Incomplete ovarian tissue removal in female dogs and cats

Gary England, Rob White

Incomplete ovariectomy (IO) is the unintentional partial or complete lack of removal of one or both ovaries during an ovariohysterectomy or ovariectomy procedure, and is often referred to as ‘ovarian remnant syndrome’. It usually has a clear clinical presentation, although there are a number of other conditions that may have similar presenting signs. In female cats and dogs these include: non-oestrous mounting behaviour, non-oestrous vulval discharge and, solely in bitches, sexual interest from males and iatrogenic pseudopregnancy. This article considers the causes, presentation, methods of diagnosis and management of IO in bitches and queens.

Occurrence

It is common practice for surgical neutering of bitches and queens to be undertaken via a coeliotomy or laparoscopy, and for either an ovariohysterectomy or ovariectomy to be performed. The ovary is fully enclosed within a bursa, which, together with the ovarian pedicle, may contain a substantial amount of fat that makes visualisation and palpation of the ovary difficult. Exteriorisation of the ovary at coeliotomy may be challenging in deep-chested animals, and traction on the ovarian pedicle is painful and may result in panting, which increases the difficulty of the procedure. Incomplete ovariectomy (IO) is not uncommon, being reported in up to one in 90 ovariohysterectomy and one in 200 ovariectomy procedures in bitches (Muraro and White 2014, Pope and Knowles 2014); however, data are not available for queens. In most cases it is the entire right ovary that has not been removed (probably because this is more cranial in position) although, less frequently, the left ovary or a portion of either or both is excised. Although a left flank approach remains widely performed in queens, there is no increased frequency for a specific ovary to fall into the abdominal cavity and become revascularised, but this has never been reported and is unlikely since the ovary is fully enclosed within a bursa.

Many females have paraovarian cysts present along the ovarian pedicle and broad ligament (McEntee 1990). These are endocrinologically inactive and not associated with any clinical signs even if they are not removed at the time of surgical neutering. IO results from the inaccurate placement of surgical clamps or ligatures, often during a demanding procedure. This may occur when using the ‘three forceps technique’ because of limited space to place each forceps. The most significant error is a failure to inspect the pedicle sites closely after ligation and transection, and not examining all excised tissue at the time of surgery before closure of the incision.

Leaving an ovarian remnant is not necessarily negligent, but an owner can reasonably expect not to pay for any investigation or remedial treatment when IO is confirmed. If in doubt about liability, it is wise to contact your professional indemnity insurers for advice.

Case presentation

The amount of tissue left behind and its location in relation to any ligatures that have been placed appears to result in three possible outcomes for presentation:

- Oestrous behaviour occurring at the normal interval with subsequent normal cyclicity;
- Oestrous behaviour being absent for several months to years and is then normal, weak or persistent, with the possibility of subsequent normal cyclicity;
- Oestrous behaviour being absent for many years until persistent, weak behaviour associated with a granulosa cell tumour is detected.

Oestrous behaviour occurring at the normal interval

In cases in which oestrous behaviour occurs at the normal interval with subsequent normal cyclicity, the authors’ frequent experience is that an entire ovary has been left in situ and ligatures have been placed distal to it. The ovary therefore retains its blood supply and functions normally such that there is follicular development, an associated rise in plasma oestrogen concentration and the female animal returns to oestrus at the expected time. Oestrous behaviour and vulval swelling is typical of a normal cycle. In bitches that have undergone an ovariectomy, a vulval discharge may occur and be serosanguineous (erythrocytes are present in the discharge as a result of diapedesis through the remaining uterus) or the discharge is seromucoid in bitches subject to an ovariohysterectomy.

In most bitches there is normal ovulation so progesterone concentrations increase, resulting in cessation of the oestrous behaviour. The corpora lutea that develop have a typical 65-day lifespan. Towards the middle of the luteal phase as progesterone concentrations start to decrease,
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Oestrous behaviour absent for many years

The aetiology of these rare cases, in which oestrous behaviour is absent for many years until persistent, weak behaviour associated with a granulosa cell tumour is detected, is unknown; however, the authors presume that ligation has occurred proximal to the non-removed tissue, such that the ovary becomes inactive and plasma concentrations of FSH and LH increase, as described earlier. Although there is some revascularisation, the ovary remains inactive, but ultimately develops a granulosa cell tumour that produces oestrogen resulting in weak signs of oestrus and then other clinical signs such as a mass effect. It is plausible that the persistent elevations of FSH and LH are responsible for the development of ovarian neoplasia, as has been proposed in women [Choi and others 2007].

In clinical practice, regardless of the aetiology in the particular case, the clinical signs reported in both bitches and queens include apparent oestrous behaviour and the presence of vulval swelling. In bitches there may also be a vulval discharge [which, in the case of an ovarietomy, may be serosanguineous, attractiveness of males and the presence of a pseudopregnancy (which must follow oestrus that may, or may not, have been observed by the owner)].

Diagnostic tests

There are a number of diagnostic tests that may be used to investigate the presence of IO. For each, it is important to understand the basis of the test so that it can be applied in the most appropriate situation.

Observation of oestrous behaviour and swelling of the vulva

Bitches and queens that demonstrate behavioural changes typical of oestrus combined with vulval swelling usually have IO. Diagnosis is simple in a bitch when this is associated with a serosanguineous vulval discharge.

Differential diagnoses that produce true signs of oestrus are few (see below) and can be eliminated by clinical history. Cases in which signs of oestrus are less pronounced and in bitches when there is no colour to the vulval discharge are more difficult to interpret and may require additional diagnostic tests, for example, vaginal cytology and vaginoscopy.

Vaginal cytology and/or vaginoscopy

Under the influence of elevated plasma oestrogen concentrations [which occur when a bitch or queen shows oestrous behaviour] there are increased numbers of vaginal epithelial cell layers. The most superficial cells become large due to the increased size of the cytoplasm and increase. At some later time, anastomosis of the ovarian vascular supply occurs and, with elevated gonadotrophin concentrations, follicles develop. The number of follicles will depend upon the volume of tissue that remains and the time taken for revascularisation. If an entire ovary remains and revascularisation is rapid there may be a normal oestrus, ovulation (in a bitch) and subsequent normal cyclicity. However, if only a small portion of ovary remains and revascularisation occurs later, there may be weak signs of oestrus or a lack of ovulation resulting in weak, persistent oestrous behaviour.

In both bitches and queens, if uterine tissue has not been removed it is possible for a later presentation to be associated with uterine disease, commonly pyometra, which has a typical clinical appearance.

Oestrous behaviour absent for several months to years

Cases in which oestrous behaviour is absent for several months to years and is then normal, weak or persistent, with the possibility of subsequent normal cyclicity, are not common and the authors’ experience is that, in most cases, the ligature has been placed proximal to the ovary and the ovary or some portion of it has been left during the clamping and transection procedure. As there is an occluded blood supply, the ovary becomes ischaemic and inactive, and there is no initial return to oestrous behaviour. Ovarian feedback to the hypothalamus and pituitary gland is removed and plasma concentrations of the gonadotrophin luteinising hormone (LH) and follicle-stimulating hormone (FSH) increase. At some later time, anastomosis of the ovarian vascular supply occurs and, with elevated gonadotrophin concentrations, follicles develop. The number of follicles will depend upon the volume of tissue that remains and the time taken for revascularisation. If an entire ovary remains and revascularisation is rapid there may be a normal oestrus, ovulation (in the bitch) and subsequent normal cyclicity. However, if only a small portion of ovary remains and revascularisation occurs later, there may be weak signs of oestrus or a lack of ovulation resulting in weak, persistent oestrous behaviour.

In both bitches and queens, if uterine tissue has not been removed, later presentation may be associated with uterine disease such as pyometra, as described earlier.
increased numbers of polymorphonuclear leucocytes and bacteria. Importantly, vaginal cytology is only useful for the diagnosis of IO when the female has alleged oestrous behaviour, since at other stages of the cycle there is no difference in the vaginal smear compared with a female that has no ovaries.

Elevated oestrogen concentrations cause changes to the vaginal epithelium that, in bitches, can be observed using a rigid endoscope; non-sedated bitches tolerate the procedure well. In pro-oestrus or oestrus the epithelium appears moist, swollen and oedematous, and is often pale in colour (Fig 2); at all other stages of the cycle and in neutered animals the epithelium is dry, flattened and pink in colour.

**Ultrasound examination**

Identification of the ovaries with ultrasound may be a difficult procedure but can be performed reliably by an experienced ultrasonographer using high-quality equipment. Throughout pro-oestrus, fluid-filled (anechoic) follicles may be detected and these increase in diameter to approximately 5 to 8 mm during oestrus immediately before ovulation (Fig 3). In a bitch, after ovulation each follicle is replaced by a corpus luteum that also has a central fluid-filled cavity and can be identified until approximately 30 days postovulation. In queens, follicle regression occurs over five to seven days after oestrus so fluid-filled follicles can be identified during this time. Occasionally, a small portion of the uterine horn may be identified adjacent to the ovarian tissue and sometimes this is distended with fluid.

Doppler ultrasound may help to identify the origin and nature of the vascular supply to tissue suspected of being an ovarian remnant – the ovarian artery arises caudal to the renal artery and is tortuous in appearance.

Imaging of an ovary during pro-oestrus, oestrus or shortly after oestrus is obviously diagnostic of IO, although failure to identify ovarian tissue does not preclude IO because imaging can be difficult in an obese animal and if the remaining tissue is small.

**Measurement of plasma progesterone concentration**

In bitches, but not queens, there is an increase in plasma progesterone concentration immediately before ovulation, which then continues to rise for the next 10 days. Progesterone is secreted for approximately 65 days after ovulation and since there is no other source of progesterone except the corpora lutea, detection of an elevated concentration (greater than 2 ng/ml or 6.5 nmol/l) will be diagnostic of IO. Importantly, progesterone will only be elevated from immediately before ovulation until 65 days after ovulation, so testing during signs of alleged oestrous behaviour may not necessarily be diagnostic. In such cases, since the bitch may have been presented...
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that progesterone concentrations may be lower than expected if only a small amount of ovarian tissue remains.

Measurement of plasma oestrogen concentration

Oestrogen concentrations are marginally increased for a few weeks before the onset of pro-oestrus and continue to rise as follicles develop. Oestrogen concentrations measured during behavioural oestrus might therefore be expected to be useful for the diagnosis of IO. However, oestrogen concentrations decrease substantially several days before ovulation in bitches, and both bitches and queens continue to demonstrate oestrous behaviour even when oestrogen concentrations are low. There is then every possibility that a sample collected while there is overt oestrous behaviour will have low oestrogen concentrations, which could give a false negative diagnosis of IO. Furthermore, oestrogen is difficult to assay as plasma concentrations are quite low (pg/ml or pmol/l rather than ng/ml or nmol/l seen with progesterone) and may be influenced by plasma lipid concentration. While elevated plasma oestrogen concentrations (exceeding 12 pg/ml or 45 pmol/l) are diagnostic of IO, low values are not diagnostic of an absence of ovarian tissue.

Stimulation of oestrogen production

While basal oestrogen concentrations are often not useful for investigating cases of presumed IO, it is possible to stimulate ovarian theca cells to release oestrogen by administering hCG (which is like LH in terms of activity) or GnRH (which stimulates an endogenous rise in LH). These stimulation tests work well for bitches and queens that are in anoestrus and the luteal phase, but do not work well when the female is in pro-oestrus or oestrus (ie, when basal oestrogen is, or has just been, elevated). For either test, a blood sample is collected before drug administration (44 iu/kg hCG intramuscularly or 2.0 µg/kg GnRH intramuscularly – it is worth noting that these are the same doses as those required to stimulate ovulation) and two hours later. A two- to three-fold increase in oestrogen concentration is diagnostic of IO, although it is feasible that the total amount of oestrogen produced is dependent upon the volume of ovarian tissue remaining. The authors have observed two cases in which oestrogen increase was only 50 per cent of initial values and a partial remnant was found at surgical exploration.

Measurement of plasma anti-Müllerian hormone

Anti-Müllerian hormone (AMH) is produced by granulosa cells from follicles at all stages of development. In many species, AMH is detectable throughout the oestrous cycle but it should not be present in ovarioctomised females, which makes it a candidate test for detecting IO in bitches. To date, one study has shown that AMH concentrations for bitches with IO (4.4 ± 1.1 ng/ml) were significantly higher than for bitches with no ovaries (0.3 ± 0.1 ng/ml). Currently though, different assay methods appear to contradict the cut-off for diagnosis of IO in bitches and queens, and most commercial veterinary laboratories do not offer this assay.

Measurement of basal LH and/or FSH

As previously mentioned, once all ovarian tissue has been removed there is an absence of ovarian negative feedback on the hypothalamus and pituitary gland such that FSH and LH concentrations increase. There have been few studies of FSH, but LH concentrations in bitches and queens with no ovaries are usually greater than 6.0 ng/ml or 58 iu/l. While this may be the basis of a diagnostic test, it must be appreciated that LH (and FSH) concentrations are elevated in pro-oestrus, oestrus and the luteal phase. Therefore, to have any diagnostic value, LH concentrations should only be measured in anoestrous (ie, essentially limited to more than 65 days after oestrous behaviour in bitches or during winter anoestrus in queens). At this time, females with IO will have LH concentrations below 2.0 ng/ml or 19 iu/l, while LH will be high in females that have no ovaries.

Which test should be used when?

This section considers which tests are most appropriate for a diagnosis of IO in bitches based on the clinical history and initial findings when presented (Tables 1 to 3). Since queens are polyoestrus, it is simplest to request presentation when the owner considers that oestrous behaviour has just begun (Table 4).

Owner considers that the bitch is currently in oestrus

When a bitch is presented during alleged oestrus, the aims are to determine whether it is in pro-oestrus, oestrus or has just ovulated, and to differentiate it from a bitch that has no ovaries. In such cases, clinical signs and vaginal cytology are especially helpful.

Owner considers that the bitch was recently in oestrus

When a bitch is presented within two months of alleged oestrous behaviour, the aims are to determine whether the bitch is in the luteal phase and to differentiate it from a bitch that has no ovaries. In such cases, measurement of plasma progesterone is especially helpful.

Owner considers that the bitch was in oestrus more than two months previously

When a bitch is presented more than two months after alleged oestrous behaviour, the aims are to determine whether the animal is in anoestrus and to differentiate it from a bitch that has no ovaries. In such cases, oestrogen-stimulation tests or the measurement of basal LH are especially helpful.

Owner considers that the queen is in oestrus

Queens are polyoestrus and most with IO will cycle approximately every two to three weeks. The simplest approach to diagnosis is to request the owner to present the queen at the time of alleged oestrus to enable differentiation from a queen that has no ovaries. In such cases, clinical signs and vaginal cytology are especially helpful.
Table 1: Diagnostic test findings in bitches presented during alleged oestrus

| Test                                                                 | Is the test diagnostic at this stage of presentation? | Recommendation and positive diagnostic findings for IO at this stage of presentation |
|----------------------------------------------------------------------|--------------------------------------------------------|-------------------------------------------------------------------------------------|
| Observation of behaviour and clinical examination                    | Yes                                                    | Bitches that have IO and are in pro-oestrus, oestrus or have just ovulated have behavioural changes that differentiate them from bitches with no ovaries; these include standing oestrus behaviour and tail deviation. Such bitches may allow mating. Clinical examination will also reveal swelling of the vulval and perineal tissue and a vulval discharge (which may be serosanguineous if the uterine tissue remains) |
| Vaginal cytology and/or vaginoscopy                                    | Yes                                                    | Bitches that have IO and are in pro-oestrus or oestrus have large anuclear vaginal epithelial cells in the vaginal smear and usually low numbers of polymorphonuclear leucocytes; the percentage of both types depends upon the exact time of presentation. Vaginoscopy will reveal a moist, swollen and oedematous epithelium that is pale in colour |
| Ultrasound examination                                                | May be                                                | A whole ovary may be detectable by an experienced ultrasonographer in bitches with IO that are in pro-oestrus, oestrus or have just ovulated because follicles/cavitated corpora lutea will be present. In females with partial ovarian tissue this may not be detectable |
| Measurement of plasma progesterone concentration                      | No                                                    | Progesterone will be low in pro-oestrus and oestrus and will only rise at the time of ovulation in late oestrus. Measurement of progesterone will not be able to differentiate a bitch with IO that is in pro-oestrus or oestrus from a bitch that has no ovaries. Testing for progesterone is best performed after signs of alleged oestrus has resolved (ie, wait and measure progesterone a few weeks later when the bitch will be in the luteal phase) |
| Measurement of plasma oestrogen concentration                         | Not reliable                                           | Oestrogen is elevated in pro-oestrus or early oestrus but declines in mid-oestrus and thereafter will be low. The diagnostic value of the test will therefore depend upon the exact time of presentation. Only elevated oestrogen concentrations are diagnostic |
| Stimulation of oestrogen production with GnRH or hCG                 | Not reliable                                           | While ovarian tissue in bitches with IO should respond to the administration of GnRH or hCG with an increase in oestrogen, the magnitude of response is variable when oestrogen is already elevated or has just been elevated. The response thereafter depends upon the exact time of presentation. Only a substantial increase in oestrogen will be diagnostic |
| Measurement of plasma AMH                                            | Test is not widely available                           | At any stage of the cycle, AMH concentrations are high in bitches with IO compared with bitches that have no ovaries |
| Measurement of resting LH                                             | Not reliable                                           | LH is low in bitches with IO and elevated in bitches with no ovaries; however, if a bitch with IO presents in pro-oestrus, oestrus or has recently ovulated, then LH concentrations may be elevated and so the test is not diagnostic at this stage |

IO: Incomplete ovariectomy, GnRH: Gonadotrophin-releasing hormone, hCG: Human chorionic gonadotrophin, AMH: Anti-Müllerian hormone, LH: Luteinising hormone

**Differential diagnoses**

There are a number of differential diagnoses for IO, as follows.

**Presence of a non-oestrus vulval discharge** *(bitches and queens)*

A number of diseases of the vestibule, vagina, urethra, bladder and kidney may result in a vulval discharge, which can have a variety of appearances. Conditions associated with a red-coloured discharge include urethral neoplasia and uterine stump granuloma. In none of these cases will there be cornification of the vaginal wall epithelium, which occurs during pro-oestrus and oestrus. These differential diagnoses therefore demonstrate parabasal and small, intermediate epithelial cells consistent with absence of oestrous.

**Apparent sexual behaviour** *(bitches and queens)*

It is common and normal for bitches and queens in anoestrus to mount and exhibit thrusting behaviour towards other non-oestrus and oestrus females. This behaviour is also seen after removal of the ovaries. In such cases, vaginal cytology will confirm that the behaviour is not associated with oestrus.

**Sexual interest from other dogs** *(bitches)*

It is not uncommon for entire male dogs, as well as female and neutered dogs, to show interest in non-oestrus bitches that have anal gland and skin disease. In neither case will there be a concomitant cornification of the vaginal wall epithelium, so vaginal cytology demonstrates parabasal and small, intermediate epithelial cells consistent with the absence of oestrus.

**Iatrogenically induced pseudopregnancy** *(bitches)*

Complete removal of the ovaries when a bitch is in the luteal phase results in a rapid decrease in plasma concentrations of progesterone. This then causes increased concentrations of prolactin and the initiation of clinical signs of pseudopregnancy. It is important to recognise that such animals do not have IO and that the occurrence of pseudopregnancy alone is not diagnostic for IO. Some cases of iatrogenic pseudopregnancy may be treated by the administration of depot or oral progestogens that suppress the release of prolactin, resulting in a temporary resolution of clinical signs. Prolactin concentrations may increase again at the end of treatment resulting in a recurrence of the pseudopregnancy. Care needs to be taken not to interpret such recurrence of clinical signs after progestogen treatment as suggestive of an ovarian remnant, which it is not.
Non-ovarian sources of oestrogen (bitches and queens)

The authors have identified a small number of cases of increased plasma oestrogen concentration associated with male attraction due to cornification of the vaginal mucosa [anuclear epithelial cells] in ovariohysterectomised bitches where there is an abnormal appearance of one adrenal gland at ultrasound examination. The exact aetiology is uncertain, but it is known that adrenal oestrogens may increase in cases of adrenal disease in other species, especially, for example, ferrets, in which an ovariectomy is commonly associated with the development of adrenocortical neoplasia [de Jong and others 2014]. It is plausible that, in ferrets, undifferentiated adrenal cells develop gonadal characteristics when they are exposed to high LH and FSH concentrations, which occur after neutering; the authors postulate that such a situation may occur in neutered bitches, although this is rare.

In some circumstances, female animals may ingest human contraceptive or hormone-replacement therapy drugs [which are oestrogens], or, very rarely, oestrogens are administered to bitches to manage urinary incontinence and these may cause short-term oestrous behaviour with increased numbers of large vaginal epithelial cells. In such circumstances, the owner is usually aware that drugs have been ingested or administered.

Table 2: Diagnostic test findings in bitches presented within two months of alleged oestrus

| Test                                | Is the test diagnostic at this stage of presentation? | Recommendation and positive diagnostic findings for IO at this stage of presentation |
|-------------------------------------|-------------------------------------------------------|--------------------------------------------------------------------------------------|
| Observation of behaviour and clinical examination | May be | Bitches with IO show no obvious behaviour changes when in the luteal phase. It is common to observe mammary gland enlargement and lactation shortly after complete removal of the ovaries if the surgery has been undertaken within the luteal phase (this is an iatrogenic pseudopregnancy caused by decreased progesterone and increased prolactin and is not diagnostic of IO). If, after a subsequent period of apparent oestrus behaviour, there is mammary enlargement and lactation and no exogenous hormones have been administered, these features are likely to be diagnostic of IO. |
| Vaginal cytology and/or vaginoscopy  | No | Vaginal cytology and vaginoscopy are not able to differentiate a bitch with IO that is in the luteal phase from a bitch that has no ovaries |
| Ultrasound examination              | May be | During the luteal phase, a whole ovary is likely to be detectable by an experienced ultrasonographer because central anechoic fluid will be present within each corpus luteum [at least for 30 days postovulatiion]. In cases in which partial ovarian tissue remains, this may not be detectable |
| Measurement of plasma progesterone concentration | Yes | Progesterone will be elevated for approximately 65 days after ovulation and so can be used to differentiate a bitch with IO from a bitch that has no ovaries |
| Measurement of plasma oestradiol concentration | No | Oestrogen concentrations will be similar in both a bitch with IO that is in the luteal phase and a bitch that has no ovaries; therefore, measurement of oestrogen is not diagnostic at this stage. |
| Stimulation of oestrogen production with GnRH or hCG | Yes | Bitches with IO that are in the luteal phase will respond to the administration of GnRH or hCG with a two- to three-fold increase in plasma oestrogen concentrations, whereas bitches that have no ovaries show no change in oestrogen concentration |
| Measurement of plasma AMH           | Test is not widely available | At any stage of the cycle, AMH concentrations are high in bitches with IO compared with bitches that have no ovaries |
| Measurement of resting LH            | No | LH is low in bitches with IO and elevated in bitches with no ovaries; however, if a bitch with IO presents in the luteal phase, then LH concentrations may be elevated and so the test is not diagnostic at this stage |

IO: Incomplete ovariectomy, GnRH: Gonadotrophin-releasing hormone, hCG: Human chorionic gonadotrophin, AMH: Anti-Müllerian hormone, LH: Luteinising hormone

Table 3: Diagnostic test findings in bitches presented more than two months after alleged oestrus

| Test                                | Is the test diagnostic at this stage of presentation? | Recommendation and positive diagnostic findings for IO at this stage of presentation |
|-------------------------------------|-------------------------------------------------------|--------------------------------------------------------------------------------------|
| Observation of behaviour and clinical examination | No | Bitches with IO when in anoestrus show no obvious behaviour changes or clinical features that can be used to differentiate them from bitches that have no ovaries |
| Vaginal cytology and/or vaginoscopy  | No | Vaginal cytology and vaginoscopy are not able to differentiate a bitch with IO that is in anoestrus from a bitch that has no ovaries |
| Ultrasound examination              | Unlikely | During anoestrus it can be very difficult to detect the ovary reliably and therefore this test is not recommended for differentiation of a bitch with IO from a bitch with no ovaries |
| Measurement of plasma progesterone concentration | No | Progesterone concentrations are basal both in bitches with IO during anoestrus and in those that have no ovaries and therefore measurement of progesterone is not diagnostic at this stage |
| Measurement of plasma oestradiol concentration | No | Oestrogen concentrations will be basal in both a bitch with IO that is in anoestrus and a bitch that has no ovaries and therefore measurement of oestrogen is not diagnostic at this stage. |
| Stimulation of oestrogen production with GnRH or hCG | Yes | Bitches with IO that are in anoestrus will respond to the administration of GnRH or hCG with a two- to three-fold increase in plasma oestrogen concentrations, whereas bitches that have no ovaries show no change in oestrogen concentration. This test is therefore diagnostic at this stage of presentation |
| Measurement of plasma AMH           | Test is not widely available | At any stage of the cycle, AMH concentrations are high in bitches with IO compared with bitches that have no ovaries |
| Measurement of resting LH            | Yes | Bitches with IO that are in anoestrus have low plasma concentrations of LH whereas bitches that have no ovaries have elevated concentrations of LH. This test is therefore diagnostic at this stage of presentation |

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Table 4: Diagnostic test findings in queens presented during alleged oestrus

| Test                                      | Is the test diagnostic at this stage of presentation? | Recommendation and positive diagnostic findings for IO at this stage of presentation |
|-------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------|
| Observation of behaviour and clinical examination | Yes                                                   | Queens that have IO and are in pro-oestrus or oestrus have behavioural changes that differentiate them from queens with no ovaries; these include vocalisation, treading, rolling, tail deviation and lordosis. Such queens may allow mating. Clinical examination may also reveal swelling of the vulva and perineal tissue and a mucoid vulval discharge. |
| Vaginal cytology                          | Yes                                                   | Queens that have IO and are in pro-oestrus or oestrus have large vaginal epithelial cells in the vaginal smear (although these may not be anuclear as in bitches) and usually low numbers of polymorphonuclear leucocytes; the percentage of both cell types depends upon the exact time of presentation. |
| Ultrasound examination                    | May be                                               | A whole ovary is likely to be detectable by an experienced ultrasonographer in queens with IO that are in pro-oestrus or oestrus because fluid-filled follicles will be present. In females in which partial ovarian tissue remains, this may not be detectable. |
| Measurement of plasma progesterone concentration | No, but levels can be stimulated to rise by the administration of GnRH or hCG | Progesterone will be low in pro-oestrus and oestrus and will not rise at the end of oestrus unless the queen is induced to ovulate. This, however, allows an ideal diagnostic test. Administration of GnRH or hCG will stimulate ovulation and a rise in progesterone, which can readily be detected by blood sampling one to two weeks later when the queen is in the luteal phase. |
| Measurement of plasma oestrogen concentration | Not reliable                                          | Oestrogen is elevated in pro-oestrus or early oestrus but declines in late oestrus and therefore will be low. The diagnostic value of this test will then depend upon the exact time of presentation. Only elevated oestrogen concentrations are diagnostic. |
| Stimulation of oestrogen production with GnRH or hCG | Not reliable                                          | While ovarian tissue in queens with IO should respond to the administration of GnRH or hCG with an increase in oestrogen, the magnitude of response is variable when oestrogen is already elevated or has just been elevated. The response therefore depends upon the exact time of presentation. Only a substantial increase in oestrogen will be diagnostic. |
| Measurement of plasma AMH                 | Test is not widely available                            | At any stage of the cycle, AMH concentrations are high in queens with IO compared with queens that have no ovaries. |
| Measurement of resting LH                 | Not reliable                                          | Although LH is low in queens with IO and elevated in queens with no ovaries, if a queen with IO presents in pro-oestrus or oestrus, LH concentrations may be elevated and so the test is not diagnostic at this stage. |

IO Incomplete ovariectomy, GnRH Gonadotrophin-releasing hormone, hCG Human chorionic gonadotrophin, AMH Anti-Müllerian hormone, LH Luteinising hormone

Treatment

Surgical removal of the residual ovarian tissue is the preferred treatment. Any non-removed tissue will be most prominent during either oestrus or the early luteal phase because of the presence of follicles or corpora lutea, respectively. As such, these times should be considered most appropriate for exploratory surgery.

During oestrus, the ovary will have an increased vascularity (Fig 4), which is produced by the elevated oestrogen concentrations, and this is considered by some inexperienced surgeons to be a contraindication to surgery at this time. Although the ovary is large during the luteal phase, in bitches from week 4 onwards, progesterone concentrations decrease and prolactin concentrations increase such that surgery from this time onwards risks inducing a prolonged iatrogenic pseudopregnancy. Therefore, in bitches it is most appropriate to perform the surgery approximately two weeks after oestrous behaviour has ceased, thus minimising both the problem of haemorrhage and the risk of pseudopregnancy. In queens, surgery is also best performed during the early luteal phase; in most cases this would be one to two weeks after induction of ovulation with GnRH/hCG and measurement of progesterone as a diagnostic aid.

An ovariectomy is performed using either open surgery via a ventral midline coeliotomy or laparoscopically (Fig 5) using a two- or three-port technique; the authors prefer the latter. The right pedicle is usually examined first but residual tissue may be bilateral so both must be carefully examined (Fig 6). If residual ovarian tissue cannot be found at the sites of the previous ovariectomy, a thorough exploration of the peritoneal cavity should be undertaken. This is especially important in queens that have bitches that have IO and are in pro-oestrus or oestrus because fluid-filled follicles will be present. In females in which partial ovarian tissue remains, this may not be detectable.

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performed, including towards the caudal poles of both kidneys, the peritoneum and the peritoneal walls, as these are sites where tissue may have retracted or become adhered to. Small islands of residual ovarian tissue might prove difficult to visualise, especially if ligature material is still present at the site of the ovarian pedicle. In such cases, it is advisable to remove any remaining vascular pedicle together with its fat pad and any residual ligature material, as there is the possibility that this will also remove unobserved ovarian material.

All excised tissue should be submitted for histopathology to confirm ovarian tissue has been removed.

Summary

IO is not uncommon in bitches and queens and is caused by a combination of an inaccurate surgical procedure and a failure to inspect excised tissue. After surgery, cases may have a variety of presentations dependent upon the vascular supply to the residual tissue, although in many cases there is normal cyclicity. While these cases may appear daunting to investigate, with an understanding of the normal reproductive physiology and endocrinology of bitches and queens, a logical diagnostic approach can be achieved. Surgical removal of residual tissue is curative.

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