CONTROL AND CANCEROUS TISSUES OF HUMAN STOMACH, SMALL INTESTINE AND LARGE INTESTINE - THE AVERAGE CONTENT OF SODIUM AND POTASSIUM

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ABSTRACT

Sodium and potassium regulate the total amount of water in the body and the transmission of sodium into and out of individual cells also plays a role in critical body functions. The movement of sodium is critical in generation of these electrical signals. Research was conducted on samples taken from women and men aged 20-90 years, derived from the stomach, small intestine and large intestine. Samples were dried at 80°C for 24 hours, and then increased temperature to 105°C and dried for seven days until dry mass was obtained. All dry material of each sample was weighted and placed in a separate mineralization tubes and mixed with 1 cm³ of 65% HNO₃ and heated at 105°C for 120 minutes in a thermostat-controlled digestion block, VELP Scientifica DK 20. Metals such as sodium and potassium were detected using FAAS method. The average content of sodium in patients diagnosed with stomach cancer is lower, than in healthy person. Indicate higher mean content of sodium in the control tissues of stomach (2151,730 µg•g⁻¹ d.m.), compared to a sodium content in tissues adjacent to the tumor (1813,958 µg•g⁻¹ d.m.) and tumor tissues (2029,442 µg•g⁻¹ d.m.). In the case of colon, control tissues have lower average content of sodium (2160,886 µg•g⁻¹ d.m.), than the tissues surrounding the tumor (3325,963 µg•g⁻¹ d.m.) and tumor tissues (3037,121 µg•g⁻¹ d.m.). The potassium level is higher in the control tissues of stomach (1428,993 µg•g⁻¹ d.m.), than in the tissues adjacent to the tumor (1091,544 µg•g⁻¹ d.m.) and tumor tissues (1220,471 µg•g⁻¹ d.m.). In the large intestine higher average content of potassium is characterized by tumor tissues (2807,234 µg•g⁻¹ d.m.) and tissues adjacent to the tumor (1712,779 µg•g⁻¹ d.m.), than control tissue (1389,703 µg•g⁻¹ d.m.). Comparing this relationship with data on potassium channels, it can be assumed that in the some case of malignant transformation in the colon, potassium channels also play a big role.

Keywords: stomach, small intestine, large intestine, sodium, potassium, cancerous tissues

INTRODUCTION

Sodium is the major positive ion (cation) in fluid outside of cells. Excess sodium (such as that obtained from dietary sources) is excreted in the urine. Sodium regulates the total amount of water in the body and the transmission of sodium into and out of individual cells also plays a role in critical body functions. Many processes in the body, especially in the brain, nervous system, and muscles, require electrical signals for communication. The movement of sodium is critical in generation of these electrical signals. Therefore, too much or too little sodium can cause cells to malfunction, and extremes in the blood sodium levels (too much or too little) can be fatal. Potassium is the major positive ion (cation) found inside of cells. The proper level of potassium is essential for normal cell function. Among the many functions of potassium in the body are regulation of the heartbeat and the function of the muscles. A seriously abnormal increase in potassium (hyperkalemia) or decrease in potassium (hypokalemia) can profoundly affect the nervous system and increases the chance of irregular heartbeats (arrhythmias), which, when extreme, can be fatal. Potassium is sometimes depleted in diseases of the intestine in which diarrhoea is a prominent symptom, such as idiopathic steatorrhoea [Libran and Mcallen, 1951] and ulcerative colitis [Posey and Bargen, 1950]. Occasionally abnormal quantities of mucus are present in the stools in these conditions. It may occur in patients with villous tumours of the large bowel and is then almost always associated with chronic watery diarrhoea and excessive loss of mucus [Southwood, 1962]. In most reports of this complication, sodium depletion and dehydration accompany the hypokalaemia. The stools and watery mucus, in some cases exceeding several litres daily, contain 103 to 158 meq of sodium and 15 to 80 meq of potassium per litre [Shnitka et al., 1961]. Southwood [1962] and Duthie and Arwell [1963] drew attention to wide variations in the concentrations of potassium encountered in rectal discharges containing mucus, in contrast to a narrower range for sodium. Roy and Ellis [1959] and Cooling and Marrack [1957] considered that the villous tumours actively secrete potassium, but Shnitka et al. [1961] and Rowe [1964] regarded the excessive loss from the surface of the tumours of mucus, rich in both sodium and potassium, sufficient to account for the electrolyte depletion. The study of mucus from the large bowel is hampered in many instances by difficulties in freeing samples from faeces or blood, while owing to dilution, the electrolyte concentrations found in material recovered from the rectal discharges of patients with villous tumours may not represent those present at the time of secretion.

MATERIAL AND METHODS

Research was conducted on samples taken from women and men aged 20-90 years, derived from the stomach (control tissues n=24 samples, tissues away from the tumor n=18 samples), tissues adjacent to the tumor n=18 samples, small intestine (control tissues n=24 samples) and large intestine (control tissues n=25 samples, tissues away from the tumor n=138 samples, tissues adjacent to the tumor n=138 samples, tumor tissues n=138 samples). Samples were dried at 80°C for 24 hours, and then increased temperature to 105°C and dried for seven days until dry mass was obtained. All dry material of each sample was weighted and placed in a separate mineralization tubes and mixed with 1 cm³ of 65% HNO₃ and heated at 105°C for 120 minutes in a thermostat-controlled digestion block, VELP Scientifica DK 20. After cooling the samples were filled to the volume of 10 cm³ with demineralized water. Metals such as sodium and potassium were detected using FAAS method, using a spectrophotometer BUCK 200A Cole-Parmer Company. All results were expressed in micrograms per gram of dry mass of the tissue (µg•g⁻¹ d.m.).

RESULTS AND DISCUSSION

In the stomach tissues occurs Na-K-ATPase [Kobayashi et al., 2003] responsible for the transport of sodium and potassium. The level of sodium in the stomach tissues is 2151,730 µg•g⁻¹ d.m., while Głogowska [2012] think, that in the
stomach is concentrated average 1786,461 µg•g⁻¹d.m. sodium [Głogowska, 2012]. Some Na⁺ ions diffuse into the inside or outside of the small intestine, depending on the concentration gradient. They are actively absorbed by the small intestine, because the cell membrane from the lateral-basal part comprises sodium-potassium pump (Na⁺-K⁺-ATPase), so that Na⁺ ions are involved in the absorption of glucose, amino acids and some other substances [Lachowicz, 1994]. Mucosa of the healthy small intestine content average 2333,614 µg•g⁻¹d.m. sodium (according to other sources 1935,298 µg•g⁻¹d.m.) [Głogowska, 2012]. In the colonic epithelium, sodium channels are usually the factor limiting sodium absorption [Bergann et al., 2009], but its level in the large intestine is 2160,886 µg•g⁻¹d.m., and according to recent studies 2031,142 µg•g⁻¹d.m. [Głogowska, 2012]. Na⁺ ion is actively absorbed by the large intestine, because the cell membrane from the intestinal lumen, is permeable to sodium ions [Lachowicz, 1994]. The average content of sodium in patients diagnosed with stomach cancer is lower, than in healthy person (Fig. 1). Indicate higher mean content of sodium in the control tissues of stomach (2151,730 µg•g⁻¹d.m.), compared to a sodium content in tissues adjacent to the tumor (1813,958 µg•g⁻¹d.m.) and tumor tissues (2029,442 µg•g⁻¹d.m.).

![Graph showing the average content of sodium in human stomach and intestine](image)

**Figure 1** The average content of sodium in human stomach

Studies Stawarz et al. [2011] showed, that in control tissues of stomach is much less of sodium (1786,461 µg•g⁻¹d.m.), than in the tissues adjacent to the tumor (2160,886 µg•g⁻¹d.m.) and in tumor tissues (1935,298 µg•g⁻¹d.m.) [Stawarz et al., 2011]. In the case of colon, control tissues have lower average content of sodium (2031,142 µg•g⁻¹d.m.), than the tissues surrounding the tumor (3325,963 µg•g⁻¹d.m.) and tumor tissues (3037,121 µg•g⁻¹d.m.) (Fot. 2), but research of Stawarz et al. [2011] indicate, that this regularity is reversed, because control tissues have the highest content of sodium (2151,730 µg•g⁻¹d.m.), while the tissues adjacent to the tumor (1424,894 µg•g⁻¹d.m.) and tumor tissues (1180,736 µg•g⁻¹d.m.) have a much lower content of this element [Stawarz et al., 2011]. This fact evidence of a protective influence of sodium in the process of carcinogenesis, and researchers hope bind mainly to the sodium selenite and sodium butyrate. Sodium selenite (Se) inhibits the growth and proliferation of colon carcinoma. The absence of p53 protein in malignant colon cancer, reducing its sensitivity to oxidative stress and DNA damage, which are derived presumably from Se, but don’t provide complete resistance to sodium selenite - induced cell cycle inhibition [Králová et al., 2009]. It was also showed the inhibitory effect of sodium butyrate, which gives opportunities for the development of new therapies aimed to preventing metastasis of colon adenocarcinoma [Dang et al., 1995].

![Graph showing the average content of sodium in human small and large intestine](image)

**Figure 2** The average content of sodium in human small and large intestine

The organ with the highest potassium content (1428,993 µg•g⁻¹d.m.) proved be the stomach. Głogowska [2012] argues that the stomach contained average 3009,798 µg•g⁻¹d.m. potassium [Głogowska, 2012]. In the upper part of the small intestine content of potassium, especially gastrointestinal origin, is higher than in the serum, which contributes to the absorption. Healthy mucosa of the small intestine contains 1330,176 µg•g⁻¹d.m. potassium, and according to other sources even 1661,282 µg•g⁻¹d.m. [Głogowska, 2012]. In the ileum potassium is secreted into the lumen through sodium absorption [Konturek, 1990]. Accumulation of potassium ions in the colon is equalized to some extent by HK-ATPase in the plasma membrane facing the light of the colon in the final part of the small intestine. Consequently there is an active transport of K⁺ ions into the cells of the mucous membranes [Lachowicz, 1994], where the potassium content is 1389,703 µg•g⁻¹d.m. Higher value (3002,031 µg•g⁻¹d.m.) obtained in their studies Głogowska [2012]. The potassium level is higher in the control tissues of stomach (1428,993 µg•g⁻¹d.m.), than in the tissues adjacent to the tumor (1091,544 µg•g⁻¹d.m.) and tumor tissues (1220,471 µg•g⁻¹d.m.) (Fot. 3).
The potassium channels (KCh) are the most ubiquitous class of ion channels. Some data suggests that the KCh are important in the development of the cell cycle, and cells require KCh to share. In this way, the potassium channels have been found to play a huge role. On the other hand are works, where it was found that control tissues of the colon have the highest potassium content (3002,031 $\mu$g•g$^{-1}$d.m.), and the tissues surrounding the tumor (2330,783 $\mu$g•g$^{-1}$d.m.) have much less of this element [Stawarz et al., 2011]. Especially, potassium channel called VGKCs, overexpressed in tumor tissues in cancer therapy. When comparing this relationship with data on potassium channels, it can be assumed that in the case of malignant transformation in the colon, potassium channels also play a big role. On the other hand are works, where it was found, that control tissues of the colon have the highest potassium content (3002,031 $\mu$g•g$^{-1}$d.m.), and the tissues surrounding the tumor (2330,783 $\mu$g•g$^{-1}$d.m.) and tumor tissues (1208,651 $\mu$g•g$^{-1}$d.m.) have much less of this element [Stawarz et al., 2011].

**The same opinion is** Bhuloka [2003] and Stawarz et al. [2011], who argue that stomach control tissues contain 3009,798 $\mu$g•g$^{-1}$d.m. potassium, tissues surrounding the tumor 1167,931 $\mu$g•g$^{-1}$d.m. potassium, and tumor tissues 1264,745 $\mu$g•g$^{-1}$d.m. potassium [Stawarz et al., 2011]. Obtained results may be related with the presence of potassium channels in cells of the stomach. Potassium channels (KCh) are the most ubiquitous class of ion channels. Some data suggests that the KCh are important in the development of the cell cycle, and cells require KCh to share. In this way, the potassium channels have been detected in several tumors and cancer cells. Potassium channels not fully cause the cancer, but are involved in the progression and pathology [Felipe et al., 2006]. Especially, potassium channel called VGKCs, overexpressed in tumor cells [Pardo et al., 2005]. There is also evidence for the existence of an interesting relationship between potassium channels and developing gastric cancer. The cancer occurs frequently and this is disclosed through Eag1 potassium channel, that plays an important role in the propagation of gastric cancer cells [Ding et al., 2007]. In the large intestine higher average content of potassium is characterized by tumor tissues (2307,234 $\mu$g•g$^{-1}$d.m.) and tissues adjacent to the tumor (1712,779 $\mu$g•g$^{-1}$d.m.), than control tissue (1389,703 $\mu$g•g$^{-1}$d.m.) (Fot. 4). Comparing this relationship with data on potassium channels, it can be assumed that in the case of malignant transformation in the colon, potassium channels also play a big role. On the other hand are works, where it was found, that control tissues of the colon have the highest potassium content (3002,031 $\mu$g•g$^{-1}$d.m.), and the tissues surrounding the tumor (2330,783 $\mu$g•g$^{-1}$d.m.) and tumor tissues (1208,651 $\mu$g•g$^{-1}$d.m.) have much less of this element [Stawarz et al., 2011].

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