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Intraruminal Fluid Administration to Goats: Effects of Handling and Fluid Temperature

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[1]Department of Physiology, College of Veterinary Medicine, Helsinki, Finland, [2]Department of Animal Physiology, Swedish University of Agricultural Sciences, Uppsala, Sweden, and [3]Department of Pharmacology and Toxicology, University of Kuopio, Kuopio, Finland.

Eriksson, L., E. Hydbring, L. Tuomisto, E. MacDonald, U.-M. Kokkonen, and K. Olsson: Intraruminal fluid administration to goats: effects of handling and fluid temperature. Acta vet. scand. 1994, 35, 289-298. – Physiological stress response to intraruminal fluid administration was studied in 5 female goats. The fluid was given through a stomach tube. The water was cold (10°C) or warm (38°C) and in an amount of 7.5-10% of body weight. Plasma concentrations of adrenaline, noradrenaline and cortisol increased significantly after both treatments. Adrenaline and noradrenaline responses were greater and more longlasting after cold water administration, but there was no difference in cortisol response between cold and warm water. Haematocrit and plasma protein concentrations increased also and the effects of cold water lasted longer. Blood pressure showed a sharp rise of short duration and was independent of water temperature. The immediate tachycardic response was similar with both treatments, but cold water caused an additional peak 15 min later. The cooling did not increase plasma histamine level.

The results suggest that stomach intubation and administration of water into the rumen leads to strong activation of hormonal and cardiovascular stress parameters even in goats well adapted to handling. Low temperature of the fluid further heightens the effect. Warming of fluids to near body temperature before their administration is thus recommended.

stress; stomach tube; cold; adrenaline; noradrenaline; cortisol; histamine; haematocrit; blood pressure; heart rate.

Introduction

Peroral administration of fluid and medicine by stomach tube is a frequently used treatment in ruminants (*Roussel* 1990). The voluminous forestomachs of adult ruminants make it possible to give great amounts of fluid per os (up to 20 % of body weight) without risk for water intoxication (*Andersson & McCann* 1955, *Olsson* 1969). The degree of stress reactions during such procedures have been difficult to measure and evaluate (*Barnett & Hemsworth* 1990, *Rushen* 1991, *Henry* 1993). Therefore we were interested in studying the extent to which restraint combined with administration of fluid are stressful in goats. If large amounts of fluid are given into the central part of body, the temperature of the fluid can affect organs near the reticulorumen. Possible additive effects of fluid temperature were tested by giving cold or body warm water to the same goats. As indicators of physiological stress responses we measured adrenaline, noradrenaline, cortisol, haematocrit, plasma protein concentration, arterial blood pressure and heart rate. Be-

cause cooling can cause release of histamine (*Garrison* 1990), the concentration of plasma histamine was also analysed.

Materials and methods

Animals

Five female goats, aged 5-10 years and weighing 45-63 kg, were used. The goats were not lactating or pregnant. They were kept in pens and moved to metabolism cages 1 to 7 days before the experiments. They were given 400 g hay and grain (with 3 g of NaCl added) at 7.00 and 15.30 h and water ad libitum. These experiments have been approven by the local ethical committees.

Surgery

For recordings of blood pressure one of the carotid arteries was exteriorized subcutaneously on the neck of two of the goats 4 weeks before the first recording, in principle as described by *Dueck et al.* (1982). Briefly, the animals were pre-medicated with atropine (0.07 mg/kg intramuscularly; Atropin^R, Kabi Pharmacia, Uppsala, Sweden) followed by an intravenous injection of acepromazine (0.4 mg/kg, Plegicil^R, Pherrovet, Malmö, Sweden) 5 min later. The goats were anaesthetised with an intravenous injection of pentobarbital (7-13 mg/kg, Mebumal vet., Pherrovet, Malmö, Sweden), which was thereafter given intermittently to maintain surgical anaesthesia. Prophylactic antibiotic treatment was given for 5 days (benzyl penicillin-procain 20 mg/kg; Penovet^R vet., Boehringer Ingelheim Agrovet, Hellerup, Denmark).

Experimental procedure

About 2h after the goat had finished its morning feed, the neck was shaved and cleaned. Under local anaesthesia (Xylocain^R, Astra, Södertälje, Sweden) a catheter (Secalon, Viggo Products, Helsingborg, Sweden) was inserted into one of the jugular veins. In 2 of the goats another catheter (Venflon, Viggo Products, Helsingborg, Sweden) was inserted through a skin incision into the carotid artery. The arterial catheter was connected to a Statham pressure transducer, and systolic/ diastolic and mean pressures were recorded on a polygraph (Grass Instruments Co., Quincy, Mass., USA). Heart rate was calculated from the systolic/diastolic tracings. To prevent clotting isotonic NaCl solution was infused continuously at a rate of 0.2 ml/min into the arterial catheter. The blood pressure recording was started at least 30min before and continued 2h after water administration. Cold water (10°C) or warm water (38°C) was given into the rumen through a stomach tube. During this procedure the goat was restrained by the experimenter, who held one arm around the neck of the goat and with the hand closed the mouth of the goat thereby preventing it from biting the tube. With the other hand the experimenter pushed the tube into the mouth and down the oesophagus into the rumen. The amount of water was 7.5-10% of the body weight (3.5-6 l), which was given in less than 2min. Two blood samples were taken before water administration and then after 2, 4, 6, 10, 15, 20, 30, 60, 90, and 120 min.

Because only 2 goats were used for the blood pressure recording, no statistical analysis of these results was possible. Every procedure was performed twice in both these goats and the mean of the two experiments was used.

Analyses

Blood was drawn into ice-chilled tubes containing K_3-EDTA and Trasylol^R (Bayer, Leverkusen, Germany) for catecholamine, cortisol and histamine analyses. For measurements of haematocrit and plasma protein concentration blood was taken into tubes containing Li-heparine. Plasma cortisol concen-

tration was determined by radioimmunoassay (Coat-A-Count, Diagnostic Products Corporation, Los Angeles, USA). Plasma levels of adrenaline and noradrenaline were analysed by HPLC-EC. Plasma (9 volumes) was precipitated with perchloric acid (20% containing 5 mM EDTA; 1 volume). An aliquot of supernatant was extracted through activated alumina prior to injection into the HPLC using the separation procedure recommended by *Mefford* (1981). The catecholamines were detected on a ESA coulometric detector using only oxidation at 0.3 V. The detection limit with this procedure was 0.1 nmol/l for both adrenaline and noradrenaline. Histamine in plasma samples was analyzed after protein precipitation with $HClO_4$ by utilizing HPLC with ion exchange separation, post column derivatization with orthophthaldialdehyde (Fluka Chemie, AG Buchs, Switzerland) and fluorescence detection (*Yamatodani et al.* 1985).

For haematocrit determinations, blood was centrifuged in capillary tubes for 5 min. Total plasma protein concentration was estimated by refractometry (AO Instrument Company, Buffalo, N.Y., USA or Atago hand Refractometer, SPR-N, Japan).

Statistics

Values are presented as means ± SE. The calculations were done using the Statistical Analysis System (SAS), procedure GLM (*SAS Institute Inc.* 1987). For testing significances within treatments the paired t-test was used. The sample immediately before water administration was used as reference value. The following statistical model was used to describe the data:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \Gamma_k + (\beta\Gamma)_{jk} + e_{ijk}$$

where Y_{ijk} is the observation ijk, μ is the mean, α_i is the effect of the individual i (i=1,2..5), β_j is the effect of treatment j (j=1,2), Γ_k is the effect of sample k (k=1,2,..12), $(\beta\Gamma)_{jk}$ is the effect of interaction between treatment and sample, e_{ijk} is the error term, e_{ijk} IND(0, σ^2).

Results

Our goats were well adapted to staying in metabolism cages and to handling. They accepted cannulations of blood vessels and blood sampling with only minor behavioural reactions. However, all goats resisted the insertion of the stomach tube into the rumen and the administration of water, and there were individual differences in the degree of resistance. After administration of cold water, the goats started to shiver within 5min and continued to do so during the rest of the experiment. Stretching of the body often occurred just before and several times during the shivering. Administration of warm water did not cause shivering or stretching of the body.

Adrenaline and noradrenaline

Basal values of the plasma catecholamine concentrations were low and stable before treatment. Both warm and cold water administration caused immediate increases in plasma noradrenaline and adrenaline (Fig. 1 a, b), which after warm water promptly returned to baseline. This rise was significantly higher after cold water, noradrenaline concentration remaining higher than after warm water for an additional 60min. Mean values of adrenaline after cold water were also at a higher level, but the difference between cold and warm water treatments reached statistical significance only at 2, 20 and 60min.

Cortisol

After warm water the rise in plasma cortisol started at once and reached significance 6min

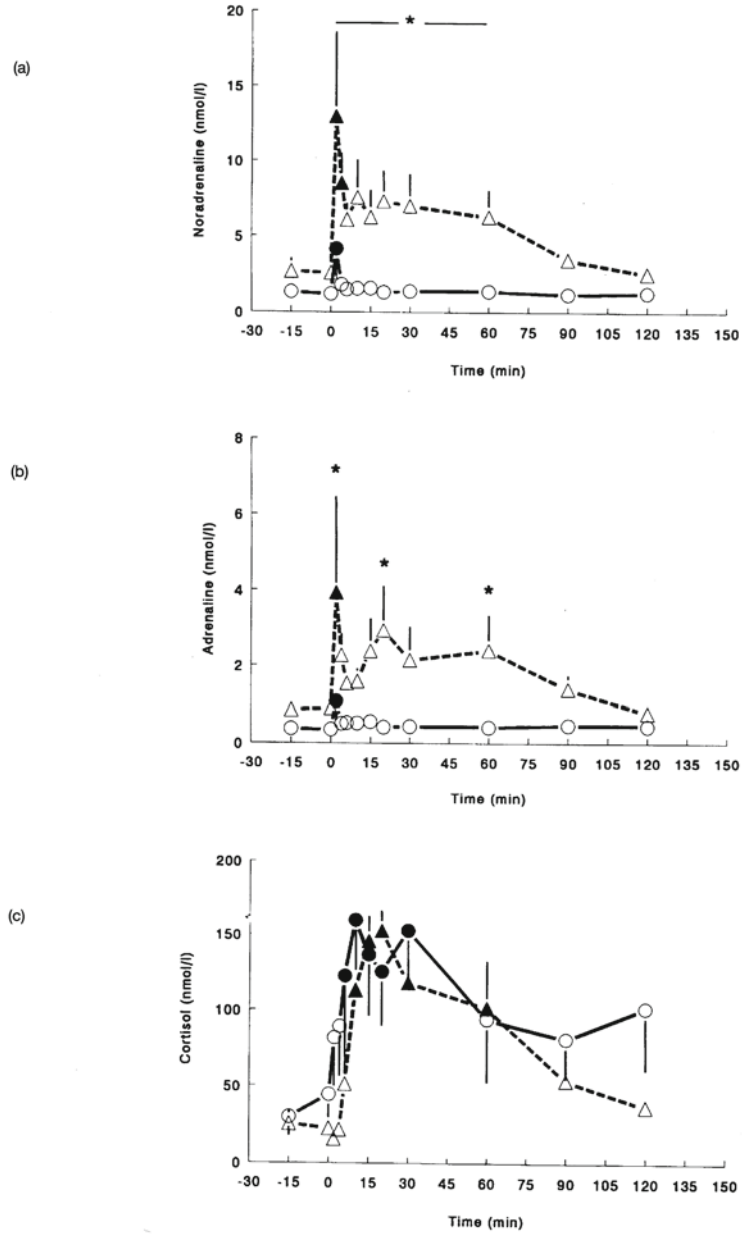

Figure 1. Plasma concentration (means±SE) of noradrenaline (a), adrenaline (b) and cortisol (c) in 5 goats given warm (circles) or cold water (triangles). Overall treatment effects were examined by analysis of variance and comparison between pre-treatment (0 min) and individual post-treatment means by paired t-test. Significant differences ($p < 0.05$) between cold and warm water treatments is shown by asterisks and within treatment with filled symbols.

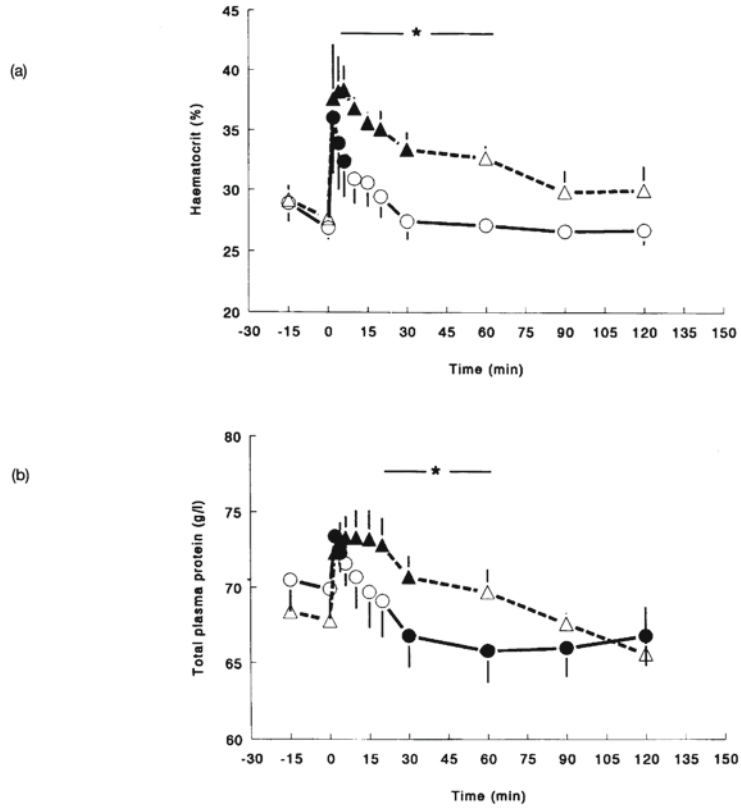

Figure 2. Haematocrit (a) and total plasma protein (b) in 5 goats given warm or cold water. Explanation of symbols and significances as in Fig. 1.

later (Fig. 1 c). The cortisol level remained elevated for 30min. Even if the concentration curves did not differ significantly between warm and cold water treatments, the rise in cortisol after the administration of cold water was obvious first after 6min and not significant until after 10min. Thereafter the concentration remained significantly elevated for 50min.

Histamine

Basal value of plasma histamine was 1.43±0.37 pmol/ml (n=4). The administration of cold water did not cause any significant changes in it.

Haematocrit and total plasma protein concentration

Both the haematocrit and the total plasma protein concentration increased immediately after the administration of water (Fig. 2 a, b). Cold water caused a larger and more longlasting increase. Warm water caused a decline in the plasma protein concentration below the initial level 30min after administration, probably due to the more rapid absorption of wa-

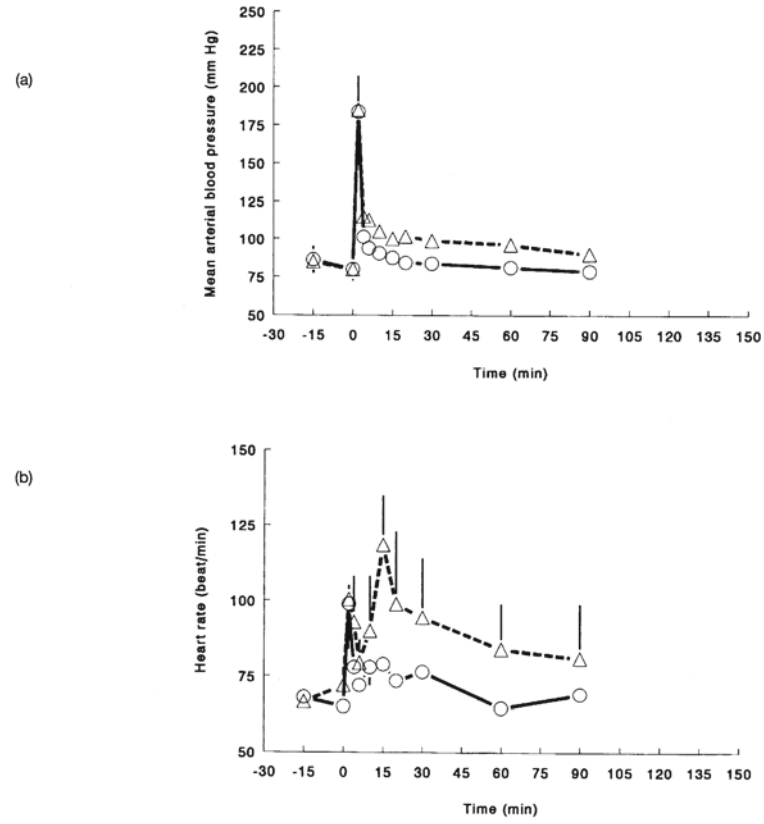

Figure 3. Mean arterial blood pressure (a) and heart rate (b) in two goats given warm or cold water. Each goat was given both treatments two times and the mean values used. Explanation of symbols as in Fig. 1.

ter at this temperature from the gastrointestinal tract.

Arterial blood pressure and heart rate

Mean arterial blood pressure showed a sharp rise of short duration during administration of water without any obvious difference between warm and cold water responses (Fig. 3 a). On the other hand, acceleration of the heart rate was more prolonged after cold water administration (Fig. 3 b). There were two peaks, one immediately and one 15min after the treatment with cold water.

Discussion

The immediate stress reaction to administration of water by stomach tube was seen in all parameters. This indicates activation of both the sympatho-adrenomedullary system and the hypothalamic-pituitary-adrenocortical system. Administration of cold water by stomach tube would be expected to be more unpleasant than warm water. This was seen in the greater rise of adrenaline and noradrenaline concentrations. That response was also more longlasting, similar to the elevations in hematocrit, plasma protein and heart rate. On the

other hand, the cortisol response was independent of water temperature.

Administration of water independently of its temperature caused immediate hormonal and circulatory activation, which indicates that restraint, introduction of stomach tube and pouring of water were stressful for the animal. In the present and previous studies the goats often had slightly higher haematocrit and plasma protein values in the first than in the second blood sample indicating some remaining arousal reaction after the catherization. It appeared, however, to be small and not detectable in plasma adrenaline, noradrenaline or cortisol levels. Even if introduction of the tube to the rumen is easy to perform, it obviously stimulates many receptors, especially in the throat and the oesophagus. Many of them are normally stimulated during swallowing securing the passage of liquid and food (*Miller* 1982). The afferent fibers have connections to nucleus tractus solitarii, and can thus affect the cardiovascular system (*Miller* 1982). The vagovagal reflex causes heart rhythm changes already during normal swallowing and especially during pharyngo-oesophagogastric manipulations. Both bradycardic and tachycardic responses, and even fatal arrhythmias can occur (*Palmer* 1976). The association of tachycardia with swallowing was found already in 1916 by *Miller & Sherrington* in the cat, and later e.g. by *Gandevia et al.* (1978) in man. In goats we have observed drinking in dehydrated goats to cause a small increase in heart rate and a marked, significant rise in blood pressure (*Olsson et al.* 1989). In our present study the immediate rise in blood pressure, heart rate and plasma noradrenaline and adrenaline concentrations both with warm and cold water administration indicates activation of the sympathetic system, which more than overcompensated for the possible bradycardic vagovagal reflex.

The haematocrit is known to increase momentarily in stress due to activation of the sympathetic system, which causes release of red blood cells from the spleen. Already in 1959 *Turner & Hodgetts* showed in sheep that the haematocrit rose by 20% due to anxiety. Acute cold exposure has been reported to increase haematocrit in sheep (*Thompson et al.* 1978). In our goats there was, in addition to the increase of haematocrit, a simultaneous, though somewhat smaller, increase in plasma protein concentration. A similar increase in plasma protein concentration has been seen in dehydrated sheep when they were allowed to drink (*Dahlborn & Holtenius* 1990). These two parameters have long been used as indirect indices of changes in plasma volume, but their correlation during the influence of vasoactive agents has recently received more attention. *Olsson et al.* (1994) found in conscious goats that infusions of the α_1-agonist, phenylephrine, caused haematocrit to rise by 16% and plasma protein concentration by 6%. Recent findings by *Kaufman* (1992) showed that the spleen may not only release a large amount of red blood cells upon stimulation by atrial natriuretic peptide, but also increase the rate of protein-poor fluid movement out of the vasculature. It remains to be shown whether a similar mechanism might explain the rise in plasma protein concentration during stress. An additional factor causing haemoconcentration could be the increased salivation due to intubation. The short duration of the increases in haematocrit and plasma protein concentration suggests, however, only a slight role for salivation.

Andersson and coworkers have in the sixties extensively studied hormonal effects of local hypothalamic cooling in the goat. (e.g. *Andersson et al.* 1963, 1967). They found a great increase in urinary catecholamine excretion, especially of adrenaline, whereas plasma cor-

tisol did not show any clear changes. Our finding of much greater and more longlasting elevation of plasma adrenaline and noradrenaline concentrations after cold water compared to warm water as well as the lack of difference in cortisol responses between cold and warm water are in agreement with their results. The activation of the sympathetic system by cold is now well documented also in other ruminant species (e.g. *Thompson et al.* 1978, *Davis et al.* 1984). Because the half-life of adrenaline and noradrenaline is short, the difference between cold and warm water effect means longlasting sympathetic activation by cold water. The profile of adrenaline concentration was very similar to that of heart rate showing first an immediate increase during introduction of the stomach tube and a second increase 15 min later due to cooling of the central parts of the body. Stimulation of β_1-receptors of the heart by adrenaline was thus obvious. In man, a dissociation between noradrenaline and adrenaline responses has been found after ingestion of water, so that, independently of water temperature, only the noradrenaline concentration increased (*Tse et al.* 1983, *Puddey et al.* 1986). Adrenaline concentration, instead, remained unchanged with warm water and even decreased with cold water (*Puddey et al.* 1986). The deglution and gastrointestinal distension were suggested to be the most likely stimuli for noradrenaline release through a sympathetic neural reflex. There are several possible reasons for the discrepance in the results between these human studies and our present studies in the goat. First, reactions in monogastric and ruminating species can differ. Secondly, giving the water by tube must be more stressful than by voluntary drinking. Thirdly, the amount of water and thus also the distension and cooling effects differed.

The goats did not show any clear changes in plasma histamine level after cooling with cold water. Histamine could thus not be the reason for release of catecholamines from the adrenal medulla. The result is in agreement with the study of *Davis et al.* (1984), where they found no changes in bovine plasma histamine after acute exposure to cold in a climatic chamber, whereas corresponding heat stress caused histamine concentration to increase in Longhorn steers. Cold stress appears thus not normally to induce release of histamine, this occurring only in some pathophysiological conditions such as in cold urticaria, whereas histamine can act as vasodilatator during heat stress (*Garrison* 1990).

Most short term physiological responses to physical and psychological stressors have their inherent limitations in interpreting animal welfare, because they are often normal adaptive reactions. However, activation of many of these systems means greater strain on the organism. It is therefore important to measure several parameters, when studying stress responses.

In conclusion, peroral administration of water by a stomach tube leads to immediate and strong activation of hormonal and cardiovascular stress parameters even in goats well accustomed to handling. Even if the cortisol response was independent of water temperature, the other responses showed, that the fluid should be given at near to body temperature. This applies not only to experimental studies but equally to animal husbandry.

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Sammanfattning

Intraruminal vätsketillförsel till get: effekter av behandling och vätskans temperatur.

Den fysiologiska stressreaktionen vid intraruminal vätsketillförsel undersöktes hos 5 hongetter genom att tillföra dem kallt (10°C) eller varmt (38°C) vatten via magsond. Vattenmängden var 7.5-10% av kroppsvikten. Plasmakoncentrationerna av adrenalin, noradrenalin och kortisol steg signifikant efter båda behandlingarna. Stegring av adrenalin- och noradrenalinkoncentrationerna var större och varade längre efter tillförsel av kallt vatten, men i kortisolkoncentrationen fanns det ingen skillnad mellan kallt och varmt vatten. Hematokrit och koncentration av plasmaprotein steg efter båda behandlingarna, men effekten av kallt vatten varade längre. Blodtrycket visade en kraftig, men kortvarig stegring och var oberoende av vattens temperatur. Den omedelbara ökningen av hjärtfrekvensen var likadan vid båda behandlingarna, men kallt vatten framkallade en ny ökning 15 min senare. Nedkylningen höjde inte histaminkoncentration i plasma.

Resultaten visar att nerförandet av magsond och vattentillförsel till våmmen leder till kraftig aktivering av hormonella och kardiovaskulära stressparametrar även i getter som är vana vid behandling. Låg temperatur av vätskan ökar effekten ytterligare. Således rekommenderas att vätskan före tillförsel uppvärms till nära kroppstemperatur.

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