Theriogenology xxx (2017) 1–9

Contents lists available at ScienceDirect

Theriogenology

journal homepage: www.theriojournal.com

Monitoring and controlling follicular activity in camelids

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ARTICLE INFO

Article history:
Received 1 December 2017
Accepted 1 December 2017
Available online xxx

Keywords:
Camelidae
Ovarian activity
Nutrition
Artificial breeding

ABSTRACT

This paper reviews that state of our knowledge concerning follicular wave dynamics, monitoring and manipulation. All camelids have overlapping follicular waves in absence of ovulation which is induced by a seminal plasma factor (βNGF). The interval between follicular waves varies. The size of the ovulatory follicle varies between 11 and 25 mm in camels and between in 6 and 13 mm in South American Camelids. The interval between induction of ovulation and next ovulatory follicle is 15 ± 1 day for all camelids. Follicular activity is best monitored by transrectal ultrasonography. Progesterone therapy for 7–15 days seems to suppress follicular dominance but does not completely inhibit follicular recruitment. Combination of estradiol and progesterone seems to provide better control of follicular activity. Both methods have provided variable results in the synchronization of follicular waves. Combination of induction of ovulation with GnRH and luteolysis at predetermined times shows some promise in synchronization of follicular dominance. These synchronization protocols require further investigation in order to provide practical approaches for fixed-time breeding. Ovarian superstimulation with FSH and eCG alone or in combination is somewhat successful. The best results are obtained when treatment is initiated at the emergence of a new follicular wave after induction of ovulation or following treatment with progesterone for 7–14 days. However, response remains extremely variable particularly in terms of ovulation rate and number of recovered embryos. Sources of this variability need to be studied including the effects of season, nutrition, doses and frequency of administration of gonadotropin.

1. Introduction

The camelidae family includes 6 major species traditionally subdivided into Old-world camelids (OWC) or camels (*Camelus dromedarius* and *Camelus bactrianus*) and New-world camelids (NWC) (*Lama glama*, *Lama guanicoe*, *Vicugna pacos* and *Vicugna vicugna*). Domestic camelids (camels, llamas and alpacas) are important livestock in several parts of the word. It is predicted that these species will be increasingly important for animal production in harsh environments due to their adaptive characteristics to desert (camelids) or altiplano (llamas and alpacas). Wild camelids (vicugna, guanaco and some Bactrian camels) are important resources that are increasingly threatened due to habitat degradation. Reproductive management and multiplication of wild camelids through the use of interspecies embryo transfer has been investigated as a mean for the preservation of these species [1,2].

Efficient reproductive management and use of reproductive biotechnologies, such as artificial insemination (AI) and embryo transfer (ET), require a thorough understanding of follicular dynamics and factors governing ovarian activity. Prior to 1990's, most studies on ovarian activity in camelids relied on behavioral and hormonal observation [3]. Effort to characterize follicular wave dynamics was mostly driven by the desire to develop AI and ET technologies. The widespread use of ultrasonography allowed in situ observation of ovarian follicular activity and better characterization of follicular dynamics, ovulation and monitoring of responses to treatments [4]. The present paper discusses the state of our knowledge on ovarian follicular dynamics in camelids, factors governing it, and its monitoring and manipulation.

2. Follicular dynamics in camelids

2.1. Follicular dynamics in absence of ovulation

Ultrasonographic and hormonal studies in the mid to late 1990's helped define follicular dynamics in several domestic camelids species [5–8]. Field and experimental observations demonstrated

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https://doi.org/10.1016/j.theriogenology.2017.12.011
0093-691X/

that ovarian activity in the female camelid is not seasonal under optimal nutritional condition [9]. However, under some conditions, female camels may display seasonal variation in follicular activity that may be partly regulated by photoperiod. All camelid species are induced ovulators, thus in absence of ovulatory stimulus (mating or hormonal induction), follicular waves occur in an overlapping manner [6,10]. Follicular waves present the typical phases of recruitment, growth, maturation and regression. The duration of each of these stages of the follicular waves is variable (Table 1).

Follicles that surpass a certain diameter (25 mm in camels, 12 mm in alpacas, 13 mm llama) have decreased ovulatory response. Some of these follicles may continue to grow and develop into large anovulatory follicles that may become hemorrhagic or luteinized (Fig. 1). Anovulatory hemorrhagic follicles (AHF) seems to be more frequent in camels [4,6] and llamas [11] than in other camelids species. The tendency for development of AHF seems to be dependent on individual female. The pathophysiology of AHF is poorly understood [6]. Clinical observations suggest that some of these AHF may be triggered by metabolic disorders in the female as well as adverse climatic conditions. Presence of AHF does not seem to disturb follicular wave patterns.

Follicular dynamic is dependent on FSH and LH stimulation [12–14]. Presence of 2 or more co-dominant follicles is not uncommon in camelids and may occur in up to 40% of follicular wave (Camels [4,15,16], NWC [17]). Behavioral changes during the follicular wave are not strongly correlated to size of the follicle and readiness for ovulation (Camels [4,18]; NWC [19–22]). Therefore the best method for monitoring follicular dynamics is transrectal ultrasonography. At peak follicular development (pre-ovulatory stage), the uterus is toned and present characteristic edema pattern on ultrasonography (Fig. 2). Color-Doppler ultrasonography can be used to monitor blood flow to the follicle during various stages of development. Blood flow to the dominant follicle increased with follicular growth [23].

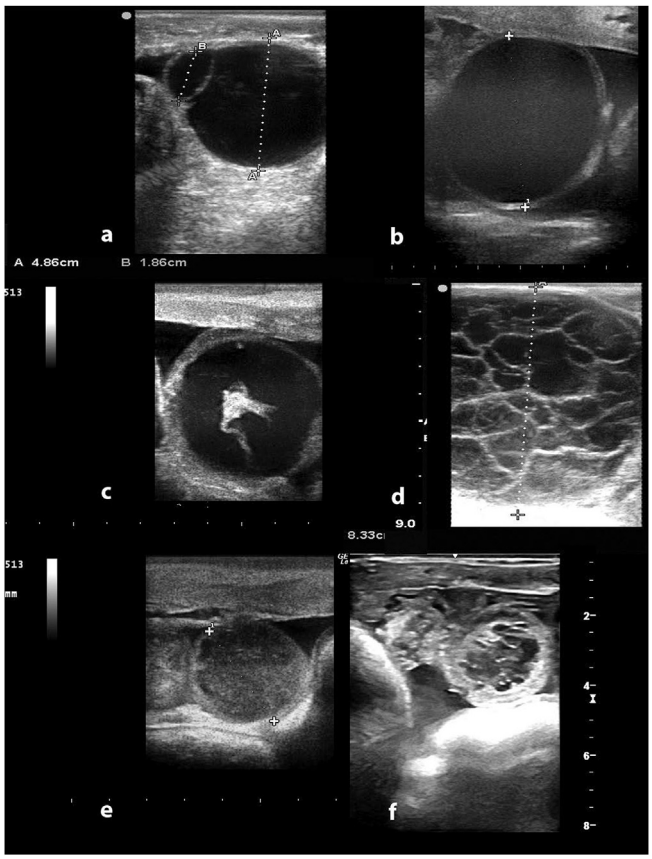

Fig. 1. Ultrasonographic appearance of anovulatory follicles in the dromedary. A) 48.6 mm thin-walled anovulatory follicle with anechoic fluid, b) 80 mm thick-walled anovulatory follicle with echogenic fluid, c) 42 mm anovulatory follicle showing some hemorrhage and intralumunal fibrin, d) 83.3 mm anovulatory hemorrhagic follicle (AHF) with characteristic multiloculated appearance, e) and f) AHF with varying degrees of luteinization.

2.2. Ovulation

The induced nature of ovulation in camelids has long been suspected based on clinical and hormonal studies [30]. However, the major breakthroughs in defining the mechanisms of induction of ovulation came in two main groups of studies. The first demonstrated the hypothalamo-pituitary response to mating represented by a sharp increase in luteinizing hormone within minutes following mating in presence of a mature follicle in OWC [31,32] and NWC [12,13]. The second group of studies led to the hypothesis of the presence of an ovulation-inducing factor (OIF) within the seminal plasma [33]. Recent studies identified the OIF as β nerve growth factor (βNGF) in llamas and alpacas [34,35] and in camels [36]. Both βNGF and endometrial inflammation are required to

Table 1
Characteristics of follicular dynamics and corpus luteum development in camelids Dromedary [4,5,24,25]; Alpaca and llama [7,26]; Bactrian camel [27,28]; Vicuna [17]; Guanoco [29].

Parameter	*C. dromedarius*	*C. bactrianus*	*V. pacos*	*L. glama*	*V. vicugna*	*L. guanacoe*
Follicular wave phases duration[a]						
Growth (days)	10.5 ± 0.5	10.9 ± 3	3–9	3–9	3.0 ± 0.2	7.0 ± 2.4
Maturation (days)	7.6 ± 0.8	7 ± 4.2	2–8	2–8	1.4 ± 0.1	3.0 ± 1.2
Regression (days)	11.9 ± 0.8	11.9 ± 4.2	3–8	3–8	2.0 ± 0.3	5.2 ± 2.1
Ovulatory follicle characteristic[a]						
Minimum size (mm)	9	9	6	7	6.2	7.2
Growth rate (mm/day)	1.8	0.7–1.8	0.43	0.5–0.9	1.8 ± 0.1	1.0 ± 0.3
Average size (mm)	10–18	10–18	8–10	9–12	8.4 ± 0.9	10.2 ± 2.1
Maximum size (mm)	25	25	12	13	11.2	16.1
Incidence of anovulatory follicles (%)	40–50	?	5	10–40	?	?
Anovulatory follicle regression (days)	8–45	?	?	4–22	?	?
Corpus luteum characteristics						
Interval from mating to ovulation (hours)	32 to 40	30 to 48	28 to 30	27–36	–	–
Size (mm)	15–25	15–25	11–15	11–18	–	–
Day at CL maximum size	7.2 ± 1.7	7.3	7–8	8	–	–
Days post-ovulation to complete luteolysis	10 ± 1.2	10.5	10–12	10–12	–	–

[a] Extreme variation in onset of postpartum ovarian follicular activity is primarily due to nutritional condition and effect on lactation anestrus and seasonality.

Please cite this article in press as: Tibary A, Monitoring and controlling follicular activity in camelids, Theriogenology (2017), https://doi.org/10.1016/j.theriogenology.2017.12.011