Electrolyte concentrations in saliva of the goat under various conditions

NOBUHIKO KOMI AND WILLIAM H. SNYDER, JR.
Department of Surgery, Childrens Hospital of Los Angeles and University of Southern California School of Medicine, Los Angeles, California

KOMI, NOBUHIKO, AND WILLIAM H. SNYDER, JR. Electrolyte concentrations in saliva of the goat under various conditions. Am. J. Physiol. 204(6): I 055-1058. I g63.-The concentrations of sodium, potassium, and chloride in the saliva of the goat are reported for the first time. The parotid duct of several animals was cannulated with polyethylene tubing and a stable flow of saliva obtained for many weeks. Variations in the concentrations under normal living conditions (resting, ruminating, eating, and the like) are given. Certain additional conclusions appear significant. Partial obstruction of the parotid flow, minor infection of the gland, and the minor stress of strapping the animal to a table produces an immediate elevation of the chloride level with minimal alterations in the other electrolytes. The effect of major stress (abdominal operation) is a markedly lowered volume, greatly reduced concentrations of sodium and chloride, and strikingly elevated levels of potassium, over a period of several days. These alterations of function of the parotid secretions are an index of the basic metabolic changes accompanying major stress.

SINCE 1878, WHEN HEIDENHAIN (1) reported on the salt concentration of dog saliva, numerous studies have been made of the electrolyte pattern in the salivary secretions of animals. Scheunert and Trautmann (2) apparently were the first to investigate the saliva of ruminants. However, we have been unable to find any detailed analysis of the electrolytes in goat saliva. The purpose of these experiments was to determine and report on the levels of electrolytes in the saliva of the goat under physiological living conditions and under stress. Several aspects of the response of the parotid gland to major operation are detailed for the first time and the significance and mechanism of this response is discussed.

MATERIALS AND METHODS

Four adult goats were used in this study. After a 24-hr fast, the animal was given a general anesthetic and a short incision was made in the cheek near the termination of the parotid duct. The duct was exposed and transected, the distal end tied, and the proximal end cannulated with a Clay-Adams PE-205 polyethylene tubing (.087-in. o.d.). The cannula was fixed in place with a single silk tie placed around the duct. The distal end of the polyethylene tubing was tied into a narrow Penrose drain which was fastened to a collecting bottle strapped to the animal's side. Steel cannulae previously used by McDougall (3) functioned well for 3 days or less, but the polyethylene tubing used in these experiments caused little or no reaction, remained open, and functioned normally for 3-4 weeks or more. In two goats we cannulated the opposite parotid after the first cannula began to work poorly. These second cannulae have continued to function normally. The method used in these studies appears to be satisfactory for several weeks, although a permanent type of fistula as described by Denuit (5) is necessary for more prolonged studies.

After the animals recovered from the anesthetic they were fed alfalfa hay and oats, and given access to rock salt and water at all times except during preoperative fasting.

The animals were sufficiently docile so that they tolerated the cannula well and rarely disturbed it in any way. Specimens could be obtained for analysis at any time during short or long periods of study. The volume secreted over any given period of time was easily collected and measured. Specimens were examined for sodium, potassium, and chloride levels. The sodium and potassium levels were determined on the model KY Baird flame photometer and chlorides were determined on the Buchler-Cotlove chloridometer.

RESULTS

1) In Table 1 are recorded the levels of the electrolytes in goats' saliva and serum during resting and ruminating under physiological conditions. We considered physiological conditions to exist when the catheter had been functioning normally for 10 days or more; when the
diet contained adequate salt; when the animal was well
and under no stress; and when the parotid gland or
duct was not infected or obstructed.

2) Changes in electrolyte concentrations during the
first 20 days following cannulation of the parotid duct
are recorded in Fig. 1. This figure is illustrative of the
results obtained in four other similar experiments in
different animals. Saliva was collected at 2-day intervals
for 1 hr at a time and at the same time each day, during
periods of resting and ruminating. At the end of the
hour the goat was fed oats for 5 min and a second
specimen obtained. Electrolyte concentrations and
volumes were determined in each of the specimens for
the day and compared.

3) Changes in electrolyte concentrations and volume
of saliva from the mildly infected parotid gland are
indicated in Fig. 2. The cannula had been functioning
normally for 49 days after cannulation. Eight-hour
specimens of saliva were obtained each day and the
volume and electrolyte concentrations recorded. On
the 51st day, a mild infection occurred as evidenced by
the thickened and opaque secretions. The infection
cleared spontaneously on the 58th day.

In two additional experiments the cannula was
partially blocked over a 2-day period. This also produced
marked elevation of chlorides and a lowered volume
but little change in sodium and potassium.

In four experiments in which the animal simply was
restrained by being strapped to the table over a 1-hr
period there was a consistent rise in chlorides, diminution
of volume, and, in this instance a moderate sustained
rise in the sodium.

4) The effect of a major abdominal operation on
volume and electrolyte concentrations of saliva is shown
in Fig. 3 and is similar to results obtained in two addi-
tional experiments on other animals. The cannula had
been functioning normally for 1 month. The animal
was prepared and a major abdominal operation (liga-
tion of the pancreatic duct) performed. Twenty-four-
hour specimens of saliva were obtained each day and
the volume and electrolyte concentrations recorded.

DISCUSSION

This study has shown that goat saliva can be collected
for a period of weeks using a simple method of can-
nulating the parotid duct. The determinations of elec-
trolyte levels are of interest since we could find no pre-
vious electrolyte determinations for the saliva of this
animal. The electrolyte levels in goats' saliva were in-
fluenced by many factors. Not only did major stress
cause significant changes, but such relatively minor
incidents as mild infection of the parotid gland, partial
obstruction of the excretory passage, and restraint of
the animal also produced volume and electrolyte
changes.

As indicated in Table 1, levels of sodium in the
saliva are slightly higher during resting than during
ruminating, whereas potassium levels are somewhat
ELECTROLYTE CONCENTRATIONS IN SALIVA

lower during resting than during ruminating. These levels are very close to those reported by McDougall (3) in the sheep.

As seen in Fig. 1, the eating of oats caused greatly increased volume and the electrolyte levels showed a lower sodium and higher potassium content than during resting or ruminating. The chloride levels, however, were variable. In these experiments, the electrolyte concentrations in saliva were altered for the first 10 days following cannulation; however, they became stabilized at the end of this time.

Figure 2 indicates that minor infection of the parotid gland will cause marked elevation of the chloride level, decrease in volume, and little change in potassium and sodium levels. A similar reaction was observed under conditions of temporary obstruction of the parotid fistula and during restraint of the animal.

The response of the parotid gland to major trauma, in this case a major abdominal operation, is one of almost complete suppression of saliva, as shown in Fig. 3. This is most marked on the 1st and 2nd days postoperatively but persists for 3 days despite the fact that the goat had begun to eat and drink again. The depression in salivary output was noted in human subjects after major trauma by Howard (6) in 1955. He found that the volume of saliva was reduced over 400% in the first 2 or 3 days. Previous experimental investigations by Gesell (7) and Gregersen and Ingalls (8) demonstrated that occlusion of the carotid artery or the loss of 500 ml of blood resulted in a diminished volume. Howard explained his findings, at least partially, on this basis. However, in our experiments it would appear that the salivary depression is too profound and too prolonged to be explained on a simple blood loss basis.

Our experiments indicate, in addition to the drop in output, a major shift in the electrolyte concentration, namely the sodium is depressed, as is the chloride ion whereas the concentration of potassium in saliva was remarkably high. Sodium falls from 170 to 30 mEq/liter and the potassium rises from 6 to 40 mEq/liter on the 1st day after surgery. These changes persist for 3 or 4 days before the ionic concentration returns to the pre-operative level.

The flow of saliva showed some interesting variations. It has been demonstrated by Coats and Wright (9) that electrical stimulation of the parotid gland in sheep produced not only marked increase in flow but also marked increase in the sodium level. Many other studies, both in animals and in man have indicated that
this is the common relationship. Denton (4) found no change in sodium concentration in the saliva of sheep with changing volume. We found that eating caused a flow rate 5–10 times higher than during resting with slight but consistent lowering of the sodium concentration.

The effect of major trauma on the salivary gland is strikingly similar to its effect on the kidney. If an antidiuretic hormone from the pituitary is responsible for the diminished urinary volume after trauma, it might be reasonably argued that an “antisalivary” hormone is responsible for the diminished volume from the parotid.

REFERENCES

The administration of cortisone produces a diminished output of sodium but allows for excretion of potassium from the kidney and it is interesting to observe that corticoids have a similar effect on saliva (10, 11).

Our graph of these ionic changes following trauma is strikingly similar to that of Denton (4) which shows the effect of dietary sodium deprivation on the saliva of the sheep, except for two facts: Denton’s studies showed the effect to be gradual over several days, and the chloride ion did not take part in the change. In our experiments, the reverse of the Na/K ratio was abrupt and the chloride changes were marked.