Neutering

Reproductive physiology
Rabbits are well known for their ability to reproduce quickly. The average litter size is 5-8 and females are able to conceive within hours of giving birth. Because rabbits can be lactating while they are pregnant, it is possible for a single female to give birth to over 40 offspring each year. Rabbits are induced ovulators with no defined oestrous cycle, although a cyclic rhythm in sexual receptivity exists. Follicular development occurs in waves, with 5–10 follicles on each ovary at any one time. When the follicles reach maturity they produce oestrogens for about 12–14 days; if ovulation has not occurred during this period the follicles then degenerate with a corresponding reduction in oestrogen level and sexual receptivity. After about 4 days a new wave of follicles develops and the doe becomes receptive again. Mating stimulates ovulation approximately 10 hours post coitus. Ovulation can also take place without mating and result in pseudopregnancy, which can be stimulated by the proximity of other rabbits or by the act of being mounted by another female or neutered male. Pseudopregnancy is shorter than true pregnancy, lasting approximately 16–18 days. Gestation lasts for 30–32 days. Foetal resorption is relatively common and can take place up to 20 days after mating. Sometimes viable fetuses are found alongside resorbing ones. Mammary development takes place in late pregnancy when the doe starts to prepare her nest by filling it with hay or other material before lining it with fur pulled from the hip, dewlap and mammary glands. Parturition usually takes place in the morning and lasts less than 30 minutes. Dystocia is rare but can be the result of foetal oversize. Torsion of the uterus is an unusual complication of pregnancy. Vaginal, or even uterine, prolapse and bladder eversion have been described in post-partum does.

Age to neuter
In rabbits the testicles descend at approximately 10–12 weeks and remain small for a further 6–8 weeks. During this period, sexual behaviour is minimal and the rabbit is unlikely to be fertile. At about 5 months of age, sexual behaviour increases and the testicles become larger. He will become fertile. Castration can take place as soon as the testicles descend. If a mixed pair is together, this will prevent breeding and the female can be left until she is older. Neutering immature females is difficult because the uterine horns are tiny, threadlike, difficult to locate and may break if any pressure is applied. For this reason, it is preferable to leave females until they are hormonally active, usually at about 5 months of age. The easiest time to neuter females is between 6 and 9 months, before large amounts of fat are laid down in the mesometrium. Ovariohysterectomy can be performed at any time during pregnancy or pseudopregnancy but after a doe has given birth, it is preferable to delay surgery until the babies are weaned at 4–5 weeks old.

Spaying females

Anatomy of female reproductive tract
Both ovaries lie in the dorsal abdomen, close to the kidneys. They are elongated elliptical structures that, in a sexually mature female, contain multiple follicles in varying stages of development. The cranial end of the ovary is attached to the fimbriae that open into the infundibulum. This is attached to the uterine tube (Fallopian tube), which forms a semicircle that encloses the ovary. These structures are enclosed in a discrete body of fat, the mesovarium, which is part of the mesometrium. The caudal end of the ovary is attached to the mesovarium by a short ligament. The uterine (or fallopian) tube is long and red in colour and can resemble a blood vessel. It opens into a long convoluted uterine body, which ends in a cervix. The right and left uterine horns are completely separate so there is no uterine body.
The two cervices are attached to form a single structure (bicornuate cervix) that separates the uterus from the vagina. The vagina is a long, flaccid, but muscular, structure that fills with urine during micturition. Contractions of the vagina occur readily and may be seen during ovariohysterectomy. The urethra lies ventral to the vagina and opens into about half way along its length, beneath the pubic bone. The external urethral orifice lies in the floor of the vagina. The part of the vagina that is distal to the urethral opening is sometimes called the urogenital sinus. It is attached to supporting musculature that can constrict and move the vagina and vulva during urination, mating and parturition.

**Ovariectomy, ovariohysterectomy or ovariohysterovaginectomy**

There is some debate about whether to perform ovariohysterectomy or ovariectomy. Ovariohysterovaginectomy is also recommended by some authors (not by me).

**Ovariectomy** is quick and avoids ligature placement close to the bladder, rectum or ureters. The procedure is becoming more common in dogs and cats and some surgeons may prefer the procedure in rabbits. It can be performed endoscopically. A concern about the procedure is that the uterine tissue that is left in situ can become cystic, neoplastic or infected. This is unlikely if ovariectomy is carried out on young rabbits. In rabbits over 1 year old, ovariohysterectomy is indicated because of the risk of uterine pathology.

**Ovariohysterovaginectomy** is sometimes recommended because the vagina fills with urine during micturition in rabbits. Although this is physiologically normal, it has led to the belief that it may be advantageous to remove as much of the vaginal body as possible to prevent reflux of urine into the vagina is possible and to prevent infection in the vaginal remnant. Ovariohysterovaginectomy is not recommended by this author.

**Surgical technique for ovariohysterectomy**

This is the recommended procedure, especially for older rabbits that may have uterine pathology. The most important part of the procedure is the positioning of the cervical ligature. The uterine horns and cervix are ligated rather than transecting the vagina. The ligature is secure and the uterine stump is sealed. Each horn is ligated separately at the bifurcation before taking the ligature around the cervical body. Once tightened, this ligature sits securely across the cervix without the need to transfix the vagina. There is no risk of urine leakage. The cervices are sterile and there is no risk of haemorrhage from the vaginal artery or interference with the ureters or the blood supply to the bladder.

**Indications for ovariohysterectomy:**

**Routine neutering.**

- To prevent unwanted litters.
- To reduce hormonal territorial behaviour and aggression.
- To prevent false pregnancies.
- To prevent reproductive disease, which is very common and often silent in mature entire females.

**Treatment of diseases of female reproductive tract**

- **Endometrial hyperplasia:** results from prolonged oestrogenic stimulation. It is characterised by thickening of the endometrium, development of mucus filled glands and accumulation of mucus in the lumen of the uterus.
- **Neoplasia:** Adenocarcinoma of the uterine endometrium is the most common neoplasm that is encountered in rabbits. The incidence increases with age and has been reported to reach 60% in females over 4 years of age and up to 75% by 7 years of age.
NEUTERING and COMPLICATIONS OF SURGERY

Uterine adenocarcinomas are often multicentric and involve both horns of the uterus appearing as globular polypoid structures that project into the uterus. As the condition advances, the tumours enlarge and coalesce so the large portions of the uterus are affected. They may contain large areas of haemorrhage, necrosis or calcification. Metastasis is slow and occurs via local spread into the peritoneum and other abdominal organs such as the liver, or by haematogenous spread to distant sites such as the lung, brain, skin or bones. Not all uterine tumours are adenocarcinomas. Carcinosarcoma, adenoma, metastasis from ovarian tumours, leiomyoma, leiomyosarcomas have also been reported.

- **Pyometra** is manifested by lethargy, inappetance, a purulent vaginal discharge, abdominal distension and a palpable abdominal mass. As in other species, pyometra is a life threatening disease but is complicated in rabbits by the ready formation of adhesions between the infected uterus and other structures and the friability of the tissue. Rupture of the uterus can occur during surgery but surgery is the only option for treatment and can be successful.

- **Developmental disorders**, such as absent uterine horns, are sometimes encountered during ovariohysterectomy in rabbits. Other abnormalities, such as a rudimentary vagina or an absent cervix have been reported. Some abnormalities occur concurrently with other problems, such as absent kidneys.

- **Endometrial venous aneurysms**. Aneurysms of the uterine and myometrial venous plexuses can develop in some females causing episodic bleeding, which can be dramatic and fatal. Intermittent haematuria may be evident.

- **Hydrometra**. The clinical signs of hydrometra are loss of body fat and muscle and abdominal distension. There may be no change in body weight. The uterus is grossly enlarged and filled with clear fluid.

- **Extrauterine pregnancy** is relatively common in rabbits and is due to the escape of a fertilised ovum into the abdominal cavity or rupture of a pregnant uterus. Implantation usually occurs on the parietal peritoneum.

Castration

**Normal male behaviour and secondary sexual characteristics**

In rabbits the testicles descend at approximately 10–12 weeks and remain small for a further 6–8 weeks. During this period, sexual behaviour is minimal and the rabbit is unlikely to be fertile. At about 5 months of age, sexual behaviour increases and the testicles become larger. Aggression towards male siblings can become serious and severe fight wounds may be inflicted by individuals that previously lived together with no problems. Wounds on the back, ears, eyelids and scrotum are common.

As maturity continues, the scent glands on the chin and anus develop and the rabbit starts to scent mark objects and accepted members of his social group (including owners) by rubbing his chin against them. He may start to deposit faeces and urine at the boundaries of his perceived territory. Sexual behaviour increases and the rabbit may start to make copulatory actions in response to being handled by the owner or attempt to mate with objects such as cuddly toys, cushions or the owner’s feet. Courtship behaviour involves running past a prospective mate (including the owner’s feet) and squirting a jet of urine over them.

As entire males get older, their head shape changes. The cheeks become wider, and the skin can become thickened along the dorsum from the neck to the rump. Histologically, the skin shows prominent, thick, dermal collagen similar to the cheek skin from entire male cats.
In old age, the testicles tend to atrophy. The scrotal skin becomes thin and stretched. Skin debris and exudate become trapped beneath the scrotum and secondary dermatitis is common. Affected rabbits are prone to flystrike.

**Anatomy of male reproductive tract**
The sexually mature male has two external testicles that lie on either side of the penis in two hairless scrotal sacs. The inguinal ring remains open throughout life and during periods of food deprivation or illness, the testicles may be withdrawn into the inguinal canal by the well-developed external cremaster muscle. Each testicle is enclosed in the **tunica vaginalis**, which has a long (2 cm) tubular section between the inguinal ring and the cranial end of the testicle. This section encloses the testicular blood vessels and the **vag deferens**. The caudal section of the epididymis is a prominent structure that can be seen through the thin scrotal skin at the caudal end of the scrotal sac where it is attached to the inner layer of the **tunica vaginalis**.

**Methods of castration**
Several techniques for castrating male rabbits have been described and everyone has their own preference. The main consideration is to close the inguinal canal to prevent herniation of abdominal contents postoperatively. Some authors describe an open castration where the testicles are removed through a scrotal, prescrotal or abdominal incision. These techniques require a secure wound repair because of the risk of herniation postoperatively. A closed castration either prescrotally or via the scrotum is often recommended. In these techniques, the **tunica vaginalis** is not opened and is dissected away from the interior of the scrotal skin. This can be difficult and time consuming, because the **tunica vaginalis** can be strongly connected to the scrotal skin, especially at the caudal end of the scrotum and especially in older males.

**Recommended technique**
The author prefers a mixed open and closed technique, which is quick and easy with no complications apart from the risk of mild skin trauma during pre-operative clipping. The scrotum is incised towards the caudal end and the testicle is exteriorised and then pulled out. The testicle is attached to the **tunica vaginalis**, which is attached the scrotal skin. Applying tension to the testicle stretches the attachments so they can easily be sectioned with scissors. The testicular blood vessels can be identified and ligated securely before sectioning and allowing the ligated end to be retracted into the tubular section of the **tunica vaginalis**. A ligature is then placed around the **tunica vaginalis** after making sure the ligated blood vessels are enclosed. The tissue is thin and the ligatures can be seen through the **tunica vaginalis**. The testicle is removed and the skin edges pulled together. No skin sutures are required.

**Scrotal ablation**
There are situations where it is advantageous to remove both scrotal sacs as well as the testicles and all their attachments. The main indication is in elderly male rabbits, where the scrotal skin has stretched and deep folds have formed between the scrotum and genitalia. These rabbits cannot clean the folds so skin debris collects and secondary infection develops. Scrotal skin tumours are another indication for scrotal ablation. Scrotal ablation is a simple, effective procedure but is more time consuming than routine castration. Sufficient skin must be left to repair the deficit with no tension on the wound so the skin may alter the direction of urine flow. Removal of the scrotal sacs gives good access to the inguinal canals so the **tunica vaginalis** can be identified and ligated securely. The skin is repaired with either buried subcuticular sutures or simple interrupted skin sutures (or both). The author’s preferred suture material is 4/0 polyglactin 910 (Vicryl Rapide), because the material is soft and comfortable for the rabbit and the sutures will 'wipe off' after 10-14 days.
Neutering cryptorchids
In cryptorchids, one or both testicles fail to descend into the scrotum. They may be in the inguinal canal or the abdomen. Even if they are abdominal, it is often possible to remove them without a laparotomy by finding the caudal end of the tunica vaginalis in the inguinal canal, opening it and gently pulling on the ligament that attaches it to the testicle. The inguinal canal of rabbits is wide and retained testicles are elliptical and narrower than normal testicles so they can slide out of the abdomen to be exteriorised and removed.

If abdominal exploration is necessary, a useful technique is to identify the bladder and follow the path of the ureter on the side of the missing testicle. The vas deferens can be identified as it loops over the ureter and it can be followed until it ends at the retained testicle. Some abdominal testicles are so small they could be mistaken for a piece of abdominal fat.

Inguinal hernias
Inguinal hernias containing part, or all, of the bladder are occasionally encountered in rabbits. It is usually encountered in an aged entire male but it been reported in a young female. The hernia is nearly always found on the left, presumably because the large caecum occupies the right inguinal area of the abdomen. In the early stages, a palpable swelling in the inguinal region may be detected by the owner. In the later stages, dysuria may be the presenting sign because, once part or the entire bladder has passed through the inguinal canal, sediment accumulates in the herniated part of the bladder, which cannot empty properly. In severe cases, partial or complete ureteral obstruction can occur. Surgical repair is usually straightforward but the testicle needs to be removed so the inguinal canal can be closed after excising the tunica vaginalis and the sac that contained the bladder.

Problems that can cause complications with abdominal surgery

Anatomical problems
- Many organs are thin walled and prone to inadvertent perforation or tearing. Minimal and gentle tissue handling is vital.
- Omentalisation if often not possible in the rabbit due to the minimal nature of the omentum.
- The vagina fills with urine during micturition

Physiological problems
- Susceptibility to granulomas and adhesion formation.
- The mesenteric tissue is very fragile and easily torn. It is imperative not to tear the mesentery from the intestine and remove the blood supply.
- Intestinal surgery is very difficult because of the thin walled intestine. A leak-proof intestinal repair without the risk of stricture formation is challenging. Enterectomy and end to end anastomosis is very difficult. Very fine suture material (5/0 or 6/0) is required.
- Gut stasis is always a risk following any surgery in rabbits. Paralytic ileus is a risk following major abdominal surgery. Good postoperative care and prokinetic therapy is important.
- Post-operative wound interference can be a problem in some individuals. Elizabethan collars are not recommended. They can be very stressful for rabbits and prevent caecotrophy. Rabbits will leave surgical sites alone if the wound has been closed without tension and is comfortable. Subcuticular sutures are recommended. Tissue glue can be helpful; so can temporarily blunting the incisors in potential candidates for wound interference (young, slim, fit lively rabbits with perfect incisors)
Complications of neutering

**Males**

- **Trauma to scrotal skin** during clipping is a potential complication. The scrotal skin is very thin. It is not under tension and is easily nicked with clipper blades. Care is required to prevent such injuries but they are usually of little consequence and heal readily.

- **Postoperative swelling and oedema of the scrotal sacs.** This may follow closed castration, either via the scrotum or pre-scrotally, when the skin has been sutured so fluid can collect under it. Postoperative swelling is most common if it has been difficult to free the tunica vaginalis from the skin and the tissue has been traumatized. Fluid collects in the scrotal sac, which can become large and uncomfortable for the rabbit. Analgesia and time usually resolve the situation.

- **Postoperative infection** is rare unless an inappropriate buried suture material is used or the surgical site was already infected or contaminated. Catgut should be avoided to ligate the spermatic cord as it can cause a tissue reaction in rabbits and act as a nidus for infection. Postoperative infection can be manifested by an inflamed, sore, suture line that the rabbit chews at, or an inguinal swelling that may develop days or weeks after surgery. Surgical exploration and removal of all infected necrotic material, including residual suture material, is necessary. The wound is left open to drain like any other abscess.

- **Herniation of abdominal contents can** occur if the inguinal ring is not closed effectively during castration, it is possible for abdominal viscera to herniate through it. The most likely organ to fit through the ring is a section of small intestine. The owner may see the prolapsed section of intestine if the scrotal wound was left open or the skin sutures were not adequate. If the scrotal skin is intact, they may see a swelling in the inguinal region or they may not notice anything at all. If the condition is not recognized and treated promptly, strangulation of the prolapsed section of small intestine can cause an intestinal obstruction so the rabbit develops gastric dilation and shock, usually within 72 hours of surgery. Treatment depends on the condition of the rabbit and the section of intestine that has prolapsed. If the condition is recognized early and the prolapsed contents are viable, they can be flushed copiously with warm saline and replaced through the inguinal canal before identifying and closing the tunica vaginalis and inguinal ring. If the intestine is not viable, enterectomy or euthanasia may be necessary.

- **Haemorrhage** can occur if the spermatic artery is not ligated securely.

**Females**

- **Haemorrhage** into the abdomen and/or vagina can come from the uterine artery if it is penetrated or torn. The artery is closely attached to the wall of the cervix. Rabbit blood clots quickly so the haemorrhage is seldom a problem but can be avoided by tying off the uterine horns rather than using a transfixing suture.

- **Urine leakage into the abdomen** is a serious complication of vaginectomy. The vagina is a flaccid structure that fills with urine during urination. If it is transected below the cervix and ligated or oversewn, pressure is applied to the ligature or suture line during urination and there is a risk of leakage. If this occurs, a local peritonitis can result, which may be life-threatening or may cause adhesions and tissue reactions involving the ureters, bladder or rectum, all of which are anatomically close to the vagina. These complications can be avoided by tying off the uterine horns at the cervix rather than transecting the vagina.
Granulomas and adhesion formation can follow any abdominal surgery but notably ovariohysterectomy. Any area of devitalized tissue can become necrotic. These areas can cause problems around the cervical or vaginal stump if they are close enough to occlude a ureter. Hydronephrosis can be the result. Granulomas can cause urinary incontinence from pressure on the bladder, especially if the vaginal stump is adherent to it. They can also adhere to the rectum and cause stricture. These complications can be reduced by ligating the mesometrium around the cervixes rather than around the vagina.

Fat necrosis. Some fat necrosis is unavoidable around ligatures in the mesometrium of obese rabbits. The fat decomposes into fatty acids and glycerol. With time, these areas of fat necrosis can calcify as calcium binds with the fatty acids. Areas of fat necrosis in the mesometrial remnants seldom cause problems but may be strikingly obvious on abdominal radiographs. If infection is present, these areas can become abscesses that spread along the lymphatics or into the omentum. The risk of fat necrosis is reduced by using fine suture material (1.5 metric, 4/0 USP) and avoiding catgut.