Short Communication


Electrical Activity in Isolated Human Tracheal Muscle

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Summary Isolated strips of the human tracheal muscle had slow fluctuations of membrane potential (slow wave), essentially similar to those of guinea-pig trachea. The average amplitude and frequency of slow wave were 7.7 mV and 19.9/min (n = 9), respectively. There was clear correlation between the electrical activity and mechanical response during the excitation caused by tetraethylammonium (TEA), carbachol, and noradrenaline and also during the inhibition by isoprenaline. The slow wave seems to be related to the basal muscle tone, which is probably maintained by endogenous leukotrienes in human and by prostaglandins in guinea-pig.

Key words: human trachea, slow wave, smooth muscle.

Isolated preparations of canine and bovine tracheal smooth muscles have neither active muscle tone nor spontaneous electrical activity under the normal condition (KIRKPATRICK, 1981). On the other hand, in the guinea-pig tracheal muscle, a large active muscle tone and spontaneous fluctuations of membrane potential (slow waves) have been observed (SMALL, 1982; HONDA et al., 1986). Since the human tracheal and bronchial muscles are known to have active tension (BRINK et al., 1980; HUTAS et al., 1981; DAVIS, 1982; ITO et al., 1985), it is interesting to examine whether or not this is associated with the electrical activity, as in the guinea-pig.

We have measured the membrane potential of the human tracheal muscle with intracellular microelectrodes, simultaneously with the tension response using a strain gauge. The preparations were obtained from 5 autopsies (51–73 years old) performed within 2 h after death. At the hospital the tissues were placed in ice-cold normal saline and then transported to the laboratory within 1 h. Small muscle strips (about 1.5 mm in diameter and 7 mm in length) were isolated from the low part (between the 8th and 3rd cartilaginous rings from the bifurcation) of the trachea. The preparations were equilibrated in normal saline for at least 1 h before starting the experiments. The normal solution had the following composition (mM): NaCl

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127, KHCO$_3$ 5.9, CaCl$_2$ 2.4, MgCl$_2$ 1.2, glucose 1.8, and Tris buffer 10 (pH being adjusted to 7.4 at 35°C). In some experiments, the guinea-pig trachea preparations were also used, and this method was the same as previously described (HONDA et al., 1986). The experiments were carried out at 35°C.

The human tracheal muscle has spontaneous electrical activity (slow waves), as observed in the guinea-pig tracheal muscle. The pattern of slow wave varied in different preparations, but a regular sinusoidal activity was most frequently observed. In some preparations, there was periodical modulation of amplitude. The amplitude and frequency of slow wave were $7.7 \pm 3.4$ mV and $19.7 \pm 5.5$/min (the mean $\pm$ S.D.) when measured from 9 preparations obtained from 5 cadavers. The amplitude was smaller and frequency was lower than those in the guinea-pig (HONDA et al., 1986). The smaller amplitude may be related to a low membrane potential (about $-45$ mV) in the human compared with that in the guinea-pig tracheal muscle (about $-50$ mV).

Figure 1 shows effects of indomethacin (5 $\mu$M) on the slow wave in the human and guinea-pig tracheal muscles. In human, indomethacin increased muscle tone slightly and this was accompanied with an increase in frequency and a small depolarization of the membrane. On the other hand, in the guinea-pig, in-
domethacin produced relaxation and slowly abolished the slow wave, without a significant change in the highest level of membrane potential. The difference between human and guinea-pig muscles is probably due to the fact that in the human an intrinsic production of leukotriene is responsible for the muscle tone and in the guinea-pig prostaglandins are involved in the active basal tone (ITO et al., 1985).

Effects of several drugs were examined in the human tracheal muscles, and some examples are shown in Fig. 2; tetraethylammonium (TEA) and carbachol produced depolarization of the membrane and increased the amplitude and frequency of slow waves. These effects on electrical and mechanical activities were
essentially similar to those observed in the guinea-pig (Foster et al., 1983; Ahmed et al., 1984). Noradrenaline (1 µM) had excitatory effects mediated through α-adrenoceptors, because this was reversed to inhibition by phentolamine (1 µM). In the guinea-pig, noradrenaline suppressed the slow wave and relaxed the preparations (Honda et al., 1986). Although the excitatory effect of noradrenaline was observed in the human preparations examined, it is quite possible that the response is dependent on age and other factors, such as the basal tone.

There was a good correlation between the electrical and mechanical activity also in the inhibitory action of isoprenaline. Isoprenaline decreased the frequency of slow waves at low concentrations and abolished the slow wave at high concentrations, as observed in the guinea-pig (Allen et al., 1985; Honda et al., 1986). The degree of hyperpolarization caused by isoprenaline varied in different preparations; and in some preparations the slow wave amplitude was increased during small hyperpolarization of the membrane caused by low concentrations of isoprenaline, as shown in Fig. 2d. These results suggest that the mechanical response and electrical activity are causally related in the human tracheal muscle, as in the guinea-pig.

REFERENCES


