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Disbudding pain: The benefits of disbudding goat kids with dexmedetomidine hydrochloride

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ABSTRACT

This study compared the effectiveness of intramuscularly administered dexmedetomidine hydrochloride and other pharmacologic techniques used in reducing disbudding pain in goat kids. A total of 30 kids aged 4–9 days old were randomly assigned to 5 treatment groups; Sham disbudded (SD, n = 6); hot-iron disbudded (295–326 °C, 4–7 s/horn bud; D, n = 6); hot-iron disbudded after a ring block with lidocaine hydrochloride and IM administration of meloxicam (LMD, n = 6); hot-iron disbudded under dexmedetomidine hydrochloride, lidocaine hydrochloride and meloxicam (DeLMD, n = 6); hot-iron disbudded under dexmedetomidine hydrochloride and saline (DeSSD, n = 6). Results indicated that there were significant increases in plasma cortisol of the D (pre-disbudding, 16.97 ± 3.3 vs. after disbudding, 58.1 ± 12.8, mean ± SE) and LMD (15.2 ± 3.0 vs. 43.9 ± 8.6: $P < 0.05$). However, the levels were slightly higher but insignificant among the sedated kids. The mean cortisol of the DeSSD kids was significantly low during 5 h after disbudding (11.2 ± 2.5, $p = 0.0436$). The total means of the pain-related behaviors were significantly high in the D and LMD kids whereas the sedated kids had relatively low values ($P < 0.05$). The DeSSD group had the lowest number of pain-related behaviors. Heart rates and rectal temperature decreased significantly in the DeSSD kids. There were no significant differences in respiration rates among all the kids. The cortisol and behavior levels observed in this study suggest a positive reduction in pain among kids disbudded under sedation with dexmedetomidine hydrochloride. It was concluded that sedation with dexmedetomidine hydrochloride prior to disbudding can improve kid's welfare.

1. Introduction

The removal or destruction of the horn bud before the beginning of actual horn growth is referred to as "disbudding" (Vickers et al., 2005). It is increasingly becoming an everyday practice in dairy goat farms. However, handling and management of horned animals pose a greater risk during management practices (Doherty et al., 2007; Alvarez et al., 2009). Disbudding of kids is achieved by both chemical and hot-iron methods most of which have been adopted from other ruminants (Alvarez et al., 2009). Such methods can be painful and invasive. Thermal disbudding in goat kids has been associated with acute pain and stress, high-intensity behaviors, and acute cortisol increase (Molaei et al., 2015). However, fewer efforts have been made to mitigate disbudding pain in goat kids (Alvarez et al., 2015b). Adoption of methods used to disbud kids have been discouraged while pre and post-analgesia, as well as multimodal analgesia in conjunction with sedatives, have been suggested when disbudding ruminants (Alvarez and Gutirrez, 2010; Duffield et al., 2010; Galatos, 2011).

Identification and prevention of pain in farm animals are vitally essential. Certain pharmacologic interventions (Nonsteroidal anti-inflammatory drugs, NSAIDs, local anesthetics, α2-agonists) are available for treatment of acute pain. Injecting sufficient amounts of local anesthetic agents such as lidocaine hydrochloride locally prior to painful husbandry procedures can effectively mitigate pain. Nonetheless, they are not practical for general farm use. This is partly attributed to the increased handling times of the animals and veterinary intervention required (Lomax et al., 2010). NSAIDS have reduced disbudding pain in small ruminants (Faulkner and Weary, 2000; Milligan et al., 2004; Ingvast-Larsson et al., 2011). A combi-

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Table 1
Experimental groups and treatment descriptions.

Experimental group	n	Treatment descriptions
Sham disbudding (SD)	6	Kids were handled and sham disbudded (cold cautery iron held against each horn bud).
Disbudding (D)	6	Kids were disbudded using hot-iron (295–326 °C) applied 4–7 s/horn bud.
LA[b] and NSAID[a] disbudding (LMD)	6	NSAID[a] administered by i.m. injection 10 min before disbudding followed by 1 mL of LA[b] injected s.c. around the base of each horn bud 5–7 min before kids were disbudded as above.
Sedative, NSAID[a] and LA[b] disbudding (DeLMD)	6	Sedative[c] administered 15 min before disbudding followed by NSAID[a] and LA[b] as above and were disbudded.
Sedative and saline disbudding (DeSSD)	6	Kids sedated as above and saline was administered in equal volumes of NSAID[a] administered i.m in the DeLMD group, followed by 1 mL of saline injected around each horn bud and kids were disbudded as above.

i.m = intramuscularly, s.c = subcutaneously.
[a]Meloxicam (Mobic® 15 mg/1.5 mL; Boehringer Ingelheim, Spain), injected i.m. (0.5 mg/kg BW).
[b] 1 mL of 2% lidocaine hydrochloride (Taiyu chemical and pharmaceutical Co., Ltd, Hsinchu, Taiwan).
[c] Dexmedetomidine hydrochloride (0.5 mg/mL; Orion Pharma, Finland), injected i.m. (0.1 mg/kgBW).

nation of xylazine HCl (0.22 mg/kg) and ketamine HCl (8.8 mg/kg) used in kids prior to disbudding is reported to have reduced pain (Ingvast-Larsson et al., 2011). However, details regarding the acute response of the kids were not provided. Oromucosally administered detomidine has effectively sedated calves prior to disbudding (Hokkanen et al., 2014). None of the calves was reported to substantially resist infiltration of the local anesthetic nor reacted to hot cauterization of horn buds. This shows that pain might have been prevented during disbudding. In another study, infiltration of lidocaine hydrochloride around horn buds before cautery disbudding of goat kids did not prevent the increase in cortisol secretion or stress-related behavioral responses (Alvarez et al., 2009). Despite the numerous research projects, there are numerous misconceptions about the amount of pain experienced by animals during painful husbandry procedures (Misch et al., 2007; Gottardo et al., 2011). It is worth mentioning that information on the management or prevention of disbudding pain in goat kids is scarce.

Dexmedetomidine hydrochloride, an alpha 2 agonist with both sedative and analgesic properties may be effective in decreasing stress-induced cortisol and pain-related behavioral responses in goat kids (Kutter et al., 2006). However, standard dosages for goats have not been described. However, a study has reported an IV dose of 2.5 μg/kg body weight in buffalo calves and goats (Khattri et al., 2013). The purpose of this study was to determine the effect of minimizing disbudding pain in goat kids by intramuscular injection of dexmedetomidine hydrochloride.

2. Materials and methods

2.1. Animals

This study was conducted at the Department of Animal Science, National Chung Hsing University. Initially enrolled were 37 kids. However, 7 were excluded because their pre-disbudded cortisol values were far above the physiological range (23.5 ± 2.9 ng/mL) reported for goats (Fazio et al., 2006).

The final number of kids used in the study included 30 healthy male and female kids (Saanen, Nubian, Toggenburg, LaMancha and Alpine genotypes) aged 4–9 days. After birth, they were kept approximately 1–2 m from the disbudding site and were fed with artificially milk 4 times a day. During the study, the kids were placed in clean and dry plastic boxes measuring approximately 1 m^2 and having heat lamps hanging over them to keep warm. There was a maximum of 3 kids/box. Data were collected on age, sex, weight (kg), temperature (°C), heart rate (beats/min), and respiratory rate (breaths/min). The experimental protocol was approved by the Institutional Animal Care and Use Committee of the National Chung Hsing University.

2.2. Experimental procedures

The experiment was conducted on separate days. Before each procedure, the body weight, temperature, respiratory and heart rates were measured for each kid and blood samples were collected into heparinized tubes. The body temperature was measured using a digital thermometer that was placed in the rectum. Heart rates were measured using a stethoscope and the respiratory rates were determined by counting the number of times the chest cavity rose and fell per second for 15 s and multiplied by 4. Respiratory measurements were repeated after few minutes following abnormal counts or panting. Repeated measurements were made immediately after disbudding and at 0.5, 1, 3, and 5 h, respectively. The temperature of the electric dehorner was measured using the Center® 307/308 Type K thermometer. The experimental groups and their treatment descriptions are summarized in Table 1.

Identification numbers were assigned to each kid. Disbudding usually began at about 9:00 to 10:00 am each day with the whole experiment lasting approximately 5 h. The hair around each horn bud was shaved with an electrically charged clipper. Each kid was restrained with the head slightly raised and the legs loosely held. During disbudding, behaviors were monitored visually and recorded by a trained assistant blind to the treatments. They were graded on a scale of 1–6 (no expression of pain-related behavior) to 6 (all expressions of pain-related behaviors) and the means were calculated. The pain-related behavioral types recorded included vocalization (continuous or non-continuous), kicks, tail wagging, ear flicks and back arching (Alvarez and Gutirrez, 2010; Ingvast-Larsson et al., 2011). Continuous (extended) vocalization was defined as vocalization throughout the application of the dehorner (scored as 3–6 vocalizations/horn bud).

The electric dehorner (295–326 °C) was placed over each horn while rocking gently for 4–7 s. Povidone iodine (gel) was applied to each horn bud and blood was immediately collected. After disbudding, the kids were placed in the clean and dry plastic boxes. Atipamezole hydrochloride (5 mg/mL; Orion Corporation Espoo, Finland) was used in an equivalent volume of dexmedetomidine hydrochloride administered for kids in the sedated groups as a reversal dosage 30 min following disbudding. Disbudded kids were monitored until 2 months after disbudding for the presence or absence of regrowth.

Blood samples were collected from the jugular veins using 23 G syringes and placed in heparinized tubes. Plasma was obtained by centrifugation at 1 300*g* for 10 min and analyzed for cortisol within the same day or was stored (−20 °C) until assayed 1–4 weeks later. The Enzyme Linked Fluorescent Assay (ELFA) procedure (Biomerieux SA France 69280 Marcy-L'Etoile mini VIDAS) was used to determine the total cortisol concentration which was expressed as nanograms per mL (ng/mL). Its use has already been validated in the dog (Proverbio et al., 2009). The measurement values of the VIDAS cortisol S kit range from 2 to 650 ng/mL and its coefficient of correlation when compared with other methods and using serum or plasma sample was 0.95.

2.3. Statistical analysis

The SAS 9.3 software (SAS Institute, Cary, NC) was used to analyze the data. The mean difference of the pain-related behaviors was analyzed using the analysis of variance (ANOVA). Paired *t*-test was used to determine within-group (intragroup) differences while Duncan's multiple range test (DMRT) was used to examine the intergroup differences. A value of $P < 0.05$ denoted significance.

3. Results

The use of dehorner lasted 4–7 s/treatment (applied 1 or 2 times/horn bud) while the duration of the disbudding procedure per treatment was within 30–90 s.

3.1. Cortisol concentration

Changes in plasma cortisol concentrations of all the groups (the intra- and intergroup comparisons) are shown in Figs. 1 and 2. Pre-disbudding cortisol values were not significantly different among groups. Immediately after disbudding, the following were

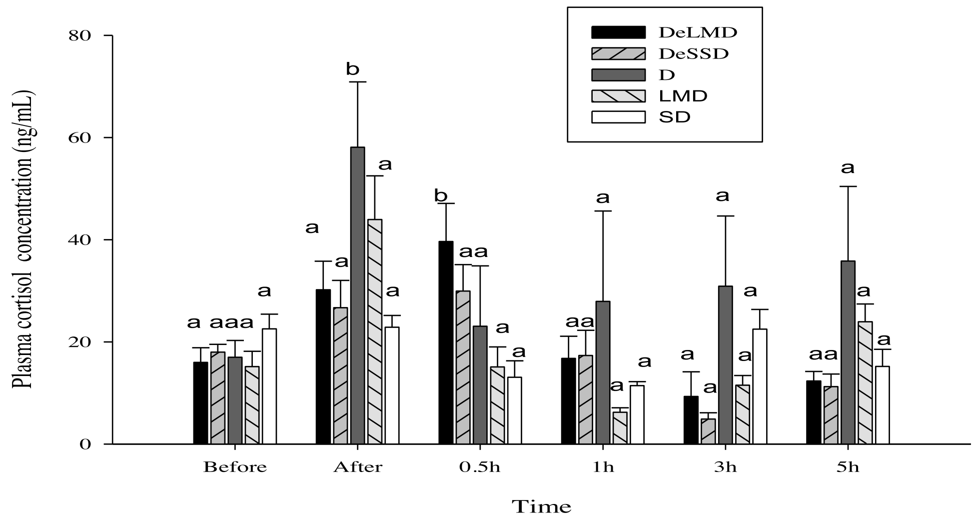

Fig. 1. Changes in plasma cortisol concentrations (ng/mL) of kids following disbudding. Mean separation by Duncan's multiple range test (DMRT). Means with a different superscript letter "b" are significantly different from the sham group (P < 0.05).

observed: (1) Plasma cortisol values were significantly elevated in the D (58.1 ± 12.8 ng/mL) and LMD (43.9 ± 8.6 ng/mL) groups (*P* = 0.0134 and 0.0044, respectively). (2) The sedated kids showed a slightly increased but statistically non-significant cortisol levels when compared with their pre-disbudding values.

During 5 h after disbudding, the mean cortisol of the DeSSD kids was significantly low (11.2 ± 2.5; p = 0.0436) while levels of the DeLMD and simulated kids were below pre-disbudding values. However, the D and LMD groups still maintained relatively higher values above their pre-disbudding levels. Compared to all other times, the sedated groups had the lowest values of cortisol at 3 h after disbudding (i.e. 4.9 ± 1.2 and 9.3 ± 4.8 for the DeSSD and DeLMD, respectively).

3.2. Behavior

The highest number of pain-related behaviors were recorded in the D (6 behaviors), followed by the LMD (5 behaviors) kids (Fig. 4). The ANOVA for the pain-related behaviors (total behavioral mean for each treatment group) were found significantly high for the D and LMD groups (P < 0.05). Most vocalizations and kicks were recorded in the D than other groups. Continuous vocalizations mostly occurred in the D group. Non-continuous vocalizations occurred mostly in the LMD group and to a lesser extent in the simulated kids (SD).

3.3. Variations of heart rate, respiratory rate and temperature

Pre-disbudding heart rates were not significantly different among groups (Fig. 3). Immediately after disbudding, they were significantly decreased in the DeLMD, (174.0 ± 23.4 vs. 126.0 ± 4.2 bpm) and DeSSD (190.7 ± 12.2 vs. 131.3 ± 7.2 bpm) groups (*P* < 0.05). The decrease in the sedated groups lasted 30 min, followed by slight increases at 1 h (*P* < 0.05). A significant decrease was recorded in the LMD group during 1 h after the procedure (*P* < 0.05) and which later returned to pre-disbudding levels at 3–5 h. It was only 5 h after disbudding that the HR returned to pre-disbudding value in the D group. Respiratory rates were not affected by disbudding.

Table 2 shows the intra and inter-group comparison of body temperature of the kids. Rectal temperatures did not differ significantly between groups prior to the procedure. Right after disbudding, they were significantly decreased in the DeSSD kids and lasted 1–3 h (*P* < 0.05), after which (3 h after disbudding) the values were similar to their initial values. Temperature values decreased significantly in the LMD group during 3–5 h after disbudding, (*P* < 0.05). The sedated groups registered lowest values during 30 min after disbudding compared to all other times.

4. Discussion

In this study, significant increases in cortisol levels were noted only in the D and the LMD kids right after disbudding. This shows that disbudding is a painful and stressful procedure for goat kids at the time of the procedure (Alvarez and Gutirrez, 2010; Alvarez et al., 2015a). Furthermore increased levels were also noted in both groups at 5 h after disbudding. This shows that pain might have persisted even after the entire disbudding procedure.

It was only in the DeSSD kids that the mean cortisol level was significantly lower than their pre-disbudding values 5 h after the procedure (18.0 ± 1.5 vs. 11.2 ± 2.5; P = 0.0436). This in an indication that dexmedetomidine hydrochloride was effective in reducing the possible long-lasting discomfort caused by thermal disbudding of the kids. However, the SD and DeLMD group had lower cortisol than their pre-disbudding values even though not significant. In addition, there were no significant differences in cortisol levels between the sedated groups at any time. This indicates that dexmedetomidine hydrochloride may either be used as a single or combined dose during disbudding. NSAIDs and lidocaine hydrochloride have been shown to eliminate blood cortisol rise (McMeekan et al., 1998; Stafford et al., 2003) hence, the increases recorded in the LMD kids were least expected.

In general, the D group showed all the pain-related behaviors followed by the LMD kids. The behaviors were similar to those previously described in calves and red deer (Faulkner and Weary, 2000; Webster and Matthews, 2006). The sedated and SD kids were noted with negligible pain-related signs. Vocalizations were observed from the application of the dehorner until when it was removed. Continuous vocalizations were observed mainly in the D group whereas non-continuous vocalizations occurred particularly in the LMD kids. Lidocaine hydrochloride is reported to have reduced vocalization in cattle (Grondahl-Nielsen et al., 1999; Doherty et al., 2007). In this study, the sedated kids did not vocalize. Head scratching was frequent between 1 and 3 h after disbudding in kids that received lidocaine hydrochloride. This is indicative of a decrease in irritation to the local anesthetic (Duffield et al., 2010).

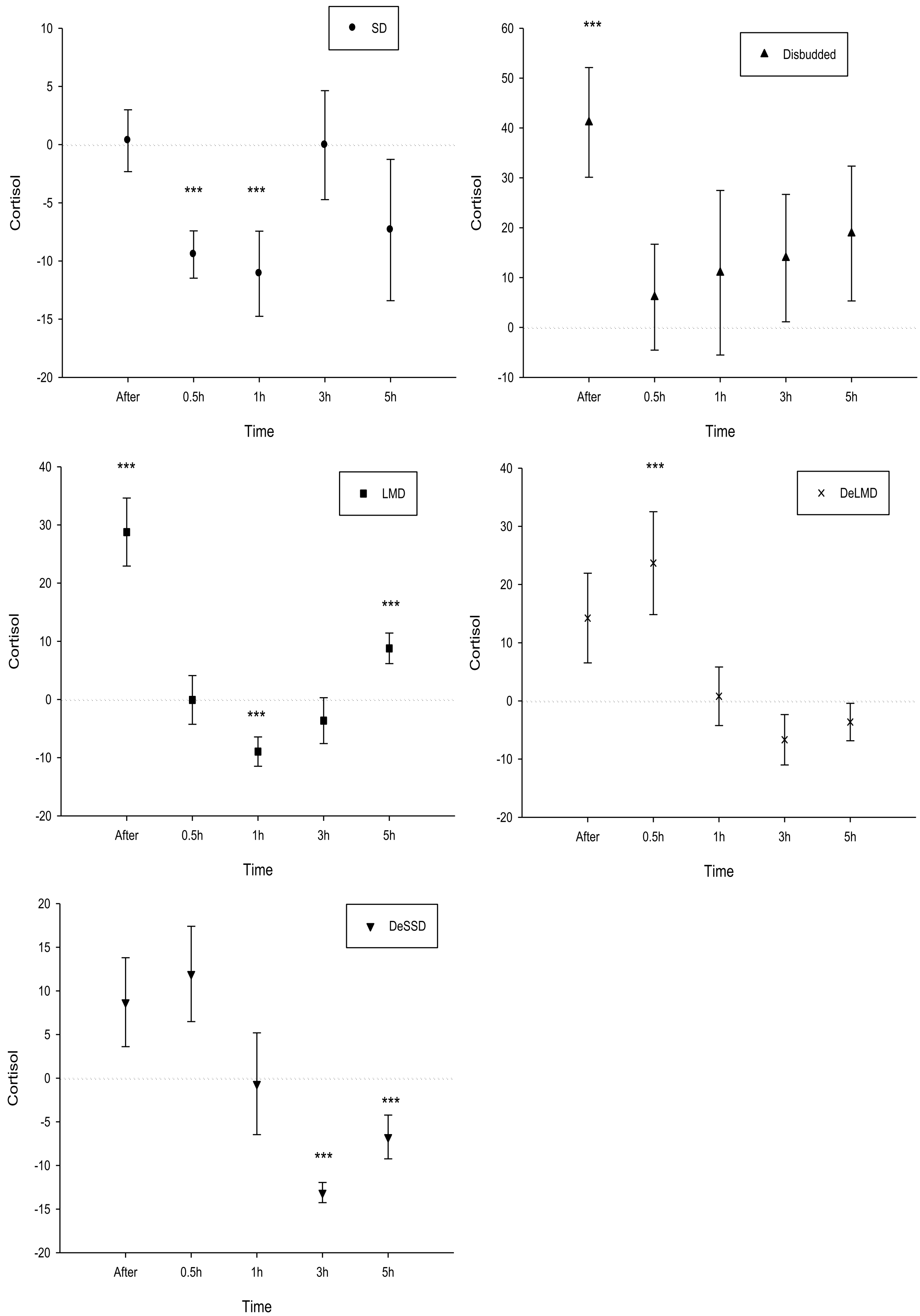

Fig. 2. Changes in plasma cortisol concentrations (ng/mL) of kids (intragroup difference) compared with baseline values. The mean difference by paired *t*-test. Superscript symbols *** are significantly different ($P < 0.05$) from the pre-disbudding values.

In a recent study carried out on thermal disbudding of goat kids, pain-related behavioral response and cortisol levels were not reduced when 1 mL of 2% lidocaine hydrochloride with epinephrine was injected at the lacrimal and infratrochlear nerves (Alvarez et al., 2015a). In our study, right after disbudding, significant increases in cortisol were noted only in the D and LMD groups. Both groups also recorded most of the pain-related behaviors, unlike the sedated groups.

Goats have been observed to be sensitive to the centrally mediated cardiovascular effects of dexmedetomidine hydrochloride (Kutter et al., 2006). This observation can be possibly linked to the decline in heart rates noted among the sedated kids. Elevated values

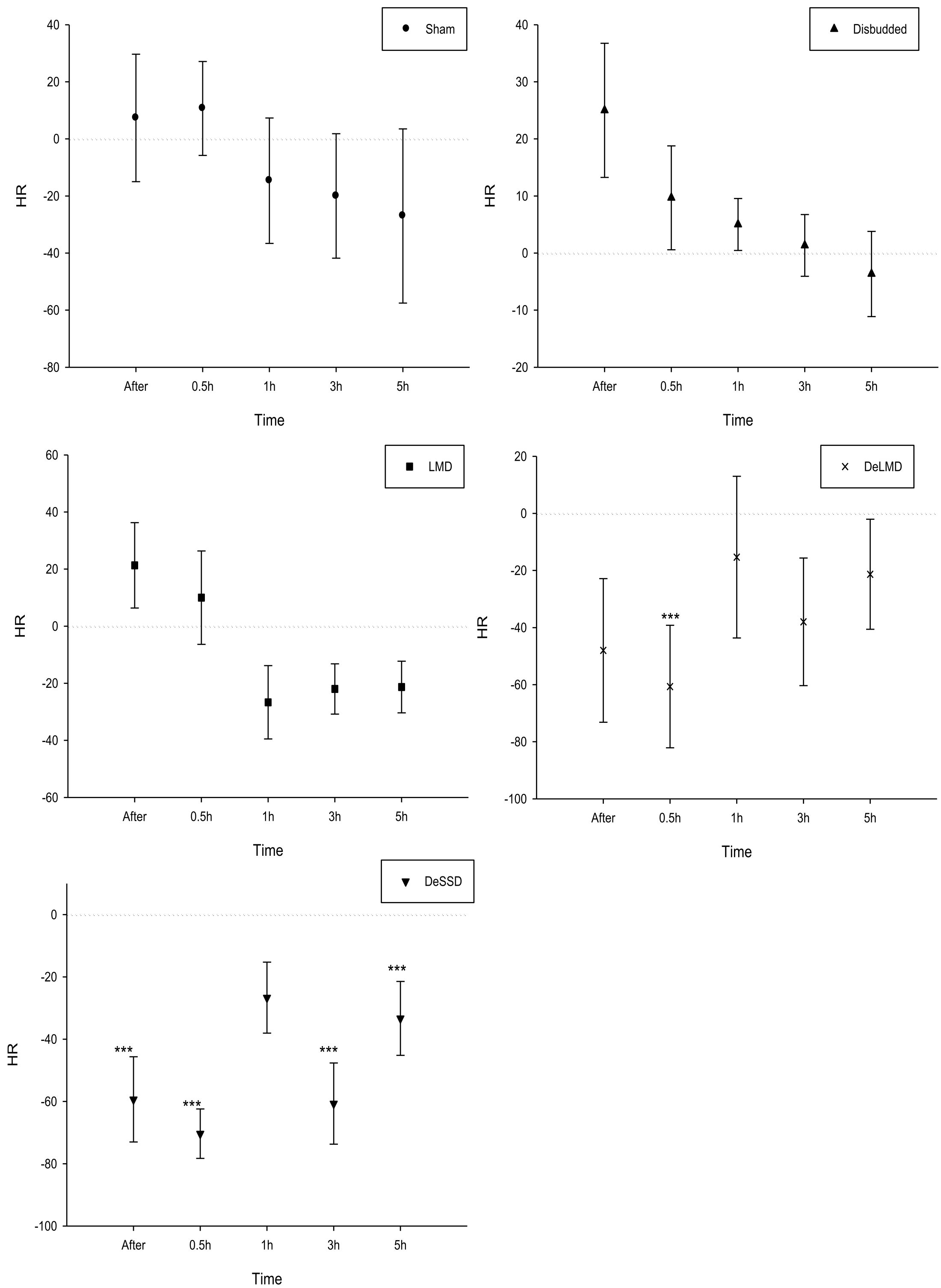

Fig. 3. Changes in heart rate (intragroup) compared with baseline values. The mean difference by paired *t*-test. The Superscript symbol "***" are significantly different ($P < 0.05$) when compared with the baseline values.

have been reported following disbudding of calves (Stewart et al., 2009).

In this study, an electric dehorner of 110 V heated at 295–326 °C was used to disbud the kids. The above temperature range was achieved within 5–10 min after being plugged into an electrical socket. The electrical and thermal property of the electric device previously used to disbud goat kids was 220 V and heated at 600 °C (Buttle et al., 1991; Al-Sobayil, 2007; Alvarez and Gutirrez, 2010). Heat-induced meningitis, cerebral infarction, and incoordination have been reported after cautery disbudding (Nation and Calder, 1985; Thompson et al., 2005). In addition, meningoencephalitis caused by thermal disbudding is described as one of the tragic diseases in goat kids. Such complications might have been caused by the high temperature of the dehorner coupled with prolonged applications on horn buds. None of such complications were observed in this study. It was imperative that the temperature of

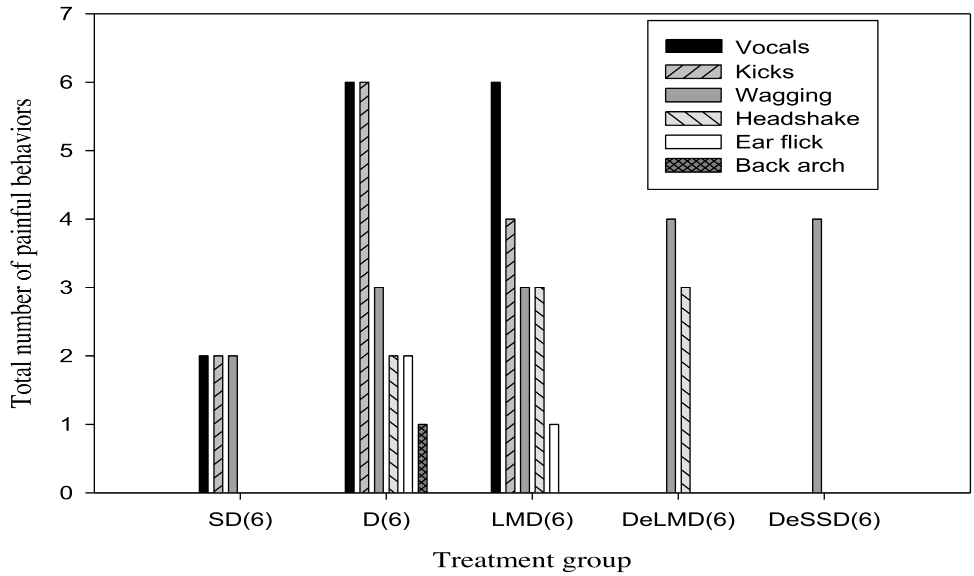

Fig. 4. Total behaviors exhibited by kids during disbudding. SD: kids sham-disbudded; D: kids disbudded without treatment; LMD: kids disbudded + NSAID; DeLMD: kids disbudded + sedative + NSAID; DeSSD: kids disbudded under saline and sedative.

Table 2
Changes in body temperature (°C) of kids following thermal disbudding.

	Time of disbudding					
Group (n)	Before	After	0.5 h	1 h	3 h	5 h
SD (6)	39.7 ± 0.1^{aA}	39.7 ± 0.1^{abA}	39.8 ± 0.1^{abA}	39.7 ± 0.1^{abA}	39.7 ± 0.2^{aA}	39.7 ± 0.1^{aA}
D (6)	40.0 ± 0.1^{aA}	40.1 ± 0.1^{aA}	39.9 ± 0.3^{aA}	39.9 ± 0.2^{aA}	39.9 ± 0.1^{aA}	39.8 ± 0.1^{aA}
LMD (6)	39.8 ± 0.1^{aBA}	40.0 ± 0.1^{abA}	40.0 ± 0.1^{aA}	39.6 ± 0.1^{abBC}	39.5 ± 0.1^{aC}	39.4 ± 0.1^{aC}
DeMLD (6)	39.7 ± 0.2^{aA}	39.3 ± 0.3^{bA}	38.0 ± 0.6^{bB}	39.0 ± 0.3^{bA}	39.6 ± 0.2^{aA}	39.4 ± 0.1^{aA}
DeSSD (6)	40.1 ± 0.1^{aA}	39.2 ± 0.3^{bBC}	38.4 ± 0.4^{bD}	39.0 ± 0.3^{bDC}	39.9 ± 0.1^{aBA}	39.6 ± 0.2^{aBAC}

Mean separation by Turkey's HSD (honest significant difference) and Duncan's multiple range test (DMRT). Means with different superscript letter(s) are significantly different ($P < 0.05$). Direction of mean separation: – Uppercase letters (along row or intra-group) and Lowercase letters (along column or inter-group). SD: kids sham-disbudded (n = 6); D: kids disbudded without treatment (n = 6); LMD: kids disbudded + NSAID (n = 6); DeMLD: kids disbudded + sedative + NSAID (n = 6); DeSSD: kids disbudded + saline + sedative (n = 6).

the electric dehorner be determined to better estimate the appropriate length of time necessary per horn bud, bearing in mind that a kid's skull is smaller when compared with that of a calf. Disbudded kids were monitored continuously for 2 months post-disbudding, and there was a complete absence of horns.

Breeds can be different in their response to the same challenge. However, in this study, the kids were not balanced by breed. This is a limitation of our study. Furthermore, to our knowledge, an appropriate dose of dexmedetomidine hydrochloride have not been described for goats hence a higher dose might have been used in this study.

In conclusion, intramuscularly injected dexmedetomidine hydrochloride prevented disbudding pain in goat kids. No observable complications were recorded during or after the study. Sedation with dexmedetomidine prior to disbudding can improve kid's welfare. However, investigations are required to determine an appropriate range of doses for disbudding goat kids.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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