surgical methods. The time for castration of cats from the perspectives of countries and veterinarians is discussed. Both the benefits as well as the negative aspects of PPG are brought out. Furthermore, the possible approach for the anaesthesia and surgery is discussed together with the dangers.

The main aim of this study was to evaluate the safety of PPG. Also the information on the possible breed-dispositions of the complications related to PPG was aimed for. The data for the study was collected via questionnaire from 02.07.2019 to 04.10.2019 in social media (*Facebook*) groups meant for cat breeders. Only the data of purebred cats was accepted for the study. The focus was on the different complications reported by breeders all over the

world and their reliance on different age groups, breeds and countries. The study concludes information about the complications like opening the stitches, infection of the wound and feline infectious peritonitis (FIP) is addressed separately from the complications. The possible complications are compared with the chi-square test to analyse the importance of the findings.

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1. LITERATURE OVERVIEW

1.1. The Cat

The domestic cat, *Felis Catus*, has spread all over the world together with human travels (Lipinski *et al.*, 2008). The process of feline domestication began in the later stage of the human evolution process, possibly before the first proven domestication in the Near East, about 9000 - 10 000 years ago (Vigine, *et al.*, 2004; Dobney, *et al.*, 2006; Lipinski, *et al.*, 2008). The purpose of this process could have been the necessity to protect the agriculturally grown crops from rodents, which was attractive to cats due to rodents providing them with a natural food source (Lipinski *et al.*, 2008). Despite many cats eventually becoming pets, the modern cat does not belong to the group of fully domesticated animals (Lipinski *et al.*, 2008). This can be seen when we think of today's cats: they are self-sufficient and demonstrate a range of characteristics from loving household member to untamed tiger (Bradshaw *et al.*, 1999; Lipinski *et al.*, 2008). There was no need to alter the cat's working ability or strength during the domestication as their job was mostly vermin control and they were loved for their grace and beauty. The breeding selection was mostly appearance-based: colour and patterns of the coat (Lipinski *et al.*, 2008). Currently, there are multiple organizations recognizing a varying number of breeds which have been developed under intense selection regarding their looks, personality, size and health aspects (Lipinski *et al.*, 2008; Kienzle, *et al.*, 2011). According to the Cat Fanciers' Association, there are 45 recognized cat breeds (Cat Fanciers' Association, 2020). On the other hand, The International Cat Association (TICA) recognizes 71 breeds for championship competition and Fédération Internationale Féline (FIFe) recognizes 48 breeds (TICA, 2018; FIFe, 2020). The division of the breeds by weight is discussed in one study which has categorized them from very light, like Siamese, to giant, represented by Maine Coon (Kienzle, *et al.*, 2011). Whereas the owning of a cat in the household has become more popular and the growth of human population has multiplied, the cat population of both purebred and not purebred cats has grown, leading to uncontrolled population control and feral cats (Bradshaw *et al.*, 1999; Root Kustritz, 2002; Bongaarts, 2009).

1.2. Feline gonadectomy

1.2.1. Feline gonadectomy

Feline neutering of male cats has been first described in 1893 by an anonymous veterinarian (Hartwell, 1996). In the Cambridge dictionary, the term neutering is defined as “to remove part of an animal’s sexual organs for avoiding to produce descendants” (Cambridge Dictionary, 2020). There are several options for neutering a male cat: surgical sterilization via removing the reproductive organs, vasectomy meaning only the spermatic cord is removed and nonsurgical sterilization to stop sperm production in the testes (Reichler, 2009; American Veterinary Medical Association, 2020). In comparison of these methods, the vasectomy and nonsurgical sterilization eliminate the reproductive function but there is no influence on sexual hormones (Reichler, 2009).

Retrospective surveys have shown that females are more likely to be sterilized than male cats (Root Kustritz, 2007). Gonadectomy is defined as the surgical removal of an ovary or testis. The terms used for female gonadectomy procedures are ovariohysterectomy which stands for surgical removal of both ovaries and uterus, and ovariectomy meaning that only ovaries are removed. The terms castration and orchiectomy are used for removing testes from a male cat. In this study the term gonadectomy represents only orchiectomy and castration as only male cats will be discussed. The benefits of gonadectomy are limiting feline overpopulation, possible avoidance of genital tract tumors, diminishing sexual behaviour, significantly reducing the possibility to be infected with Feline Immunodeficiency Virus (FIV) and Feline Leukemia Virus (FeLV) and thus increasing cats’ life expectancy (Reichler, 2009). Currently, gonadectomy is one of the most common surgical procedures performed on cats and dogs (Howe, 2015).

It is possible to separate two different gonadectomy types based on the age of the animal: traditional age gonadectomy (TAG), performed on animals with six months of age or older and prepubertal gonadectomy (PPG) performed on animals younger than six months (Valcke, 2017). The age considered and recommended for PPG varies among different studies: 6-14 weeks (Root, 2002; Joyce and Yates, 2011), 8-12 weeks (Porters *et al.*, 2014)

and 8-16 weeks of age (Root Kustritz, 1999). The main benefits of PPG are population control in shelter cats (Porters *et al.*, 2014), prevention of arbitrary breeding (Root Kustritz, 2018; Gagnon *et al.*, 2020), fast surgical recovery and minor complications (Gangon *et al.*, 2020).

1.2.2. Gonadectomy compared to non-surgical sterilization

Gonadectomy is beneficial for removing both the ability to reproduce as well as the unwanted sexual behaviour (Reichler, 2009; Porters *et al.*, 2014; Yates *et al.*, 2019). The purpose of the non-surgical sterilization of male cats is, ideally, to suppress spermatogenesis, androgenesis and libido to avoid management problems at breeding season and descendants (Kuladip *et al.*, 2011). There are several benefits of non-surgical sterilization for male cats: the procedure is less time-consuming because there is no need for anaesthesia, local anaesthetic agent is used exclusively (Kuladip *et al.*, 2011) and therefore this procedure is free from anaesthetic and surgical complications (Kuladip *et al.*, 2011). Also, all the resources needed for the surgery are not needed, so it is possibly cheaper to use it in the developing countries which lack the funds for purchasing surgery equipment, sterile materials and more medicaments (Kuladip *et al.*, 2011). The long-term non-surgical method is deslorein implant has the ability to overthrow steroid sex hormones up to 25 months in prepubertal cats (Fontaine, 2015). Second option is intratesticular injection, performed using a sterile needle inserted from the ventral part of the testis cranially and the solution injected while pulling the needle out (Kuladip *et al.*, 2011). The disadvantage is that the medicament used for injection, calcium chloride and zinc gluconate, is expensive and after the injection animals do have testicular swelling up to 72 hours and discomfort right after injecting (Kuladip *et al.*, 2011; Kutzler, 2015). Depending on the number of procedures to be performed, it can still be more expensive in case of large numbers of animals and the procedure itself needs further research (Kuladip *et al.*, 2011; Kutzler, 2015).

A vasectomy removes the ability to reproduce but the sexual behaviour remains, making this the ideal procedure for free roaming male cats (Howe, 2006). As their territorial behaviour remains, it helps to avoid the migration of intact males. Relying on the literature search, the most reliable articles are from the 1980s and the method can be considered outdated.

1.3. Suggested time for the appropriate age to castrate cats

1.3.1. Suggested time for castrating cats set by institutions

The opinion regarding cats' age during the castration still varies depending on the country's statement and necessity for the control of the stray feline population as well as on the veterinarian's perspective. The common age for kittens to be gonadectomized is about six months (Olson, 2001) however there is proof that it is possible to neuter cats safely between six and twenty-four weeks of age (Howe *et al.*, 2000; Joyce *et al.*, 2011; Porters *et al.*, 2014). PPG is described as "neutering well before the onset of puberty" which means it is done before 23 weeks of age (Howe, *et al.*, 2000; Farnworth, *et al.*, 2013). Recommendations for PPG in kittens is becoming more favoured (Farnworth *et al.*, 2013).

The European Convention for the Protection of Pet Animals (1987) states that gonadectomy should be supported to reduce unintended breeding of stray cats and veterinarians should be encouraged to practice it in greater volumes (Council of Europe, 1987). The British Small Animal Veterinary Association (BSAVA) supports The Cat Group's opinion that cats should be neutered at about four months of age (BSAVA policy statement 2019). On the other hand, the American Veterinary Medical Association (AVMA), the American Animal Hospital Association, the American Humane Association and the Humane Society of the United States recommend castrating cats at six to fourteen weeks of age (Root Kustritz, 2002). From November 1st of 2017, it is mandatory to neuter all shelter cats before they leave for a new home and all the other cats not intended for breeding to be neutered before reaching six months of age in the region of Wallonia, Belgium (Service Public de Wallonie, 2017). At the same time, Swedish national recommendations state that cats should be castrated starting at the age of six months (Pernestål *et al.*, 2012). International organizations like the Society for the Prevention of Cruelty to Animals and Society for Theriogenology also favour PPG to be performed as early as six to fourteen weeks of age (Root Kustritz, 2002). The mentioned recommendations and statements describe the problems with feline population control depending on the country: in the United States of America cats are described as feral

compared to Sweden where the problem is almost absent (Murray *et al.*, 2015; Root Kustritz, 2018)

In Estonia, The Shelter for Homeless Animals of Tartu accepted 981 male cats from 01.01.2018 to 31.12.2019 and only 86 (8.8%) of them were castrated at the time of arrival to the shelter (personal communication, 20.01.2020). To address the local problem, the Narva City Council has stated a policy that from year 2020 all the cats within the city limits need to be sterilized (Riigi teataja, 2020). It states that the cats who have an owner need to be sterilized within their first year of life. Narva is the first city in Estonia to regulate feline sterilization by law. In the Estonian Requirements for keeping pets, nothing is stated on the topic of sterilizing the cats living in homes or shelters (Riigi teataja, 2009).

1.3.2. Opinion of veterinarians regarding the appropriate age of feline castration

Opinions on gonadectomy and when it should be performed vary amongst veterinarians depending on housing, wellbeing of the cat and how the animal's natural social behaviour may be affected (Murray *et al.*, 2008; Root Kustritz, 2012). Up to 90% of the veterinarians in New York enforce mandatory neutering of cats before adoption to avoid the possibility of unwanted litters (Spain *et al.*, 2002; Root Kustritz, 2007). A survey amongst the veterinarians of the United Kingdom found that 51% of them recommended neutering starting from six months of the animal's age, while in the state of New York it was around 35%, the majority recommending PPG (Spain *et al.*, 2002; Murray *et al.*, 2008). For feral and stray cats, there was strong support amongst UK veterinarians to castrate them prepubertally, although only 28% of veterinarians perform it (Joyce *et al.*, 2011). PPG is also more familiar to practitioners in New Zealand and Australia as 65% of veterinarians are adapting it into their job (Farnworth *et al.*, 2013). The possible explanation for this phenomenon is that there has been less training on PPG for veterinary students in the United Kingdom (Spain *et al.*, 2002).

1.4. Prepubertal gonadectomy

1.4.1. Benefits of the prepubertal gonadectomy

The term early-age gonadectomy is implying only to the age of the surgical castration whereas prepubertal gonadectomy means that the procedure is done before the onset of puberty (Little, 2011). The age at which puberty appears in male kittens varies considerably but it usually occurs between the age of eight to ten months, but can show as early as three and a half months (Little, 2011). The traditional recommended age for sterilizing cats is approximately between five and eight months (Joyce *et al.*, 2011), which means there is a possibility that it is not done before the cat reaches their sexual maturity. Castrating cats prepubertally may have a key effect on the number of stray animals and reducing their population, and it has been done in the United States of America for twenty years (Root Kustritz, 2002). This helps to reassure that there will be no unplanned litters among adopted cats and removes the owner's responsibility to castrate the male cat after going to a new home since compliance to it is estimated to be less than 60% (Howe *et al.*, 2000). It is also beneficial for cat breeders, who can place pet animals to their permanent homes as early as at 12 to 14 weeks of age to help their socialization, training and lack of necessity to deal with the consequences of "bad" breeding which means not breeding standard animals with possible hereditary defects (Root Kustritz, 2002; Ahola *et al.*, 2017).

Sterilizing cats at a young age has several benefits regarding anaesthesia and surgery. Young animals tend to tolerate anaesthetics better and the quantity needed for the procedure is usually smaller than in older animals (Joyce *et al.*, 2011). Recovery from surgery and anaesthesia is also faster and with less complications (Joyce *et al.*, 2011). The advantage of PPG is shorter surgery time and less blood from the incisions because of smaller blood vessels compared to adult animals (Joyce *et al.*, 2011). It is also confirmed that the postoperative complications are not greater in PPG than in TAG (Porters *et al.*, 2014).

The major benefit of castration of male cats is their reduced sexual behaviour, which the owner usually finds disturbing and might encourage them to abandon the pet. A decrease in sexual behaviour after castration of male cats is a strongly supporting evidence of benefits of gonadectomy (Root Kustritz, 2017). Urine spraying is a normal behaviour for male cats and is done to mark their territory and to repel the other males and improve the possibility to access fertile females. The presence of spraying is under hormonal control and castration may help prevent it along with roaming and fighting with other male cats (Hart, 1996). A survey in adult male cats with urine spraying and other behavioural problems showed that castration was an effective solution for eliminating these problems in 80 to 90% of

problematic animals (Hart *et al.*, 1973). Evidence shows that 12% of male cats castrated prepubertally take up spraying later in life, which might suggest that being sterilized at an early age does not have a significant benefit to prevent the territorial marking problem over castration done later in life for resolving an ongoing problem (Hart, 1996). Another study found that the early age of castration is significantly associated with aggression towards the veterinarian, frequent hiding, shyness around strangers and sexual behaviour. It needs to be considered that shyness and hiding might be the results of stressful events so it is impossible to determine if these were the consequences of PPG or behaviour which could be associated with being adopted at a young age (Spain *et al.*, 2004).

Cats neutered before twenty-two weeks of age compared to those neutered in older age were not predisposed to have any conditions related to long-term immunosuppression like upper respiratory tract infection onset after one year of age, FIV, FeLV or other repeated infections in the same animal (Spain *et al.*, 2004). Reduced cases of FIV, connected to castration, might be reported because of reduced aggression by decreased male hormones in cats and therefore less bite wounds, as FIV is commonly transmitted through these (Joyce *et al.*, 2011). Another research has shown that among early-age neutered cats, there were fewer incidences of feline asthma and gingivitis (Spain *et al.*, 2004). Castrating the cat at an early age also prevents the possibility of testicular neoplasia (Joyce *et al.*, 2011).

Feline Coronavirus (FCoV) is the agent causing an immune-mediated feline infectious peritonitis (FIP) (Hartmann, 2005). FCoV-specific antibodies are found in most of the cats (up to 90%) in the multiple cat households and in half of the single cat household (up to 50%) (Hartmann, 2005). Even though FCoV infection is found largely in cats, it is usually clinically seen as gastrointestinal tract signs like diarrhoea and only up to 10% result in fatal FIP (Tasker, 2018). The highest prevalence has been found in young cats up to three years of age in the multiple cat households. The purebred as well as intact male cats are also in higher risk group (Rohrbach *et al.*, 2001; Pesteneau-Somogyi *et al.*, 2006). The major route for getting the virus is through contact with feces (Pedersen *et al.* 1995). The virus is endemic in cat populations who are living together in a small place like shelter and catteries (Hartmann, 2005) whereas free roaming cats do not have the same locations for dumping the feces and therefore have a smaller opportunity to get FCoV (Hartmann, 2005). The higher prevalence of FIP in certain breeds like Sacred Birman, Ragdoll, Abyssinian and Rex-breeds has been reported (Pesteneau-Somogyi *et al.*, 2006). Since the purebred cats have a smaller

genetic variety, they are grown in the catteries and they can have more stress from more frequent breeding and of constant socialization, it might affect the prevalence of FIP in this population (Kass *et al.*, 1995; Pesteneau-Somogyi *et al.*, 2006).

1.4.2. Negative aspects of prepubertal gonadectomy

Some of the possible risks of neutering are obesity and becoming overweight after PPG, which has been demonstrated to have a prevalence of 63% in some populations (Lund *et al.*, 2005; Colliard *et al.*, 2009; Larsen, 2017). Castrated cats with unlimited access to food are more likely to gain body weight and have a higher body fat percentage compared to cats with controlled eating habits (Backus, 2011). One study demonstrated that the gonadectomized cats gained body weight in 30.2% of cases when assessed one and three months post-surgery compared to 11.8% of intact cats (Fettman *et al.*, 1997). It needs to be emphasized that the weight is gained due to increased food intake and unchanged energy expenditure (Backus, 2011). The food intake might be the result of changed hormonal milieu, such as increases in concentrations of prolactin, leptin and insulin-like growth factor-1, and decreases in concentrations of sex hormones like oestrogens and testosterone (Larsen, 2017). Significant reduction of oestradiol is seen in male cats after castration, which might be a potential large-scale factor impacting the rise of food intake seen after gonadectomy (Backus, 2011). The solution for weight gain is to either increase the energy expenditure or to decrease energy intake at least 11% up to over 30%, based on the weight-gain of a certain animal (Backus, 2011; Wei *et al.*, 2014; Larsen, 2017). Furthermore, obesity can lead to diabetes mellitus, constipation, orthopaedic issues, altered haemostasis, urinary tract disease, hepatic lipidosis and skin diseases (Scarlett *et al.*, 1998; Lund *et al.*, 2005). However, there seems to be no difference on the obesity risk relating to the age of gonadectomy so this means that from the aspect of PPG, this is not a concern to affect the decision of how old the animal should be before castration (Spain *et al.*, 2004; Larsen, 2017).

There are more possible health risks suggested to be related to early age gonadectomy. For example, skin diseases, immune deficiencies, lower urinary tract obstruction (Johnston, 1993). One retrospective cohort study included the cat owners who had adopted PPG cats (neutered before twenty-two weeks of age), evaluating the possible long-term health risks of this procedure. The research showed that concerns about urinary obstruction, anatomical differences of the penis and feline lower urinary tract disease (FLUTD) should not be used

as an excuse to postpone castration of male cats because they are not relevant (Spain *et al.*, 2004).

There is only one article published where it has been demonstrated that cats neutered at either seven weeks or seven months of age have had delayed closure of the distal radial physis compared to intact animals. The comparison was made only by the age of castration and it had no effect on the problem. Furthermore, clinical significance is unknown (Root *et al.*, 1997).

1.5. Clinical considerations for prepubertal gonadectomy

1.5.1. Anaesthesia

There is always a health-risk regarding animals during anaesthesia and surgery. Anaesthesia in pediatric animals needs careful consideration when choosing anaesthetic agents, as well as precise maintaining and monitoring during anaesthesia. On the other hand, young animals usually tolerate anaesthesia well and the recovery from it is quick (Joyce *et al.*, 2011). Before the procedure it is necessary for the animal to undergo a complete physical examination and the veterinarian should be confident that the cat is vaccinated and free from parasites. It is compulsory that the patient does not have one or both testes retained in the inguinal canal or in the abdomen. In this case it is recommended to wait until both testes have descended into the scrotum (Root Kustritz, 2002). It is also necessary to consider the dangers when it comes to different breeds of cats and tolerance of anaesthetics (Joyce *et al.*, 2011).

Paediatric animals are predisposed to hypothermia more than adults because of young animals' greater surface area, volume ratio, less subcutaneous fat and reduced ability to shiver. For minimizing this risk, it is crucial to provide them a warm environment pre- and postoperatively and during the operation itself, for example, with a warm air blanket. Possible complications for hypothermic animals during the surgery are decreased heart rate, anaesthesia that is too heavy and prolonged recovery after the operation. (Faggella *et al.*, 1993; Root Kustritz, 2002)

If possible, the animals should be handled before the surgery as minimally as possible to avoid over excitement, because it can lead to the need for more anaesthetics than

recommended. To reduce the risk of overexcitement, intramuscular (IM) administration of pre-anaesthetics may be required, although administration of intravenous (IV) fluids is also endorsed and therefore the intravenous drip is needed. If the animal is relaxed enough and it is possible to insert IV drip without IM medicaments injection, it is possible to administer some prior anaesthetics through IV route. (Faggella *et al.*, 1993; Root Kustritz, 2002)

Other physiological differences between mature cats and kittens are renal and hepatic functions, which differ until the animal is twelve to fourteen weeks of age. Renal blood flow and glomerular filtration rate are decreased and hepatic enzyme systems do not function as fast as in adults. This leads to subsequent prolonged effect of anaesthetic agents before being metabolized and excreted. Plasma protein concentrations are reduced as a result of liver's slow protein production, leaving an extra amount of anaesthetics unbound and accessible at the time of anaesthesia. Considering these differences, it is suggested to use anaesthetic agents at somewhat lower doses than used in adult animals to achieve the same effect. The fact that a greater proportion of kitten's blood supply goes directly to the brain needs to be recognized when choosing the dosages for anaesthetic agents. (Faggella *et al.*, 1993; Root Kustritz, 2002)

Kittens are also predisposed to hypoglycemia since they have small reserves of glycogen in skeletal muscle and liver so therefore, they have markedly slower glycogenolysis and gluconeogenesis (Root Kustritz, 2002). The blood glucose level should not drop down to 5 mEq/l (Joyce *et al.*, 2011). To avoid hypoglycemia, kittens should not be made to fast for too long before anaesthetic induction, but provided with possibility, to eat up from three to four hours before anaesthesia is begun and offer food shortly after the procedure is done. Intravenous fluid administration also helps to prevent the consequences of hypoglycemia (Root Kustritz, 2002). Hypoglycemia may be also the reason for prolonged recovery (Joyce *et al.*, 2011).

In kittens, the most important cardiopulmonary change to be acknowledged during anaesthesia is the possibility for variability of cardiac output, so it is strongly recommended to monitor the heart rate and if it is necessary to manipulate in order to avoid hypotension and decreased oxygenation of tissues. It is also mandatory to examine the respiratory rate, because paediatric animals are limited in their abilities to respond to an elevated carbon dioxide concentration in blood or tissues and their lungs have small oxygen reserves (Joyce

et al., 2011). To minimize the risk of not having enough oxygen in the body, it is recommended to use anaesthetic equipment with possibility to have a minimal dead space in the lungs and minimize resistance in the respiratory system. The breathing mask or endotracheal tube should be tight-fitting. The high respiratory rate and increased alveolar ventilation leads to faster take-up of inhalational anaesthetic agents and should not be forgotten (Faggella *et al.*, 1993; Root Kustritz, 2002). The non-invasive monitoring techniques include pulse oximetry, capnography and Doppler (Joyce *et al.*, 2011).

For paediatric animals there are several anaesthetic protocols which are safe for use. Choosing “the best technique” based on protocols is defined by the depth of sedation, shortest time for induction and recovery and best quality of induction and recovery (Faggella *et al.*, 1993; Joyce *et al.*, 2011; Porters *et al.*, 2014). There are several options of anaesthetic protocols for PPG like combination of medetomidine (80 µg/kg IM), ketamine (5 mg/kg IM) and butorphanol (0.4 mg/kg IM) which includes good analgesia and possibility to use atipamezole for reversing the anaesthesia (Joyce *et al.*, 2011). Another option is to use medetomidine (80 µg/kg IM) with ketamine (5 mg/kg IM) but these agents do not include analgesia or ketamine (5-10 mg/kg IM) together with midazolam (0.25 mg/kg IM) together with isoflurane but to be considered that minimal perioperative analgesia is gained (Joyce *et al.*, 2011). Other suggestions include isoflurane (4%) via mask for premedication and for maintenance as well but 2-3% and via endotracheal tube; the second protocol advises to perform the premedication using atropine (0.045 mg/kg IM) and for induction as well as for maintenance isoflurane via mask, although analgesia may be poor for both of them (Faggella *et al.*, 1993; Porters *et al.*, 2014).

On the other hand, the RSPCA Greater Manchester Animal Hospital is combining medetomidine, ketamine, midazolam and an opioid (methadone or buprenorphine) (Joyce *et al.*, 2011). In paediatric animals, described complications during anaesthesia when being gonadectomized are cardiac arrest, drug overdose, regurgitation and aspiration during the operation along with changes in cardiac rate or rhythm. It is necessary to remark that incidence of any of these complications were not greater in kittens neutered less than twelve weeks of age compared to cats gonadectomized at twelve to twenty-four weeks of age (Howe, 1997; Root Kustritz, 2002).

After an anaesthesia it is mandatory to keep the animal warm until the kitten is ambulatory,

to prevent hypothermia. For avoiding hypoglycemia, the food can be offered shortly after the animal can stand. It is also important to not forget the proper analgesia. (Joyce *et al.*, 2011; Porters *et al.*, 2014)

1.5.2. Surgery

Preparation for sterile surgery of a PPG patient is the same as it is for TAG. The described protocols are based on two records: one where the research in which PPG was performed on kittens of eight to twelve weeks old (Porters *et al.*, 2014) and the other one in which PPG was done on cats of six to fourteen weeks of age (Root Kustritz, 2002). The benefit of PPG is that surgery time is usually shorter and blood vessels are smaller, which results in less blood from the incisions (Joyce *et al.*, 2011). The shaved area should be atraumatic and as minimal as possible. The animal should be free from excessive liquid used for cleaning the operation area and it is recommended to use non-alcoholic scrub solutions for preventing the loss of body heat (Root Kustritz, 2002; Porters *et al.*, 2014).

There are two described surgical approaches for PPG. There were no preferences to using suture materials over the use of spermatic cord (Porters *et al.*, 2014). The castration begins with stabilizing one testicle in the scrotum between fingers. A longitudinal incision in the scrotal skin is made on the particular testicle. The spermatic vessels need to be ligated to stop the bleeding either with knot or ligation. Ligation can be done with fine suture materials as 2/0 to 4/0 chromic gut, polydioxanone and polyglactin as Vicryl without opening the vaginal tunic. The spermatic cord is sectioned between the ligature and the testicle after which the testicle is removed. The remaining end is placed in the scrotum and the skin wound is left open. The procedure needs to be repeated with the other testicle. It is also possible to tie the spermatic cord on itself in a single throw without opening the vaginal tunic. The spermatic cord is sectioned between the testicle and the ligature, the testicle is latter detached. The stump is placed in the scrotum and the skin incision is left open. (Root Kustritz, 2002; Porters *et al.*, 2014).

Compared with gonadectomy performed at TAG, the time for surgery was significantly shorter in PPG only in one study and no complications were described neither during the operation or when describing problems with the wound, although this depends on the experience of the surgeon (Porters *et al.*, 2014). In conclusion, the data supports the scientific

evidence for the safety of PPG in male cats (Faggella *et al.*, 1993; Howe, 1997; Joyce *et al.*, 2011; Porters *et al.*, 2014).

2. MATERIALS AND METHODS

2.1. The data collection

The data was collected via online questionnaire (Appendix 1) from 02.07.2019 to 04.10.2019. Information about the questionnaire was spread in the social media (*Facebook*) groups meant for the cat breeders. The publication method and aim of the questionnaire was to reach the breeders of purebred cats all over the world. To be included to the study, the cat needed to be purebred but there were no breed restrictions. The kittens had to be gone through surgical sterilization instead of alternative options for neutering.

2.2. Questionnaire

The questionnaire included 13 questions, 8 of them with pre-set answer options and 5 as open questions. The questions were about the kittens owned by the breeder, details about gonadectomy, vaccination status of the kitten at the time of the surgery and FIP status. Questions about the kittens were the breed, country, where the surgery was performed, the age and the number of the kittens taken to the PPG. Specifically, it was asked how many kittens and which kind of complications they had after the PPG. Furthermore, the breeders answered if any of the kittens died during or after the surgery and did the kittens wear protective collar or suit post operation. The questions about vaccination were if the kitten was vaccinated at the same time with the surgery against panleukopenia, cat flu and/or rabies. Also the FIP status up to two years after the operation was asked: did any of the PPG kittens develop FIP and how many of them. And finally, there was possibility to clarify the answers given before as open text.

There were three main aspects that were considered as possible problems related to PPG in this study: complications, FIP and death. FIP and complications were addressed separately

because FIP can figure as a complication but it is possible that this is not the consequence of neutering.

2.3. Statistical analysis

All statistical analysis was performed in Microsoft Excel. The chi-square test was performed to compare the number of complications and cases of FIP between breeds, countries and age groups. The Fishers Exact Test was used to decide if the specific complication affecting the population was statistically significant. The results with $p \leq 0.05$ were considered statistically significant.

3. RESULTS AND DISCUSSION

The questionnaire was replied by 210 breeders around the world. It included answers about 6646 kittens taken to the PPG. The biggest advantage of this questionnaire was including the breeds separately and possibility to include a large number of kittens. The structure of it left the possibility to look at the complications and FIP status in the breeds, in different countries and by the age groups. In the similar focus has been mainly on the age of the cats and so wide variety of different breeds have not been addressed regarding of the PPG (Rohrbach *et al.*, 2001; Pesteneau-Somogyi *et al.*, 2006; Tasker, 2018).

The answerers were assured that the questionnaire is anonymous to protect the breeders and veterinarians. At the same time, it made the answers untraceable and therefore it was not possible to ask for further clarifications. From the returned questionnaires it came clear that breeders could either emphasize the problems they had with PPG or they were keen on suggesting that this procedure has no adverse effects on the kittens and the objectiveness was not always met. For example, in the case of Mozambique with only two cats reported from the country with both of them having complication was unclear if the owner had understood the aim of the questionnaire to give answers about the whole litter(s) objectively.

Three answerers gave information about two different countries in one form and did not clarify the number of kittens who had undergone PPG in each of the countries. There is also the possibility that there could have been more answers from the breeders but the first sentence in the questionnaire stating that the aim was to find out about complications, misguided these answerers whose cats had not had any complications regarding to PPG and thought that their information about PPG was not necessary for this study.

In the study the majority of the information provided about the breeds and countries is discussed separately to avoid the possibility to track certain individuals and possible harm done to local breeders and veterinarians. Breed and country are described together only when necessary to clarify the results.

3.1. The dataset

The population included to the study, was divided into 5 different groups according to the age when the PPG was performed. The demography of the population was defined by the countries where the kittens were gonadectomised

There were 30 cat breeds represented and the three most popular ones were Maine Coon with 1193, Bengal with 782 and Ragdoll with 696 kittens. The whole population used in the present study is shown in table 1. There are currently 48 recognized cat breeds according to the Fédération Internationale Féline and this study concludes 70.8% of these breeds which is considerable sample size (FIFe, 2020). They have been categorized by multiple features and in this research, we focus on the one which divided them by the weight, based on Kienzle and Moik (2011) who classified the cats in the categories like very light, light, medium, large and giant, leaving some of the breeds into two categories because of the different weight of the representatives.

In this study the cats were placed only into one of the categories were set to the bigger weight class to approach the fact that the cats tend to be rather over- than underweight (Kienzle, *et al.*, 2011; Ohlund, 2018). These categories do not include all the cat breeds viewed in this study because of the shortage of research dividing breeds into categories based on weight. For the reason to find out the correlation between the size of the cat and complications due to PPG it is necessary to use the information provided.

Table 1. Cat breeds and their population represented in the study

Breed	Category based on weight ¹	Number of kittens	Proportion from all kittens (%)
Abyssinian		33	0.5
American Curl		4	0.1
Australian Mist		200	3.0
Bengal		782	11.8

Breed	Category based on weight ¹	Number of kittens	Proportion from all kittens (%)
British Short/Longhair ²	Large	160	2.4
Burmese		302	4.5
Burmilla		10	0.2
Cornish Rex		88	1.3
Devon Rex		88	1.3
Domestic Short/Longhair ³		31	0.5
European Breed	Light/medium	50	0.8
	Category based on weight ¹	Number of kittens	Proportion from all kittens (%)
Korat		30	0.5
Kurilien Bobtail	Giant	1193	18.0
Maine Coon		100	1.5
Manx/Cymric ²	Large	573	8.6
Norwegian Forest Cat		194	2.9
Ocicat	Very light	484	7.3
Oriental Short/Longhair/ Siamese/ Balinese ^{2,3}	Light	181	2.7
Persian/ Exotic ²⁴		15	0.2
Peterbald		50	0.8
Pixie-bob		696	10.5
Ragdoll	Light/medium	480	7.2
Russian Blue	Light/medium	307	4.6
Sacred Birman		3	0.0
Relkirk Rex	Large	339	5.1
Siberian Cat/ Neva Masquerade ²⁴		34	0.5
Somali		51	0.8
Sphynx		144	2.2
Tonkinese		4	0.1
Turkish Angora			

¹ Based on Kienzle and Moik (2011)

² Different breeds according to FIFe (FIFe, 2020)

³ Not recognized according to FIEe (FIFe, 2020)

3.1.1. The age of the kittens at the time of PPG

The literature shows that if in the United States, the PPG has been widely recommended for some time (Root Kustritz, 2002) and the Council of Europe has been suggesting it from the 1987 (Council of Europe, 1987) but as for the veterinarians, these suggestions vary considerably. The most remarkable example here is that although majority of United Kingdom veterinarians support PPG, only 28% perform it (Joyce *et al.*, 2011).

The questionnaire offered possibility to choose from 5 different age groups when the PPG surgery of the kittens was performed. Most of the kittens had gone through PPG between the

age of 11 to 18 weeks, including two groups as 11-14 weeks of age with 4942 and 15-18 weeks of age with 1090 kittens. Based on the literature the PPG is counted to be performed before 23 weeks of age (Howe, *et al.*, 2000; Farnworth, *et al.*, 2013) and in this study 99.4% of the population is in that age.

Table 2. Kittens of the study divided by age groups

The age group	Number of cats in that group	Proportion from the whole population (%)
Under 10 weeks	558	8.4
11-14 weeks	4942	74.4
15-18 weeks	1090	16.4
19-22 weeks	20	0.3
23-26 weeks	36	0.5

The answers were about 24 countries where the PPG was performed. Although it was asked for the country where the surgery was performed, it is not impossible that any of the answerers did not answer for the country where the kittens were born or grown. The three most represented countries were the United States, Denmark and the United Kingdom with 1204, 888 and 657 kittens accordingly. In the literature found on this topic there is PPG mostly described in one or a few of the countries (Spain *et al.*, 2002; Root Kustritz, 2007). In three cases the breeder had gonadectomized the kittens in two different countries but did not specify how many kittens had surgery in which country. Due to this, they were not included into the one specific country group.

For the data analysis the countries were divided by the continents. The Europe was represented by half of the countries (55.4%) in this study. All the countries represented are named in the table 3.

Table 3. Countries and their kitten population represented in the study

Continent	Country	Number of kittens	Proportion from the whole population (%)
Africa		197	3.0
	Mozambique	2	0.0
	South Africa	195	2.9
Asia		15	0.2
	Russia	15	0.2
Australia/Oceania		1082	16.3
	Australia	582	8.8
	New Zealand	500	7.5
Europe		3682	55.4

	Austria	139	2.1
	Belgium	155	2.3
	Denmark	888	13.4
	Finland	351	5.3
	France	290	4.4
	Germany	180	2.7
	Germany & Sweden	17	0.3
	Hungary	21	0.3
Continent	Country	Number of kittens	Proportion from the whole population (%)
Europe	Italy	21	0.3
	Lithuania	60	0.9
	Netherlands	546	8.2
	Norway	1	0.0
	Poland	280	4.2
	Serbia	10	0.2
	Slovenia	27	0.4
	Sweden	24	0.4
	Sweden & Finland	15	0.2
	United Kingdom	657	9.9
North America		1650	24.8
	Canada	346	5.2
	United States	1204	18.1
	United States & Canada	100	1.5
South America		10	0.2
	Argentina	20	0.3

3.2. Factors affecting the safety of PPG

3.2.1. Complications

If there were any complications during or after the PPG, breeders were asked to name them. There were eight different complication types including the ones that the study brought out and the problems described by the answerers. The complications named in the questionnaire were bleeding, infection of the wound and opening of the stitches. The breeders were asked to bring out the other complications not mentioned in the questionnaire. The breeders added to the list: complications due to anaesthesia, later kidney problems possibly secondary to PPG, anatomical abnormalities, urinary tract problems possibly due to PPG and some of the answers were unspecified. In one previous study it was noted that the only complication after castration noted was scrotal swelling or hematoma (Pollari *et al.*, 1996). The complications

described at castration according to one study were seen in 0% of the kittens younger than seven months (Pollari *et al.*, 1996). In this study 30 kittens had complications making up 0.5% of the reported population.

There were no complications noted in the age group of 10 weeks or younger. The most of the complications were seen in the age group of 11-14 weeks which was also the biggest age group and therefore represented better. These kittens had the prevalence of complications 0.4% with 18 complications noted: bleeding in 6 kittens, infection of wound in 4 kittens, opening the stitches in 1 kitten, complications due to anaesthesia in 1 kitten and unspecified complications in 6 kittens. The prevalence of complications in the age group of 15-18 weeks old kittens was 0.7%. with 8 complications: infection of the wound in 1 kitten, opening the stitches in 1 kitten, complications due to anaesthesia in 5 kittens and anatomical abnormalities in 1 kitten. The age group of 19-22 weeks old kittens had 1 complication which was urinary tract problem possibly due to PPG and the prevalence of the complications in this age group was 5.0%. The age group of 23-26 weeks old kittens had 3 kittens with complications: infection of the wound described in 1 kitten and kidney problems as complications possibly due to PPG in 2 kittens. The complications prevalence in the age group was 8.3%. The percentages were higher in the older age groups because of the small population. The discussion about the specific problems is found above.

Statistically it had a low prevalence and not statistical significance. There have been mentioned problems due to later obesity including hepatic lipidosis, diabetes mellitus and urinary tract problems (Lund *et al.*, 2005; Larsen, 2017) but since these problems develop later in life it is impossible to evaluate the long-term complications. On the other hand, the complications most seen on the surgery of the paediatric animals are drug overdose and cardiac arrest (Howe, 1997; Root Kustritz, 2002) which have been mentioned in this study for seven kittens. The group where the complications were noted the highest, impacting the age, was 23-26 weeks but it could be due to small number of cats and one of the complication types, kidney problems related to PPG is under a question. Although there has been description in the literature about urinary tract problems (Spain, *et al.*, 2004; Lund *et al.*, 2005), the kidney problems are not mentioned and therefore questionable in here if they figured due to PPG or were impacted by some other factor. The problem was specified later and it was mentioned that the cats were not related to each other and neutered in the same place. The kittens were taken to the neuter because of urinating everywhere and afterwards

the veterinarian had said that the kidney problems were from neutering too early, according to the owner. This information raises the question whether the urinating was a behavioural problem or could have been an illness and therefore it is questionable if the problem is related to the PPG. What is more, since the owner described only two kittens, who were the only representatives from the country, it is highly possible that reason for answering was based on an emotional connection and is not objective.

The complication described as an anatomical abnormality is also under a consideration of validity in this study as for the complications related to the PPG. The anatomical abnormality was specified later as monorchid and it was said that the veterinarian had not discovered this before the surgery where the cat was under anaesthesia for 45 minutes while veterinarian was looking for the missing testicle. The cat went into the cardiac arrest and was resuscitated. The complication caused the death of the kitten after two days of the surgery by second cardiac arrest. In this case it is clearly shown that this complication is affected by the incompetent behaviour of the veterinarian. In the several studies, it has been suggested not to perform PPG in kittens with undescended testes (Root Kustritz, 2002; Porters *et al.*, 2014). Bleeding, infection of the wound, complications due to anaesthesia and unspecified problems represented 80% of all the complications. The distribution of the complications by the breeds is represented in the table 4.

Half of the kittens reported with complications were from two breeds: Bengal Cat and Ragdoll. Complications in Bengal were seen in 9 kittens, 1.2% of the breed population in the study.

The most represented complication was due to anaesthesia reported in six kittens, all of them Bengal cats. In commentaries given by breeders there were mentioned ketamine and injection anaesthesia. Even though no information regarding ketamine usage risk in the Bengal cats specifically could not be found in scientific literature, it has been stated for a long time that ketamine has a lot of side effects like elevated blood pressure and heart rate, profuse salivation, skeletal muscle hypertonus and it can cause delirium (White *et al.*, 1982). Therefore, based on the statistical analysis this kind of anaesthetics should be used with careful consideration or the standardized protocols should be used for Bengal cats with suggested ketamine dosages (Joyce *et al.*, 2011). The possible impact on different injectable anaesthetic compounds has not been studied specifically in Bengals and needs further research.

Table 4. The distribution of the complications by breeds.

Breed	Kittens in the breed	Kittens of the breed with complications	Proportion of complications in the breed (%)	Complication	Kittens in that complication group
Bengal	782	9	1.2		
				Bleeding	1
				Infection of the wound	2
				Complications due to anaesthesia	6 ¹
British Short/Longhair	160	1	0.6		
				Opening the stitches	1
Devon Rex	88	1	1.1		
				Anatomical abnormalities	1
Domestic shorthair	31	2	6.5		
				Kidney problems	2 ¹
Maine Coon	1193	2	0.2		
				Bleeding	1
				Infection of the wound	1

Norwegian Forest Cat	573	3 0.5			
				Infection of the wound	3 ²
Ocicat	194	1 0.5			
				Urinary tract problems	1
Ragdoll	696	8 1.1			
Breed	Kittens in the breed	Kittens in the breed with complications	Proportion of complications in the breed (%)	Complication	Kittens in that complication group
				Bleeding	4 ¹
				Unspecified	4 ¹
Russian Blue	480	2 0.4			
				Unspecified	2
Sacred Birman	307	1 0.3			
				Opening the stitches	1

¹kittens from different litters

² kittens from separate litters

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Another breed reported with multiple complications was Ragdoll with eight kittens: four with bleeding and four had unspecified complications. The four of these kittens who had bleeding after the PPG were all from the same breeder and the procedure was done in one country, possibly by one veterinarian. The population represented from this breeder was rather small with 12 kittens and therefore it is questionable if this is the complication affecting the breed or could have been possibly the consequence of the veterinarians' possible incompetence. There is also no literature overview bringing out the possibility that in the Ragdoll there could be more bleeding or other complications after the PPG.

The infection of the wound was found in Bengal, Maine Coon and in three different answerers Norwegian Forest Cats. It has been shown that after the castration, postoperative infection can be related to the usage of antibiotics and could be affected by the inexperienced surgeons (Vasseur *et al.*, 1988). The most common bacteria found in cats wounds is *Pasteurella multocida* environment and obligate anaerobes, that can be found in all around of the environment (Roy *et al.*, 2007). This means that there are many different factors which have an impact on the infection of the wound and the best effective way to prevent it is antibiotic therapy (Vasseur, *et al.*, 1988). In this study it is impossible to track back the complications and relate them to concrete factor. All except Bengal, are either large or giant breed cats which might imply that the bigger cats are in the higher risk group for bleeding after the PPG but further research is needed.

The opening of the stiches was found in two cats whereas it is important to bring out that they were both from the Netherlands. One answerer had only one cat in the represented population (British Short/Longhair) and had added information about animals' smaller jawline, paws and shoulders compared to the other cats of the same age. This raises a question if these cats were from the same breed or litter and if so, and is the comparison justified or not. If these were not from the same breed or litter, there it is a possibly unreliable comparison for this study. The other answerer had 10 kittens in the population (Sacred Birman) and one of them had an opening of the stiches. It was explained that the kitten had one testicle in the abdomen and that stitch opened. It was also answered that the kittens wore no protective collar which might be the explanation for this complication.

There was one litter of Domestic Short/Longhair with 2 kittens which both had kidney problems possibly due to the PPG which has already been discussed. This comprised 6.5% from total number of kittens reported in this breed. The high percentage was due to small number of kittens in the study and cannot be considered as breed specific trait. The same problem was encountered in the discussion of countries – this breed was the country's only representative.

As for the countries where PPG was performed, the majority (70%) of all of the complications were reported from two countries – Finland and Netherlands. Cats from these countries represented 13.5% of the population and had the similar complications with one exception: the complications due to anaesthesia were represented only in the Netherlands and both litters had gone through the PPG in Bengal, as mentioned before. This could mean that the cats were taken to the same veterinarian who had used unstandardized protocol for the anaesthesia and due to this was the prevalence of the anaesthetic complications this high. The other problems in the Netherlands were: bleeding and infection of the wound (1 kitten) and opening the stitches (2 kittens). In Finland they were bleeding (4 kittens), infection of the wound (3 kittens) and unspecified complications (4 kittens). The veterinarian's readiness and skills are important for performing PPG without complications (Spain *et al.*, 2002) and although not mentioned in literature specifically about these countries, it might be the case that the techniques are not performed every day and therefore some complications occur.

Other countries where the complications were represented were in the alphabetical order Australia (2 kittens who had unspecified complications), Canada (1 kitten with urinary tract problem possibly because of PPG), Denmark (1 kitten who had bleeding and 2 kittens with infection of the wound) and the United States (complication noted in 1 kitten who had anatomical abnormality). Based on the literature (Root Kustritz, 2007) and discussion before, in this study the cats' number per country was highest in the United States (1204 kittens) and if to consider this problem caused by the lack of veterinarian's knowledge then it is in correlation with the study researching veterinarians' opinions on the PPG.

For the statistical analysis the countries were categorized by the continents. Europe was compared to other continents because of the majority of the population. There was statistical significance between the continent and complications. Therefore, we can conclude that in the Europe there is a higher risk for the complications but as for this study the Europe was

represented with more countries and more kittens than the rest of the world. The literature describes a strong support among United Kingdom veterinarians for the PPG but only 28% of them actually perform it (Joyce *et al.*, 2011) whereas in New Zealand it is practiced by 65% of the veterinarians (Farnworth *et al.*, 2013). The training and confidence of veterinarians might be different and explain the differences in the complication distribution.

The effect of the weight on the risk of the complications was tested. Very light, light and medium breeds were compared to large and giant breeds (table 1) and the chi-square test result was $p < 0.001$ indicating there is statistical significance between the size of the cat and complications. Although, as mentioned before, some of the complications were possibly caused by the veterinarian's lack of knowledge or skills and not by the PPG itself.

There was statistical significance between the age and complications. Therefore, if the kitten is under 15 weeks of age, the PPG might have more complications than in older kittens. Although considering the complications and literature, it is influenced by the anaesthetics used and veterinarian experience (Joyce *et al.*, 2011). It is also important to emphasize that these statistics shows the complications as the owners described and without discredit to veterinarians.

3.3. Feline infectious peritonitis

In the questionnaire the FIP status was viewed in two years period after the surgical sterilization of male kittens. Feline infectious peritonitis (FIP) was reported in 60 kittens. Therefore, there were 0.9% kittens in the population who developed FIP. The research has shown that FCoV, FIP causative agent, is causing FIP only about in 10% of cases when infected (Tasker, 2018) and the risk factors for this disease are catteries, young age up to three years old and intact males (Rohrbach *et al.*, 2001; Hartmann, 2005 Pesteneau-Somogyi *et al.*, 2006). In this study the only risk factor not represented is being intact. To include the literature, the population of kittens who developed FIP is not higher than prevalence according to Tasker (2018).

Almost half (46.7%) of the kittens who had FIP within two years after the PPG were from two breeds (table 5).

The most reported cases with FIP within two years period after gonadectomy was Sacred Birman breed with 21 kittens, 35% from the kittens who had FIP and 307 of all the kittens reported from this breed. There was one breeder who reported that from 100 kittens 15 had FIP. There was also added that FIP clearly seems breed-related because they have not seen this disease in their other breed. It has been found that certain breeds seem to be more susceptible and Sacred Birman is one of them (Pesteneau-Somogyi *et al.*, 2006). One breeder of another breed brought out that these kittens who developed FIP were from the bad line of the breed and are not used for breeding anymore.

The second breed which had the most FIP prevalence was Maine Coon with 7 kittens, 11.7% from the FIP population. This breed is not listed in the predisposed breeds list (Tasker, 2018) and the problems occurred in several countries (Denmark, Finland, Germany, United Kingdom) separately. There was one answerer who marked that FIP might not have happened due to PPG. This data needs further research to assess Maine Coon as possible risk breed.

The other breeds listed for the possible higher-risk breeds by Tasker (2018) were Ragdoll (5 kittens with FIP in this study), Abyssinian and Rex which had no reported FIP cases in this study. This could be explained with the small number of kittens represented in the present survey.

The other countries where FIP was seen were in the alphabetical order Argentina, Canada, France, Italy, Lithuania, Netherlands South Africa and the United States.

Table 5. The distribution of the FIP by breeds

Breed	Number of kittens who developed FIP	Kittens in the breed	Proportion of FIP in the breed (%)	Proportion of FIP from the FIP population (%)
American Curl	1	4	25	1.7
Bengal	2	782	0.3	3.3
British Short/Longhair	5	160	3.1	8.3
Burmese	4	302	1.3	6.7
Kurilien Bobtail	3	30	10	5.0
Maine Coon	7	1193	0.6	11.7
Norwegian Forest Cat	5	573	0.9	8.3
Oriental Short/Longhair /Siamese /Balinese	2	484	0.4	3.3
Persian /Exotic	4	181	2.2	6.7
Ragdoll	5	696	0.7	8.3

Sacred Birman	21	307	6.8	35.0
Siberian Cat /Neva Masquerade	1	339	0.3	1.7

There were two age groups in which FIP was present. 53 kittens who developed FIP in two years after PPG were castrated at 11-14 weeks of age with prevalence of 1.1% in the age group and 0.8% from total population. The remaining 7 kittens who developed FIP were castrated at the age of 11-18 weeks and the FIP prevalence within the age group was 0.6% and from the total population 0.1%.

3.3.1. The death

Based on the questionnaire there was difficult to distinguish the number of the kittens who died as the result of the PPG. It has been shown in the literature that in the cats the mortality during the castration is 0.03% (Levy *et al.*, 2017). The mortality rate for this survey was 0.2%. There were three breeders who answered that the death of the kitten occurred during the surgery when the PPG was performed in the 11-18 weeks old kittens. Two breeders reported that kittens died within two days after the surgery in the same age group 11-18 weeks of age. Eight breeders had kittens that died to the complications later and the surgery age represented excluded only under 10 week old kittens. It needs to be considered that all of these cats might not have died because of the complications of PPG and the reporting of the data could have been biased as discussed before.

3.3.2. The vaccination status

The vaccination status was included in the questionnaire but since it had no significant statistical impact on the complications or on the FIP status it is not described here in more details. There are no previous studies which included vaccination status during the PPG. The vaccination status of the cats is found on the table 6.

Table 6. The vaccination status among kittens

Age	10 and younger	11-14 weeks	15-18 weeks	19-22 weeks	23-26 weeks
Vaccinated against panleucopenia + cat flu	53	2061	171	0	0

Vaccinated against rabies	0	109	51	0	0
Vaccinated against both of them	1	549	310	0	0
Vaccinated against neither of them	504	2223	558	20	36
Kittens in the age group	558	4942	1090	20	36

3.3.3. Collar and suit

The questionnaire included question about wearing a protective collar or suit after the surgery. It was shown in another study conducted in Finland that only 4.1% of the male cats wore the protective collar after the castration (Väisänen *et al.*, 2007) but the impact on the collar to the complications was not discussed. In this study, the majority of the kittens (99.1%) wore no protective collar or suit after the surgery and owners found it necessary to add collar or suit in only 43 cases possibly due to the cat showing interest to the operation wound. For 15 kittens the owners had decided to use the collar and 4 were wearing the suit straight after the PPG.

3.3.4. Attitude of the breeders regarding PPG

There were 45 answerers who specified problems or added commentaries at the end of questionnaire. 28 of them described the procedure positively. Many answerers recommended PPG because of the fast recovery and very little influence if all on the kittens later on. There was suggested to vaccinate the kittens at the same time and place the microchip.

8 people had negative commentaries and specifications to complications which were discussed before. One answerer mentioned that the complication was due to owner accidentally pulling the stitch. Two answerers described anatomical difference on a kitten and one of them death due to the incompetent veterinarian. One answerer pointed out that the veterinarian performs PPG based on the body weight and the minimal is 1.5 kg.

Overall attitude of the breeders was positive and they recommend PPG as a good and comfortable procedure for neutering the male kittens to send them to the new homes

without any fear of “bad” breeding (Root Kustritz, 2002) and kittens’ possible sexual behaviour like spraying or aggression (Spain *et al.*, 2004) towards the new owner.

CONCLUSIONS

The aim of the present thesis was to give an overview of the PPG procedure and to evaluate the safeness of PPG, including different cat breeds Possible complications and FIP status related to this procedure were compared between different age groups, breeds and countries represented in this study.

The statistics showed, that PPG is safe if performed correctly although some of the cat breeds seem to be in a higher risk group for certain complications.

The FIP might be breed-disposed but the animal’s age at the time of gonadectomy procedure has no impact on its risk. The FIP prevalence in two-year period after PPG in the purebred cat population represented in the thesis was 0.9%. The study showed higher FIP prevalence in the Sacred Birman cat breed.

Several complications related to PPG were reported by the cat breeders. It was noted that the veterinarians’ preparation to perform the surgery and their knowledge about anaesthesia protocols together with the breeder’s education about different risks is crucially important. Overall the complications were seen in 0.5% of the study population of 6646 cats which was not statistically significant. Therefore we can conclude that even though the risks exist with every surgery, PPG if performed considering the advised methods and anaesthesia protocols, is a safe procedure in purebred cats.

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ÜLDKOKKUVÕTE

Prepubertaalne gonadektoomia isastel kassidel: retrospektiivne küsitlusel põhinev noorte kasside kastreerimise ja võimalike tõuliste iseärasuste uuring.

Antud lõputöö eesmärk oli anda ülevaade PPGst ning hinnata selle turvalisust, sealhulgas erinevatel kassitõugudel. Töös vaadeldi võimalikke komplikatsioone ning FIP staatust seoses PPGga võrreldes esindatud vanusegrupe, tõuge ja riike. Selleks analüüsiti küsimustikku, mis sai tõukasside kasvatajatelt üle kogu maailma kokku 6646 vastust. Statistilise analüüsi jaoks kasutati programmi Microsoft Excel.

Andmeanalüüsi käigus selgus, et PPG on üldjuhul ohutu, kui anesteesia ja operatsioon teostatakse vastavalt soovitudele, kuigi mõnel kassitõul võib olla soodumus teatud komplikatsioonideks.

Kuigi on võimalik FIPi esinemise tõuline eelsoodumus, ei leitud FIPi ja kastreerimisvanuse vahelist seost. FIPi esinemine kahe aasta jooksul peale PPG teostamist oli 0.9% uuringus vaadeldud kasside kogupopulatsioonist. Käesolevas töös leiti, et FIPi esinemissagedus võib olla tõenäolisem puha birma kassidel.

Kassikasvatajad andsid teada mitmetest erinevatest PPG käigus ja järgselt komplikatsioonidest. Samas toodi välja, et selle protseduuri õnnestumine sõltub nii loomaarsti oskustest antud protseduuri läbi viimisel ning anesteetikumide valikust kui ka kassiomaniku teadlikkusest võimalikest komplikatsioonidest. Komplikatsioone tähendati 6646 kassist 0.5% hulgas ja probleemide esinemissagedus ei olnud statistiliselt oluline.

Lõputöö autori seisukoht on, et kuigi iga operatsiooniga kaasneb risk, on PPG õigesti sooritades turvaline võimalus puhtatõuliste kasside kastreerimiseks.

APPENDICIES

Appendix 1. Questionnaire for cat breeders

Early neuter in male kittens

The purpose of this study is to map possible complications in early neuter surgery in male kittens. In this study early neuter is considered to be done for a 26 weeks or younger kitten. These results will be useful to all breeders, as knowing what is normal helps us understand cats better and prevent possible problems.

From the published results it is impossible to recognise any owner or a cat. All results are handled confidentially. The reliability of the results depends on the number of the answers and accuracy of answers. All answers are valuable!

Breed of the cat: Abyssinian/ American bobtail/ American curl/ American shorthair/ American wirehair/ Australian mist/ Bengal/ British short/longhair/ Bombay/ Burmese/ Chartreux/ Cornish rex/ Devon rex/ Domestic short/longhair/ Don sphynx/ Egyptian mau/ European/ German rex/ Havana brown/ Japanese bobtail/ Korat/ Kurilien bobtail/ La perm/ Lykoi/ Maine coon/ Manx/Cymric/ Munchkin/ Nebelung/ Norwegian forest cat/ Ocicat/ Oriental short/longhair/Siamese/Balinese/ Persian/exotic/ Peterbald/ Pixiebob/ Ragamuffin/ Ragdoll/ Russian blue/ Sacred birman/ Savannah/ Scottish fold/straight/ Selkirk rex/ Siberian cat/neva masquerade/ Singapura/ Snowshoe/ Sokoke/ Somali/ Sphynx/ Thai/ Tonkinese/ Toyger/ Turkish angora/ Turkish van

In what country were the kittens operated:

How many kittens have you taken to early neuter?

How old were kittens when they were operated?

If you had kittens operated in different ages, fill out a new form for different age kittens

- 10 weeks or younger
- 11-14 weeks
- 15-18 weeks
- 19-22 weeks
- 23-26 weeks

How many kittens had complications after the surgery?

What kind of complications did the kittens have?

You can specify how many of each complication in the open question in the end

- Infection of the wound
- Opening of the stiches
- Bleeding
- Other
- No complications

Did any of the kittens die during or after early neuter?

- During surgery
- Within 2 days after surgery
- To complications later (specify how long after in the open question in the end)

Did the kittens wear collar or suit after surgery?

- Collar
- Suit
- Nothing was needed
- First nothing, but became interested and had to use collar or suit

Was the kitten vaccinated at the same time with panleukopenia and cat flu?

- Yes
- No

Was the kitten vaccinated at the same time with rabies?

- Yes
- No

Did any of the early neutered kittens develop FIP?

- Yes
- No
- These cats are still under 2 years old

How many kittens developed FIP after early spay?

Don't answer this if none of the kittens developed FIP

Anything else you want to add that wasn't asked?

Any other symptoms or side-effects related to early neuter? Number of complications etc.

Appendix 2. Non-exclusive licence for depositing the final thesis and opening it for the public and the supervisor's (supervisors') confirmation for allowing the thesis for the defence

Hereby I, **Hedvig Liblikas**
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