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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 80ºC for 24 hours, and then increased temperature to 105ºC 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 cm^3 of 65% HNO_3 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 $\mu g \cdot g^{-1}$d.m.), compared to a sodium content in tissues adjacent to the tumor (1813,958 $\mu g \cdot g^{-1}$d.m.) and tumor tissues (2029,442 $\mu g \cdot g^{-1}$d.m.). In the case of colon, control tissues have lower average content of sodium (2160,886 $\mu g \cdot g^{-1}$d.m.), than the tissues surrounding the tumor (3325,963 $\mu g \cdot g^{-1}$d.m.) and tumor tissues (3037,121 $\mu g \cdot g^{-1}$d.m.). The potassium level is higher in the control tissues of stomach (1428,993 $\mu g \cdot g^{-1}$d.m.), than in the tissues adjacent to the tumor (1091,544 $\mu g \cdot g^{-1}$d.m.) and tumor tissues (1220,471 $\mu g \cdot g^{-1}$d.m.). In the large intestine higher average content of potassium is characterized by tumor tissues (2307,234 $\mu g \cdot g^{-1}$d.m.) and tissues adjacent to the tumor (1712,779 $\mu g \cdot g^{-1}$d.m.), than control tissue (1389,703 $\mu g \cdot g^{-1}$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 [Lubran 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 Atwell [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, tumor tissues 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 80ºC for 24 hours, and then increased temperature to 105ºC 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 cm^3 of 65% HNO_3 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 cm^3 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 ($\mu g \cdot g^{-1}$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 $\mu g \cdot g^{-1}$d.m., while Głogowska [2012] think, that in the stomach is concentrated average 1786,461 μg•g^{-1}d.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 latero-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^{-1}d.m. sodium (according to other sources 19354,298 μg•g^{-1}d.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^{-1}d.m., and according to recent studies 2031,142 μg•g^{-1}d.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^{-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.).

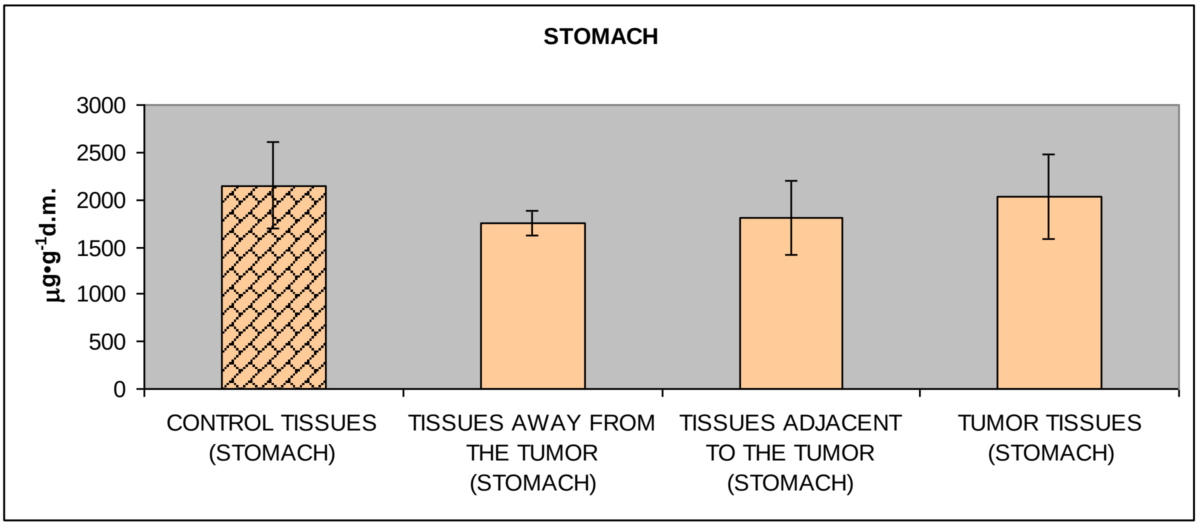

Figure 1 The average content of sodium in human stomach

Studies Stawarz et al. [2011] showed, that in control tissues of stomach is much less of sodium (1786,461 μg•g^{-1}d.m.), than in the tissues adjacent to the tumor (2012,869 μg•g^{-1}d.m.) and in tumor tissues (843,756 μg•g^{-1}d.m.) [Stawarz et al., 2011]. 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.) (Fot. 2), but research of Stawarz et al. [2011] indicate, that this regularity is reversed, because control tissues have the highest content of sodium (2031,142 μg•g^{-1}d.m.), while the tissues adjacent to the tumor (1424,894 μg•g^{-1}d.m.) and tumor tissues (1180,736 μg•g^{-1}d.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].

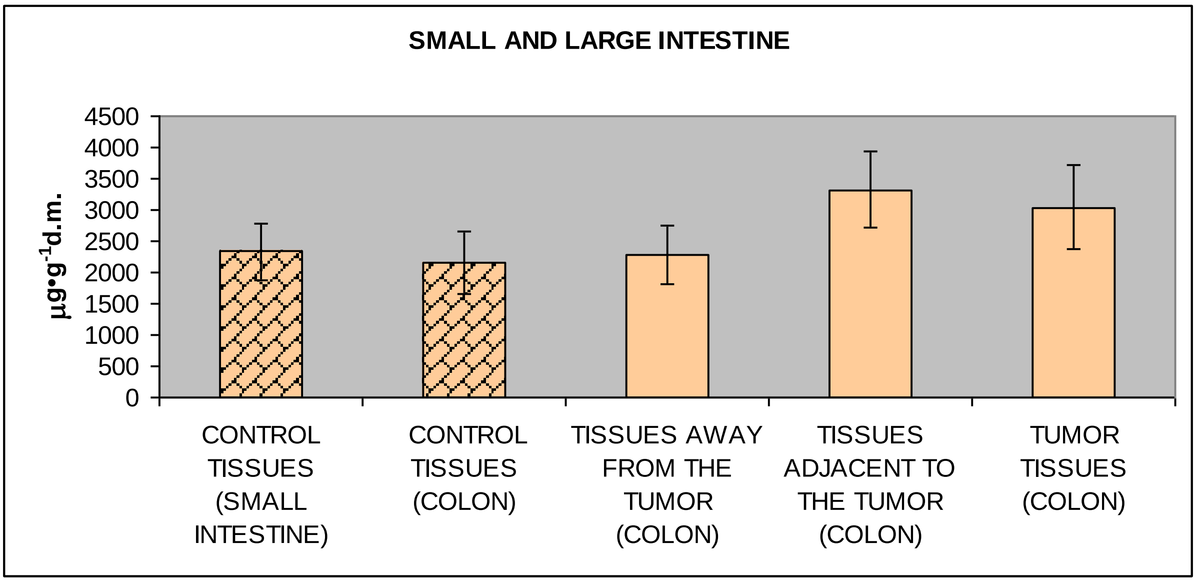

Figure 2 The average content of sodium in human small and large intestine

The organ with the highest potassium content (1428,993 μg•g^{-1}d.m.) proved be the stomach. Głogowska [2012] argues that the stomach contained average 3009,798 μg•g^{-1}d.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^{-1}d.m. potassium, and according to other sources even 1661,282 μg•g^{-1}d.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^{-1}d.m. Higher value (3002,031 μg•g^{-1}d.m.) obtained in their studies Głogowska [2012]. 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.) (Fot. 3).

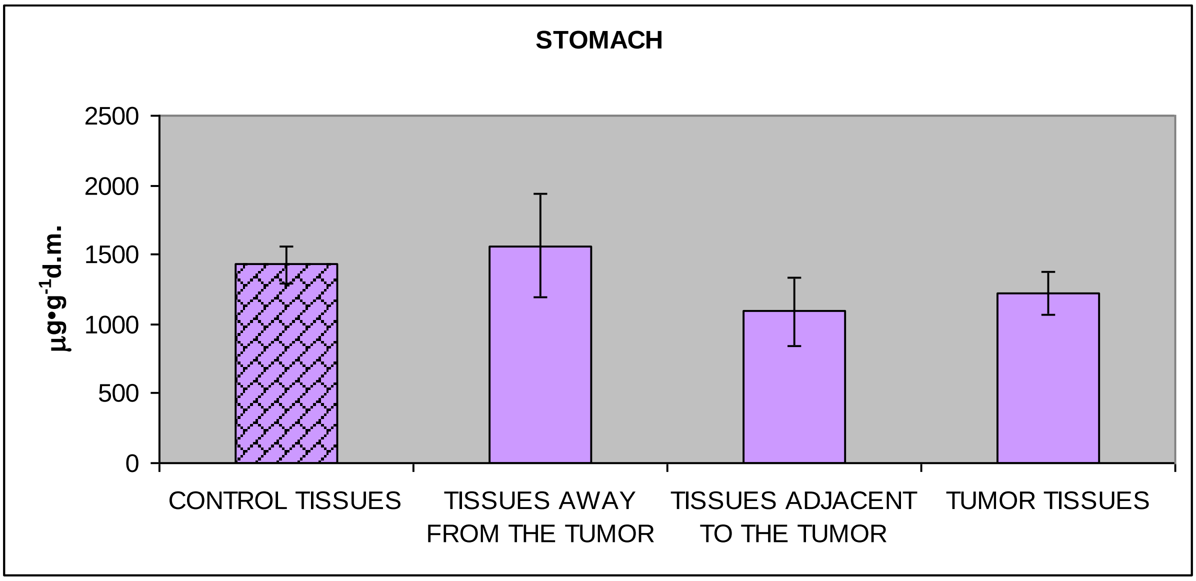

Figure 3 The average content of potassium in human stomach

The same opinion is Bhuloka [2003] and Stawarz et al. [2011], who argue that stomach control tissues contain 3009,798 µg•g^{-1}d.m. potassium, tissues surrounding the tumor 1167,931 µg•g^{-1}d.m. potassium, and tumor tissues 1264,745 µg•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 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.) (Fot. 4). 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. On the other hand are works, where it was found, that control tissues of the colon have the highest potassium content (3002,031 µg•g^{-1}d.m.), and the tissues surrounding the tumor (2330,783 µg•g^{-1}d.m.) and tumor tissues (1208,651 µg•g^{-1}d.m.) have much less of this element [Stawarz et al., 2011].

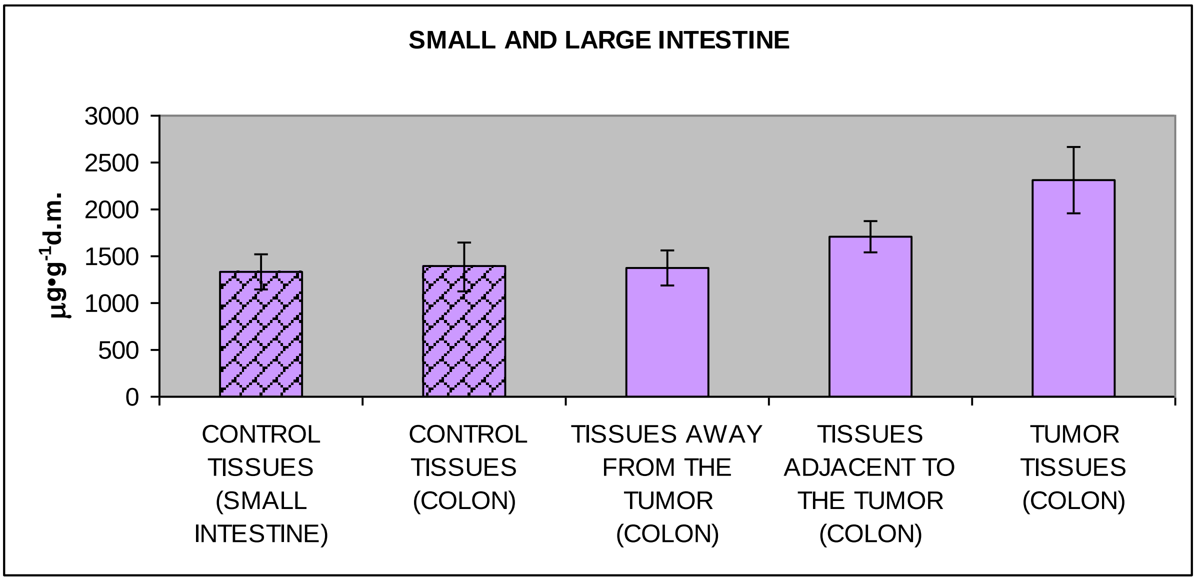

Figure 4 The average content of potassium in human small and large intestine

REFERENCES

BERGANN, T., PLÖGER, S., FROMM, A., ZEISSIG, S., BORDEN, S.A., FROMM, M., SCHULZKE, J.D. 2009. A colonic mineralocorticoid receptor cell model expressing epithelial Na+ channels. W: *Biochemical and Biophysical Research Communications*, 382, 2, 280-285 http://dx.doi.org/10.1016/j.bbrc.2009.03.006

BHULOKA, R.S., JOHN, CH.M., NAGA, R.G.J., VIJAYAN, V., SEETHARAMI, R.B., RAVI, K.M., SUNDARESWAR, B. 2003. Trace elemental analysis of carcinoma kidney and stomach by PIXE method. W: *Nuclear Instruments and Methods in Physics Research B*, 207, 345-355. http://dx.doi.org/10.1016/S0168-583X(03)00463-4

COOLONG, C., MARRACK, D. 1957. Potassium-secreting tumour of the colon. W: *Proceedings of the Royal Society of Medicine*, 50, 272-274. http://dx.doi.org/10.1016/S0140-6736(59)91669-1

DANG, J., WANG, Y., DOE, W.F. 1995. Sodium butyrate inhibits expression of urokinase and its receptor mRNAs at both transcription and post-transcription levels in colon cancer cells, 359, 147-150. http://dx.doi.org/10.1016/0014-5793(95)00029-9

DING, X., LUO, H., JIN, X., YAN, J., AI, Y. 2007. Aberrant expression of Eag 1 potassium channels in gastric cancer patients and cell lines. W: *Medicine Oncology*, 24, 345-350.

DUTHIE, H.L., ATWELL, J.D. 1963. The absorption of water, sodium, and potassium in the large intestine with particular reference to the effects of villous papillomas. W: *Gut*, 4, 373-377.http://dx.doi.org/10.1136/gut.4.4.373

FELIPE, A., VICENTE, R., VILLALONGA, N., ROURA-FERRER, M., MARTINEZ-MÁRMOL, R., SOLÉ, L., FERRERES, J.C., CONDOM, E. 2006. Potassium channels: New targets in cancer therapy. W: *Cancer Detection and Prevention*, 30, 375-385. http://dx.doi.org/10.1016/j.cdp.2006.06.002

GŁOGOWSKA, M. 2012. Zawartość sodu i potasu w komórkach ludzkiego przełyku, żołądka, jelita cienkiego i jelita grubego u pacjentów krakowskich szpitali. W: *Badania w dydaktykach nauk przyrodniczych*, 32-35.

KOBAYASHI, M. 1990. Studies on trace elements in cancerous stomach tissue of the patients with stomach cancer. W: *Hokkaido Igaku Zasshi The Hokkaido Journal Of Medical Science*, 65, 3, 320-335.
KONTUREK, S. 1990. Układ trawienny; 271-342. W: TRACZYK, W.Z., TRZEBSKI, A.: *Fizjologia człowieka z elementami fizjologii stosowanej i klinicznej*. Warszawa. Państwowy Zakład Wydawnictw Lekarskich.
KRALOVA, V., BRIGULOVA, K., CERVINKA, M., RUDOLF, E. 2009. Antiproliferative and cytotoxic effects of sodium selenite in human colon cancer cells. W: *Toxicology in Vitro*, 23, 1497-1503. http://dx.doi.org/10.1016/j.tiv.2009.07.013
LACHOWICZ, L. 1994. Czynność układu trawiennego; 565-578. W: GANONG, W.F.: *Fizjologia-podstawy fizjologii lekarskiej*. Warszawa. Wydawnictwo Lekarskie PZWL.
LUBRAN, M., McALLAN, P.M. 1951. Potassium deficiency in idiopathic steatorrhoea. W: *Ibid*., 1, 321-322.
PARDO, L.A., CONTRERAS-JURADO, C., ZIENTKOWSKA, M., ALVES, F., STÜHMER, W. 2005. Role of Voltage-gated Potassium Channels in Cancer. W: *The Journal of Membrane Biology*, 205, 115-124. http://dx.doi.org/10.1016/j.bbamem.2014.12.008
POSEY, E.L., BARGEN, J. A. 1950. Metabolic derangements in chronic ulcerative colitis. W: *Gastroenterology*, 16, 39-50.
ROWE, P.B. 1964. A mucus-secreting villous adenoma of the rectum. W: *Gut*, 5, 250-252.
ROY, A.D., ELLIS, H. 1959. Potassium-secreting tumours of the large intestine. W: *Lancet*, 1, 759-760.
SHNITKA, T.K., FRIEDMAN, M.H.W., KIDD, E.G., MacKENZIE, W.C. 1961. Villous tumours of the rectum and colon characterized by severe fluid and electrolyte loss. W: *Surery, Gynecology and Obstetric*, 112, 609-621.
SOUTHWOOD, W.F.W. 1962. Villous tumours of the large intestine: their pathogenesis, symptomatology, diagnosis and management. W: *Annals of the Royal College of Surgeons of England*, 30, 23-45.
STAWARZ, R., GŁOGOWSKA, M., KILIAN, K., GOC, Z., MASSANYI, P. 2011. Biogenic and Toxic Metals Content in Cancerous Tissues and Adjacent Normal Tissues of Digestive System of Human. W: *International Conference on Environmental Science and Technology*, 6, 9-12.