Open standing castration in Thoroughbred racehorses in Hong Kong: Prevalence and severity of complications 30-days post-castration

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Key words: castration, complication, open standing, Thoroughbred racehorse, antimicrobial resistance

Abstract

Reasons for performing the study: Complications following open standing castration (OSC) in Thoroughbred racehorses are well recognized but variation in their prevalence and severity between populations is not well documented.

Objectives: To describe the prevalence and severity of complications in the 30-days following OSC.

Study design: A retrospective cohort study of veterinary clinical records relating to horses that underwent OSC between July 2007 and July 2012.

Methods: Complications were graded on a severity score from N, no complications, to C3, severe complications. Additional data were accessed for each horse including age, import date, racing history, trainer and veterinarian performing the castration. Bacterial culture and antimicrobial sensitivities were performed on a limited number of castration wounds that became infected.

Results: In total 250 horses were castrated in Hong Kong using the OSC technique over the period of the study. Sixty percent (150/250) of horses experienced some type of post-castration complication, with eight horses experiencing a severe (C3) complication requiring intensive veterinary treatment. Scrotal swelling, funiculitis and seroma formation were present in 70.0%, 36.7% and 24.7% of cases, respectively. Most horses experiencing complications required wound reopening (87.3%; 131/150), and/or an extended course of first-line antimicrobials and/or non-steroidal anti-inflammatory drugs (75/150; 44.7%). Eight horses had cultures submitted for bacterial sensitivity, with 16 bacterial isolates grown. *In vitro,* the bacteria cultured were sensitive to enrofloxacin (81%; 13/16) and ceftiofur (100%; 16/16). Resistance was detected to penicillin, gentamicin, oxytetracycline, metronidazole, and trimethoprim-sulphadiazine.

Limitations: Differences in post-castration management cannot be accounted for in this study.

Conclusions: Complications following OSC in horses in Hong Kong was common. The majority were mild and were successfully treated using antimicrobials and simple wound management. Given the high rate of complications and antimicrobial usage identified in this study, a review of the technique is warranted.

Introduction

Three surgical techniques are commonly used for equine castration: 1. Open, in which the parietal tunic surrounding the testicle is incised and, usually, retained, 2. Closed, where the portion of the parietal tunic surrounding the testis and distal spermatic cord is removed, and 3. Half closed, where an incision is made through the exposed parietal tunic at the cranial end of the testis or distal end of the spermatic cord allowing the testis and part of the spermatic vasculature to be prolapsed through the incision prior to removal [2]. The procedure can be performed in a standing sedated patient or under general anaesthesia [3-5]. Open standing castration (OSC) in a standing sedated patient relies on infiltration of local anaesthetic into the testes [6]. While there are many variations in finer aspects of the technique, the principles of incision of the skin, fascia and parietal tunic, causing the testicle to prolapse from the scrotum, are common to all. The ligament of the tail of the epididymis is severed and the testis, associated neurovascular cord, epididymis and distal portions of the *vas deferens* are crushed and transected using emasculators [7].

While the castration procedure is relatively straightforward, post-operative complications including excessive oedema of the scrotum and surrounding tissues, infection and fever, haemorrhage, lameness, hydrocele formation, peritonitis, eventration, penile paralysis, scirrhous cord formation and death are well recognised [4; 5; 7; 8]. Previous studies have documented the prevalence of complications associated with castrating horses using the standing sedated method to be between 16% and 22%, compared to 6% to 10% when castration was carried out under general anaesthesia [9-11]. Oedema and localised sepsis (infection of the spermatic cord, henceforth called funiculitis) have been reported by veterinarians as the most common complication following castration using the open standing method, with a prevalence of 22% to 27% [4; 10].

Thoroughbred flat racing has occurred in Hong Kong since 1884 and is administered by the Hong Kong Jockey Club (HKJC). All horses are imported as there is no breeding in the region [12].Fillies are rarely imported. The majority of colts are castrated at some stage in their career and OSC has long been the method of choice. To date there have been no studies on complications following castration of horses at the HKJC and little on intensively managed racing populations elsewhere. Therefore, the objective was to describe the prevalence and severity of complications in the 30-days following castration using the OSC technique in this population. Additionally, the study aimed to describe the choice of prophylactic antimicrobials and non-steroidal anti-inflammatory drugs (NSAID) and the sensitivity of bacteria in cases where infection occurred.

Methods

Study design, sample population

The study was a retrospective cohort study of horses castrated at the Sha Tin training complex, Hong Kong, between July 2007 and July 2012. The training complex provides full time stabling and training facilities to approximately 1,250 horses with 24 licenced trainers. The racing season extends from early September until mid-July, the break coinciding with the hottest time of the year. Approximately one third of the horse population is replaced each racing season. The Department of Veterinary Clinical Services (DVCS) at the HKJC is the sole provider of veterinary care for this population of horses. All clinical records of horses in training at the HKJC are collated within the Veterinary Medical Information System (VMIS), a custom designed Microsoft Access database. A search of all horse records stored within the database was conducted using the key word “castration”. For a horse to be eligible for inclusion in the study two testicles had to have been removed using Serra-type emasculators with an OSC technique.

Open standing castration was defined as the technique described by Beard [6]. Briefly, in a sedated standing horse both testes and subcutaneous space along the proposed incision lines were anesthetised by infiltration of local anaesthetic. The skin and parietal tunic were subsequently incised, allowing the testicle to prolapse out of the tunic and scrotal fundus. The ligament of the tail of the epididymis was transected and sterile Serra type emasculators were placed directly around the spermatic cord [7]. Individual veterinarians applied minor variations to the basic technique, such as ligation of the testicular blood vessels, removal of the median raphe and digital stretching of the wound incisions on completion of the castration. Surgeons typically stood on the left of the horse and completed the procedure on the right testicle before repeating it on the left side. Skin incisions are left open for the wounds to drain and heal by secondary intention.

Veterinary records of all the horses that had been castrated were examined. Cases that did not meet the criteria were excluded. The following data were recorded for each case: age, import date, trainer, veterinarian who performed the castration, date of last race, eligibility to race, including pending Official Veterinary Examination (OVE) and relevant clinical records for the 30-days after castration. An OVE is issued by the HKJC Veterinary Regulatory Department in response to a recorded injury or poor race performance and further racing is not allowed until the horse undergoes and passes a health check by a regulatory veterinarian.

Case definition

Data on complications that occurred in the 30 days following castration were extracted from the clinical notes in the VMIS. The data were reviewed and the severity of complication was categorised into one of five groups: N, NEX, C1, C2 or C3, depending on specific keywords:

- Group N had no record of complications and horses were administered first-line antimicrobials and NSAID for less than or equal to seven days. "First-line antimicrobials" were procaine penicillin, trimethoprim-sulphadiazine (TMPS) and oxytetracycline, given at standard dose rates.

- Cases categorised as NEX had no record of complications and received an extended course (longer than seven days) of the first-line antimicrobial and/or NSAID.

- Cases categorised as C1 had a record of mild complications, which included mild swelling of the scrotum due to seroma formation, mild localised infection or discharge, funiculitis, a single digital opening of the scrotal wound for the purposes of drainage, mild colic (heart rate (HR)<45beats per minute (bpm)) that responded to conservative treatment, or post-operative bleeding requiring haemostasis using clamp or packing.

- Cases categorised as C2 had a record of moderate complications, which included moderate swelling of the scrotum due to seroma formation requiring digital opening of the wound on one or more occasions, funiculitis in the form of a moderately hardened and warm scrotum, loose faeces, moderately painful colic signs (HR 45-60 bpm) that responded to conservative treatment or an episode of pyrexia (temperature>38.6°C (101.5°F) but <39.7°C (103.5°F)).

- Cases categorised as C3 had a record of at least one severe complication that required urgent and/or sustained veterinary attention. This included records of pyrexia >39.7°C, excessive and prolonged haemorrhage at the time of surgery, severe colic (HR>60) that required hospitalisation, colitis, peritonitis, scirrhous cord or other conditions requiring aggressive medical and/or surgical intervention.

A putative diagnosis of localised infection or funiculitis was made when purulent material was present at the wound associated with gross thickening of the spermatic cord and/or culture of potentially pathogenic bacteria. In addition, localised infection or funiculitis was presumed if the horse had been prescribed a course of reserved antimicrobials (enrofloxacin or ceftiofur). Reserved antibiotics were prescribed on the basis of bacterial culture and sensitivity or empirical knowledge that these antibiotics were effective against bacteria resistant to first-line drugs in the prevailing environment.

Culture and sensitivity

In cases for which culture and sensitivity was performed, a sample was collected from the depth of the surgical wound using an aerobic, Amies agar gel[1] swab. Briefly, within 3 hours of collection the swab was plated onto blood agar and McConkey growth medium and incubated at 37°C. A first visual inspection at 24 hours allowed subculture onto blood agar of any moderate or heavy growths thought to be pathogenic using established colonial morphological characteristics [13]. All plates were returned to the incubator for a further 24 hours at 37°C. At 48 hours after the initial plating, the bacterial colony on the sub-cultured blood agar plates were individually harvested and mixed in saline to form a suspension. The suspension was added to ID 32 E cupules and a reagent strip incubated at 37°C for a further 24 hours for the purpose of bacterial identification. Excess suspension was then swabbed onto Mueller Hinton[2] 2 agar plates and an antimicrobial disk dispenser[3] was used to discharge 7 antimicrobial impregnated disks in order to measure bacterial sensitivity. The antimicrobials tested were ceftiour, enrofloxacin, gentamicin, oxytetracycline, metronidazole, penicillin G

[1] Copan Amies agar gel swab. www.copaninnovation.com
[2] Biomerieux
[3] Oxoid antibiotic disk dispenser

and TMPS. At 72 hours, the ID 32 E reagent strip was processed using the mini API[4] and a digital recording of the bacteria identified was produced.

Statistical analyses

Data were stored in a purpose designed Microsoft Excel spreadsheet. Data were described using counts and percentages or using medians and interquartile ranges (IQR) when continuous. A binary outcome of complication (1: horses in C1 to C3 categories) and no complication (0: horses categorised as N or NEX) was defined. While each castrated horse could only have one trainer and treating veterinarian, within trainers, one trainer could have multiple treating veterinarian and similarly treating veterinarians could treat horses from multiple trainers (Supplementary Table 1). As such, univariable logistic regression models with random effect terms for i) trainer, ii) veterinarian and iii) trainer and veterinarian were assessed for associations to the outcome of complication (yes/no). For the analyses, age was categorised as 2, 3, 4 and 5+ years.

Associations between time until return to galloping or training and complication category was determined using the Kruskal-Wallis test. All statistical analyses were conducted in Stata IC version 11 (StataCorp, College Station, TX, USA).

Results

Description of the study population

Between July 2007 and July 2012, 280 racehorses in training were castrated. Thirty horses were omitted from the study as they did not meet the inclusion criteria: 24 horses were castrated using general anaesthetic, of which six were cryptorchid surgeries, four horses were imported with only one testicle (n=2) or as cryptorchids (n=2), one horse developed peritarsal

[4] Biomerieux

sepsis and required adjunctive treatment and one horse had inconsistent notes relating to the castration. In total, 250 cases remained eligible for inclusion in the study (Figure 1). Across all years, 24.4% (61/250) of horses were castrated in the month of July (Supplementary Figure 1).

One horse was missing data for performance and demographic variables (age, sex and racing history). The number of castrations where a complication occurred and the total number of castrations is presented in Supplementary Table 2. All other horses in the study population were aged between 2 and 7 years (median 3, IQR 3 to 4 years) and had been in Hong Kong a median of 171 days (IQR 86 to 270 days) before being castrated. Fifty-six percent (140/249) of horses had raced in Hong Kong prior to being castrated. Of the horses that had raced, the median time between last race and castration was 10 days (IQR 5 to 27 days). Thirty-three horses had a pending OVE at the time of castration, 12 horses (4.8%) were injured in the 30-days prior to castration. Horses included in the study were in the care of 24 different trainers, with a median of 10 (IQR 7 to 13) horses per trainer. Thirteen veterinarians performed castrations with a median of 8 (IQR 5 to 25) castrations each. The maximum number of castrations performed by one veterinarian was 65.

Post-castration complications

Forty percent (100/250) of horses experienced no complications. Sixty-six horses (26.4%) were categorised as N and 34 horses (13.6%) as NEX. With trainer (P=0.002), or veterinarian (P=0.001) or veterinarian and trainer held constant (P<0.001), there was no statistically significant association between a horse having a post-castration complication and horse signalment or the month, season or year of castration (Supplementary Table 3). Caterpillar plots of each of the random effects investigate are presented in Supplementary Figure 2.

206 Of the 150 horses that experienced complications, 85 (56.7%) were categorised as C1,
207 57 (38.0%) as C2 and 8 (5.3%) as C3. Most of the horses with complications had a record of
208 scrotal swelling (70.0%; 105 horses), followed by funiculitis (36.7%; 55 horses) and seroma
209 formation (24.7%; 37 horses) (Table 1). Most horses with complications (87.3%; 131 horses)
210 had a record of digital opening of the wound. In the C2 complication category, 75.4% (43/57)
211 of horses received at least one digital opening of the wound; 15 once and 28 more than once.
212 In the C1 category, 30.6% (26/85) of horses had a record of digital opening of the wound and
213 one horse in the C3 group. Horses in the C3 category experienced colic (n=1), colitis (n=2),
214 severe haemorrhage (n=2), moderate scrotal swelling, funiculitis and pyrexia of >39.7°C (n=1),
215 thrombophlebitis and pyrexia of >39.7°C (n=1) and scirrhous cord (n=1). Six of the eight C3
216 horses were hospitalised.

217 **Antimicrobial use**

218 Post-surgery medication use was unavailable for six horses; therefore, data were
219 analysed for 244 horses. One horse did not receive first-line antimicrobials at the time of
220 surgery and one horse did not receive first-line antimicrobials but received reserved
221 antimicrobials (enrofloxacin and ceftiofur). One hundred and nine horses (44.7%) received an
222 extended course of the first-line antimicrobials and/or NSAID. An extended course of first-
223 line antimicrobials and/or NSAID were used in 48% (41/85) of horses grouped as C1, 53%
224 (30/57) in the C2 group and 50% (4/8) in the C3 group. Reserved antimicrobials were used in
225 42% (36/85), 81% (46/57) and 38% (3/8) of C1, C2 and C3 complications, respectively. Overall,
226 9% (8/85) of C1, 39% (22/57) of C2 and 13% (1/8) of C3 horses received both an extended
227 course of first-line antimicrobials and reserved antimicrobials. Enrofloxicin and ceftiofur were
228 both used in 22 horses, regardless of complication category.

229 **Return to racing**

In total, five horses failed to return to galloping after OSC. Horses for which no complication was recorded returned to galloping a median of 29 days (IQR 16 to 50; n=98) after castration. The interval was 37 days (IQR 25 to 51; n=147) for horses with complications (Figure 2). There was a significant difference between the complication categories and the time horses took to return to galloping (P=0.002). Twenty four horses did not return to racing. Horses returned to racing a median of 95.5 (IQR 68 to 145.5; n=92) and 108.5 (IQR 75 to 165; n=134) days post-castration for no complications and complication groups, respectively. Eight horses in the C2 group failed to return to racing. There was a significant difference between the complication categories and the time horses took to return to racing (P=0.03).

Culture and sensitivity

Eight horses (28.3% of horses with purulent drainage and/or funiculitis; 5.3% of horses with complications) had samples collected for culture and sensitivity. TMPS had been used prophylactically at the time of castration in seven of these and oxytetracycline in the other horse.

Seventeen different bacterial isolates were cultured. Five isolates were gram positive: *Streptococcus equi* subspecies *zooepidemicus* (n=4), *Staphylococcus aureus* (n=1). Twelve isolates were gram negative: *Escherichia coli* (n=5), *Proteus mirabilis* (n=4), *Klebsiella pneumonia* (n=2) and *Morganella morganii* (n=1).

Sensitivity testing showed that the bacteria cultured were resistant *in vitro* to oxytetracyclines (n=15; 88%), TMPS (n=14; 82%), gentamicin (n=8; 47%), metronidazole (n=15; 88%) and penicillin (n=12; 71%). Bacteria cultured were sensitive to enrofloxacin in 13 out of 17 cases (76%) and all samples were sensitive to ceftiofur (n=17; 100%). *In vitro,* four of the six bacteria cultured were susceptible to the combination of gentamicin and penicillin; *S. equi* subspecies *zooepidemicus, S. aureus, E. coli* and *P. mirabilis*.

Discussion

This retrospective study of clinical records from a closed population of horses found that 60% of all horses castrated in Hong Kong using the OSC technique suffered some type of complication within 30-days of the procedure. This is two to three times higher than has been reported in other studies utilising survey-based data collection of veterinary clinical records. There are several possible explanations for the high prevalence of complications here. It is conceivable that clinicians who undertook the procedures in the current study had less ability or were less diligent in their practice than those involved in previous studies. This seems unlikely, as all the veterinarians who undertook the castrations that were the subject of study were experienced and made every effort to practice to the highest standard. Another possibility is that the surgical techniques practiced or the post-operative care were suboptimal. However, the OSC technique is relatively standard and varies little between centres, as does the post-operative care. There may be factors associated with the environment, such as type of bedding, sand on exercise tracks or climatic conditions that predisposed to complications. The weather is hot and humid over the spring and summer in Hong Kong, which may be considered a risk factor for complications post castration. However, analysis of the data revealed no association between month or season and rate of complication. Further investigation of other potential risk factors, particularly stable management, is warranted. Another possibility is that the recording of “complication” was more comprehensive here than in previous studies. Using a higher threshold for the definition of complication (C2 and C3 only) would have meant a complication rate which is closer to other studies [9-11]. A requirement to diligently maintain accurate clinical records together with daily attendance of stables by each veterinarian may have resulted in a greater proportion of horses with complications being recorded. This would be particularly pertinent with mild complications that may not have received veterinary attention in other populations.

While most of the complications were mild or moderate in nature, eight horses (3.2%) experienced complications that were graded as severe. The horses with mild to moderate complications were managed successfully with minimal intervention, including further antimicrobial and/or NSAID medication and wound drainage. The majority of horses with severe complications required hospital-level intervention. No horses castrated in Hong Kong over the five-year study period died due to complications associated with the OSC procedure. Other than death, the range of complications was comparable to those reported in previous studies [4; 5; 7; 8]. OSC is considered a clean, contaminated procedure and for this reason it is routine practice to administer prophylactic antimicrobials and NSAID at the time of surgery [9; 14; 15], with the prophylactic use of antimicrobials discontinued by 24 hours post-surgery [16]. This was the case in the current study, with only two horses not receiving prophylactic antimicrobials. Conversely, compared to Kilcoyne *et al.* [9] the continuation of antimicrobial treatment beyond prophylaxis, as reported here, in some cases for extended periods of time after surgery, is unusual. The extended use reported here reflects the perception by clinicians that infection occurs as a consequence of contamination of the wounds post-operatively rather than at the time of the procedure.

In the cases here where culture and sensitivity was performed, bacteria were identified that were resistant to a wide spectrum of antimicrobials, including those routinely used for prophylactic therapy during OSC. Ideally antimicrobial therapy is based on findings from culture and sensitivity of bacteria involved. However, this approach requires delaying therapy at least 72 hours and clinicians were cognisant that bacteria involved were most likely to be sensitive to enrofloxacin and ceftiofur. This is substantiated by the observation that these “reserved” antimicrobials were effective at resolving infections, with or without culture and sensitivity results prior to treatment. Nevertheless, the use of antimicrobials, particularly those in the reserved category, needs to be protected [18]. At the time of this study, a consensus statement regarding specific criteria for the use of antimicrobial therapy at the

HKJC had not been developed and, therefore, selection of antimicrobials was made by the individual veterinarian [17]. Subsequent to this study and in-line with a general shift in policy, the DVCS now reviews and audits all cases that are prescribed antimicrobial drugs on a monthly basis.

While only 28% of horses with signs of infection had samples submitted for culture and sensitivity analysis, this study has identified potential patterns of antimicrobial resistance amongst bacteria involved in post-operative infection in this specific group of horses. The use of TMPS and oxytetracylines as first-line antimicrobials may be potentially contraindicated based on these limited results. Bacteria isolated showed greater sensitivity to, a combination of penicillin and gentamicin than to TMPS and oxytetracyclines. In addition, this combination had a broadly similar *in vitro* sensitivity to enrofloxacin and ceftiofur. While the prophylactic use of penicillin during castration has been reported [4], it is not routinely used in racehorses due to the requirement for frequent intravenous administration as the sodium salt and to the long withdrawal times prior to racing when used in preparations containing procaine. Given that the majority of horses, regardless of whether or not they experienced a complication, did not race for 68-days following castration, the concern over the use of procaine penicillin does not appear to be warranted.

This study is limited by the fact that 13 different veterinarians performed the castrations on the horses that were studied. Therefore, there will inevitably have been variation in the OSC techniques used, therapies prescribed and data recording practices at the time of surgery and during subsequent aftercare. In addition, management of horses in the days following castration by trainers was not recorded. Variation in stable practices could have affected the number and severity of complications experienced and this is something worthy of further investigation. Due to the high number of veterinarians performing the surgeries and different management practices by trainers post-castration, it is difficult to quantify the

effects of these factors on the complications described, although their effects were significant. The HKJC provides a unique opportunity to follow the outcome of horses after procedures like castration. However, the intensive housing of horses at the HKJC, the way they are managed mean that the data should be interpreted with caution in relation to other centres.

Conclusion

While the prevalence of complications following OSC was high, the vast majority of complications were mild or moderate in nature. The severity of complication did not adversely affect the subsequent ability to race. Multidrug resistance was detected in a limited number of samples from horses in which infection arose at the surgical site. Ceftiofur and enrofloxacin were shown to be efficacious following bacterial culture and sensitivity testing and were commonly used to manage post-castration complications. These "reserved" antimicrobials were often prescribed in the absence of culture and sensitivity testing, on the basis of past experience by clinicians at the time. This study provides an opportunity to improve welfare and antimicrobial usage through an examination of existing OSC protocols in order to better inform future best-practice if the OSC technique is to remain the predominant method of castration in Hong Kong.

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Conflict of interest

The authors note not conflict of interest

352 Figure 1: Flow chart of inclusion criteria, complication categorises and antimicrobial
353 treatments for horses undergoing castration at the Hong Kong Jockey Club (2007 to 2012).

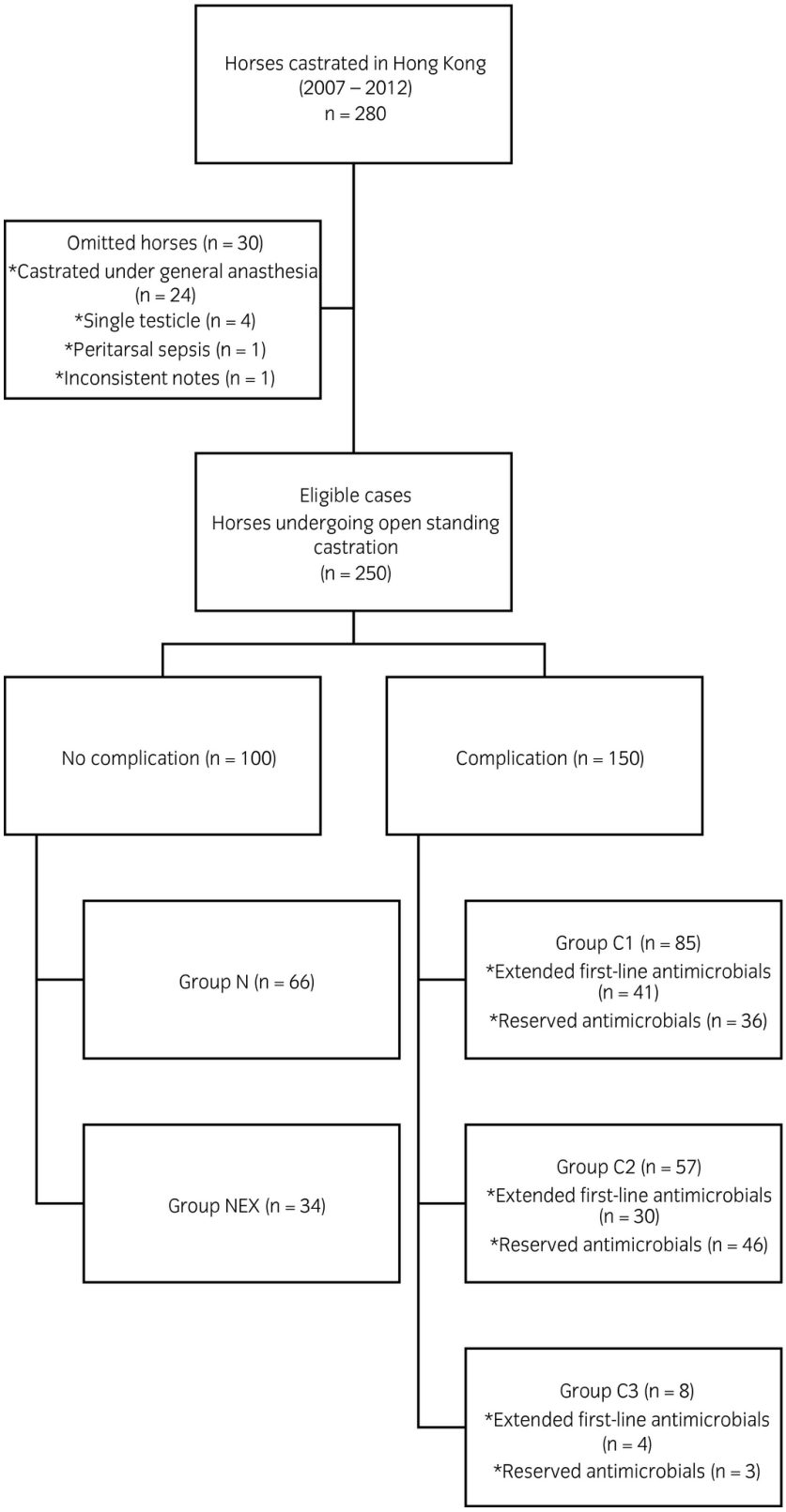

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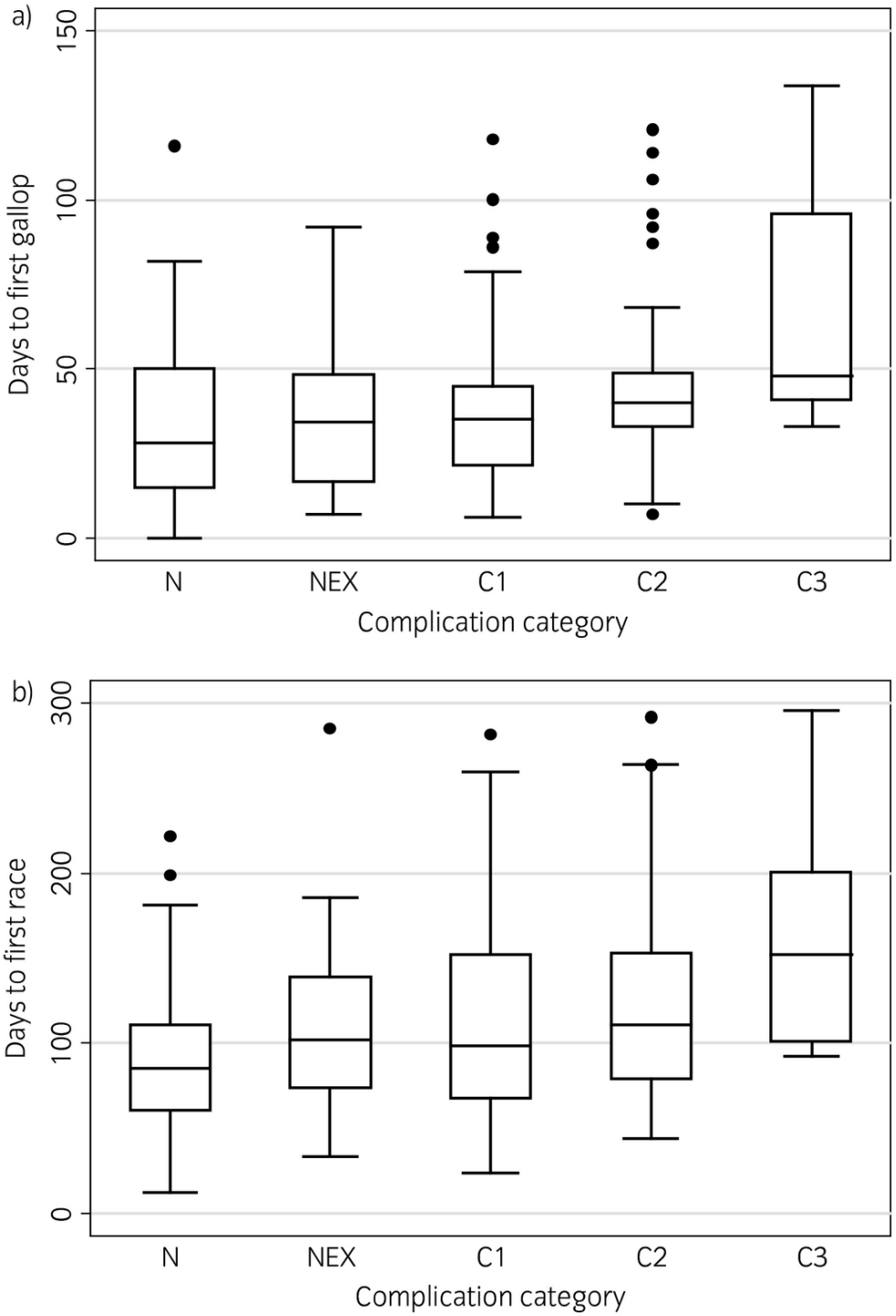
Figure 2: The number of days until first gallop (A) and first race (B) for horses castrated at the Hong Kong Jockey Club between 2007 and 2012. Note: (A) scaled to include all horses that galloped <150 days' post-castration, (B) scaled to include all horses that raced in <300 days' post-castration.



Supplementary Figure 1: Horses castrated per month by the open standing technique at the Hong Kong Jockey Club between 2007 and 2012 (n=250)

Supplementary Figure 2: Caterpillar plots of the random effect terms (and standard errors) for the random effect of veterinarian, trainer and trainer and veterinarian for logistic regression analysis for risk factors for castration complications (yes/no) in the 30-days post open standing castration. Data collected from 250 open standing castrations conducted at the Hong Kong Jockey Club between 2007 and 2012*

Supplementary Table 1: Number of open standing castrations (number of complications in the 30-days post castration) performed by veterinarians for each trainer at the Hong Kong Jockey Club. Data collected from 250 open standing castrations conducted at the Hong Kong Jockey Club between 2007 and 2012*

Supplementary Table 2: The number and percentage of castration complications (yes/no) in the 30-days post open standing castration, stratified by exposure variables. Data collected from 250 open standing castrations conducted at the Hong Kong Jockey Club between 2007 and 2012*

Supplementary Table 3: Univariable logistic regression analysis results for risk factors for castration complications (yes/no) in the 30-days post open standing castration, including a random effect term for i) trainer and veterinarian, ii) veterinarian and iii) trainer. Data collected from 250 open standing castrations conducted at the Hong Kong Jockey Club between 2007 and 2012*

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