

## Effect of Vincristine and Vinblastine from Vinca Rosa on Microtubules of Tumor H22 Cell Line

Ibrahim H.Mohammed (Ph.D)

### Abstract

**Background:** Vinca alkaloids ( vincristine and vinblastine) are microtubular toxins of chemically similar nature that disrupt microtubule function by binding to a site on  $\beta$ -tubulin and suppressing microtubule dynamics.

**The aim of Study:** The study aims to evaluate biological activity of vincristine and vinblastine on microtubule hepatic H22 cell line by used GF tubulin

**Methods:** In this experiments we used the stable tumor cell line of H22 hepatic cell to investigate the action of vincristine and vinblastine onto the microtubule network.

**Results:** An experimental work was conducted to determine the biological activity of vincristine and vinblastine on microtubule hepatic H22 cell line by used GF tubulin and the recovery of its disruption. Cells were treated with Vincristine and Vinblastine at various concentrations from 20  $\mu\text{g/ml}$  to 400  $\mu\text{g/ml}$  for 60 min. Microtubules were detected by means of indirect immunofluorescence. No differences were found between the two cytostatics.

**Conclusion:** The cells showed changes in the arrangement of microtubules even at the 80  $\mu\text{g/ml}$  concentration of cytostatics after 60-min exposition. Its damage increased with increasing concentration of cytostatics

**Keywords:** Microtubule disruption, Cytoskeleton recovery, vincristine, vinblastine.

Department of Biology/ College of Science/ Diyala University /Diyala/ Iraq.

### الخلاصة

شملت الدراسة تأثير المستخلصين النباتيين الخام لنبات عين البزون وهما قلويدات الفنكرستين والفنبلاستين بتركيزات 20, 40, 80, 100, 200 مايكروغرام/مل الى 400 مايكروغرام /مل مختلفة ولمدة ساعة واحدة على النبيبات الدقيقة لخلايا الكبد الفاري السرطانية المعلمة بجين التيبولين . كذلك شملت الدراسة استعمال تراكيز عالية تصل الى 1000 و 2000 مايكروغرام /مل من القلويدتين لنبات عين البزون لمدة ساعة واحدة وقد لوحظ ان عدد الخلايا التي تأثرت بالنبيبات التي بداخلها ازدادت بازدياد التركيز المضاف وذلك باستخدام جهاز المجهر المضيئ. ان النبيبات الدقيقة قد تأثرت عند استخدام تراكيز عالية من هذا المستخلص حيث لوحظ الموت الخلوي على الخلايا كذلك تحولها الى تراكيب شبه كروية ومن ثم اضمحلالها وكذلك شملت الدراسة اخذ تركيزين من المستخلص وهما 20 مايكروغرام/مل ولفترات مختلفة 6 و 8 و 10 و 12 ساعة حضانة و 400 مايكروغرام /مل لمدة عشر دقائق وكان الغرض من الدراسة هو امكانية اعادة النبيبات الدقيقة الى حالتها الطبيعية بعد زوال المؤثر، وقد لوحظ ان النبيبات الدقيقة تعود الى حالتها الطبيعية بعد زوال تأثير المستخلصين الفنكرستين والفنبلاستين بعد فترة 12 ساعة من خلال استخدام المجهر المضيئ.

### Introduction

In eukaryotic cells the cytoskeleton is formed by three major structural elements microtubules, microfilaments, and intermediate filaments [1]. The cytoskeleton plays a specific role in cell division,

maintenance and changes of cell shape, in intracellular contacts, interaction with membranes, extracellular matrix, and in cell motions.

Microtubules are filaments with the largest diameter of all cytoskeletal components.

Microtubular network is important for the execution of many cell functions. They play an important role in cell division.

The microtubular diameter measures about 25 nm. Microtubules are composed of 13 equally spaced protofilaments [2]. Tubulin is the basic protein of the microtubules and molecules of tubulin are arranged in dimers containing both its forms:  $\alpha$ -tubulin and  $\beta$ -tubulin. Microtubules are continuously changeable structures [3] and polymerisation and depolymerisation of MTs is regulated by extracellular and intracellular factors [4]. The presence of Guanine triphosphate (GTP) at microtubule ends is necessary to maintain the stability of the polymer [5]. The cytoskeleton can be damaged through the effect of many external factors or chemical agents [5–11].

The opposite ends of free microtubules show different sensitivities to microtubule depolymerising agents such as low temperature, calcium or colchicines [12]. The mitotic spindle is a self-organising structure that is constructed primarily from microtubules. Among the most important spindle microtubules are those that bind to kinetochores and form the fibres along with chromosomes movement.

Vinca alkaloids vincristine and vinblastine are microtubular toxins of chemically similar nature [13] that disrupt microtubule function by binding to a site on  $\beta$ -tubulin and suppressing microtubule dynamics. Although they are closely related in physical and chemical properties, they have various effects on the human body.

Vinca alkaloids perturb the kinetochore-microtubule attachment. This activates a checkpoint pathway that ensures proper attachment of chromosomes to the mitotic spindle [14–16]. When microtubules fail to attach to one or more kinetochores as a result of drug treatment, the checkpoint components continue to generate signals that inhibit the metaphase/anaphase transition that

delays cell cycle progression and induces programmed cell death [17].

At higher drug concentrations, vinca alkaloids induce the assembly of spiral filaments of tubulin, which, consequently, can interact laterally and form paracrystals [18].

This action is similar to the action of colchicine, but is different from that of paclitaxel, which promotes the polymerization of tubulin polymers to form abnormal stable microtubule structures [19]. Vincristine and vinblastine have been widely used to treat cancer (e.g. acute leukaemia, Hodgkin's disease) [13].

## Materials and Methods

### Cell line

In this experiments the stable cell line of H<sub>22</sub> hepatic cell was used cell line were obtained from the Department of Biology, Faculty of Medicine, Huazhong University in Wuhan - China. The cell line were grown on uncoated coverslips in a Dulbecco's Minimal Essential Medium (DMEM) with 10 fetal bovine serum (PAA), 2  $\mu$ M glutamine (PAA), 100  $\mu$ /ml penicillin, and 100  $\mu$ g/ml streptomycin (China) [20].

### Exposure to Vincristine and Vinblastine:

The first series of experiments, to investigate the action of vincristine and Vinblastine onto the microtubule network, a solution containing 1 mg of vincristine in 1 ml of the medium or an original solution containing 5 mg of vinblastine sulfate in 5 ml of medium was mixed with 3 ml of growth medium in each of the Petri dishes so that the final concentration of vincristine, or vinblastine was 20, 40, 80, 100, 200 or 400  $\mu$ g/ml, the second series of experiment the cell cultivated with extraction 1000  $\mu$ g/ml and 2000  $\mu$ g/ml (vincristine only). Each concentration was in two dishes. The second series the cells were exposed to the drugs for 60 min at 37 °C. After the treatment, the samples were washed three times for 4

minutes concurrently with control samples in phosphate-buffered saline (PBS, pH 6.9) and processed for immunofluorescence microscopy in China.

In third experiments the cells were cultivated for, 6, 8, 10,hrs and 12 hrs with a final vincristine concentration of 20 µg/ml or for 10 minutes in a medium containing vincristine at a concentration of 400 µg/ml. The samples were washed three times for 4 minutes concurrently with control samples in PBS.

**Statistical Analysis:**

The differences are compared by using data acquired with Duncun [21].

**Results**

**Table1:** shows considerable changes in the distribution of microtubules at high concentration in 60 min and untreated control cells. Cells exposed to drugs at concentrations of 20 µg/ml and 40 µg/ml for 60 min did not show considerable changes in the distribution of microtubules. But when cells exposed to drugs at concentrations of 80 µg/ml to 400 µg/ml for 60 min there were significant differences in all other groups. The quantity of microtubules in the cytoplasm was significantly higher (P<0.05) .

**Table (1):** Effect of Vincristine at various concentrations of H<sub>22</sub> cell line in mouse considerable changes in the distribution of microtubules.

concentration µg/ml	Vanblastin		Vincristin	
	%	changes microtubules	%	changes microtubules.
control		0.00±4.20 a		0.00±4.20 a
20	13.33	0.56±0.56 f	7.14	0.11±0.30 f
40	30.09	0.11±1.60 e	26.19	0.20±1.10 e
*80	55.47	0.08±2.33 d	36.42	0.17±2.21 d
*100	79.28	0.08±3.33 c	50.00	0.11±2.53 c
*200	83.33	0.40±3.50 c	57.82	0.17±2.43 c
*400	91.19	0.03±3.83 abc	69.04	0.051±2.90 b

Different letters means the presence of significant different at (P<0.05).

Untreated control cells (Fig. 1) showed a microtubule network regularly distributed along the whole cell content. When cells exposed to drugs at concentrations of 20 µg/ml for 60 min did not show

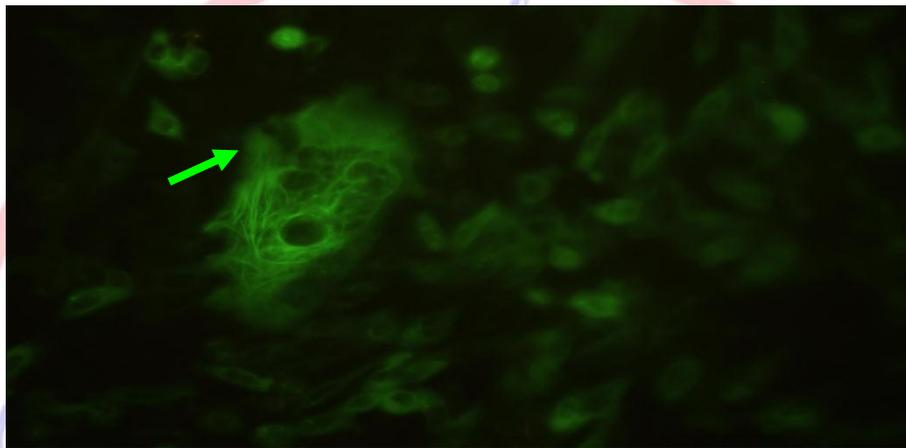
considerable changes in the distribution of microtubules.

Cells exposed to vincristine or vinblastine at concentrations of 80,100, 200and 400 µg/ml for 60 min showed changes in the

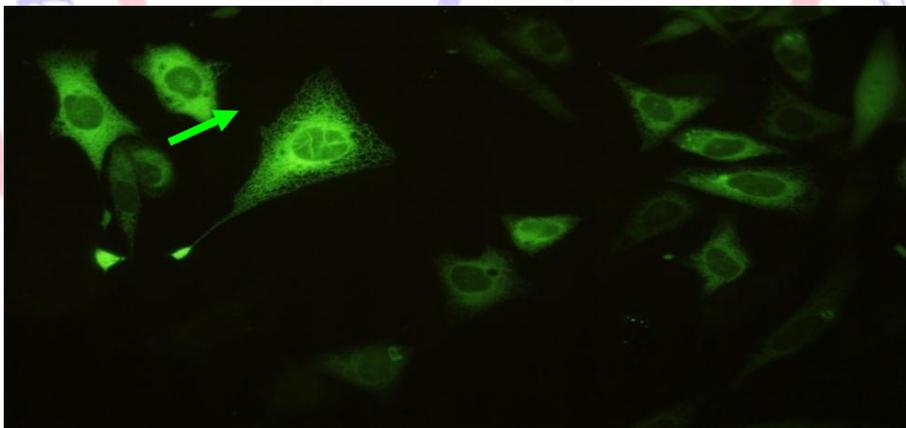
arrangement of the microtubular network.(Figs. 2, 3).

The network of cytoplasmatic microtubules at concentrations of 10, 80  $\mu\text{g/ml}$  was thinned down, and individual fibres showed a wavelike shape. The network damage increased with increasing concentration of cytostatics. The microtubules were more

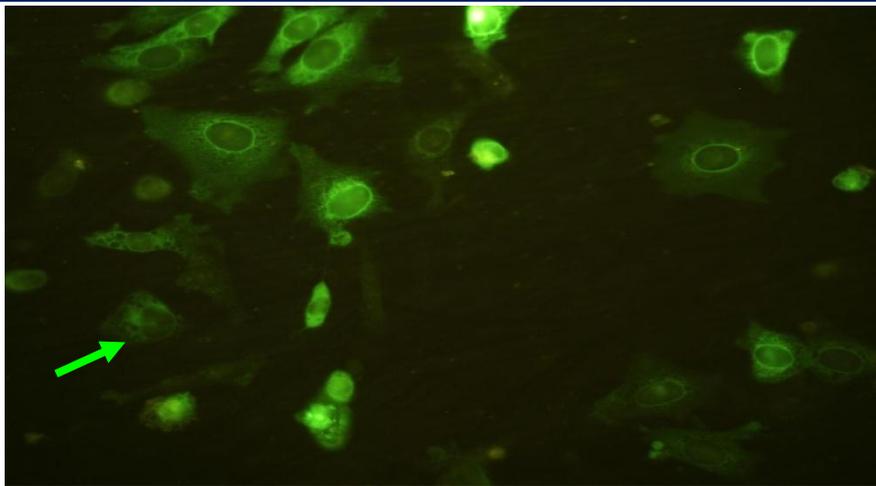
thinned down and fragmentation of fibres occurred. At a higher concentration of 400  $\mu\text{g/ml}$ , sometimes blebs were formed (Fig. 4). Cells exposed to vincristine at concentrations of 1000  $\mu\text{g/ml}$  and 2000  $\mu\text{g/ml}$  formed paracrystals (Fig. 5),No significant difference was detected between vincristine and vinblastine treated cells.



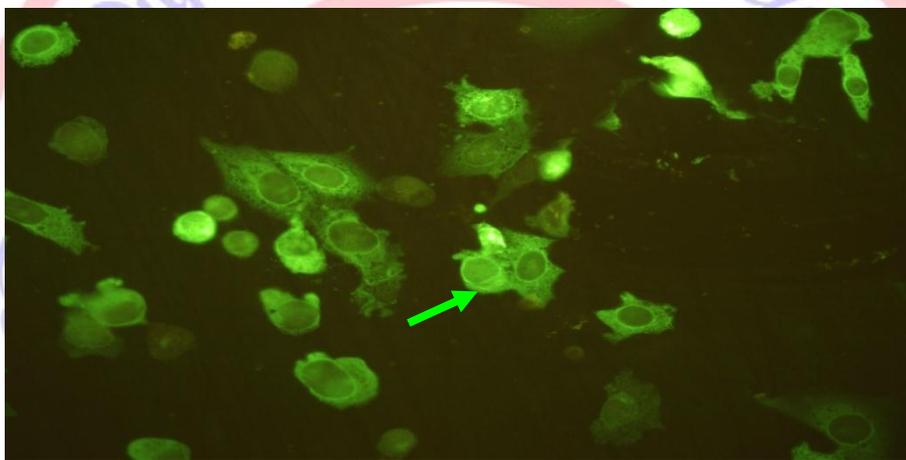
**Figure (1):** Microtubules of untreated control cells of H<sub>22</sub> line. The network is regularly distributed along the whole cell content.



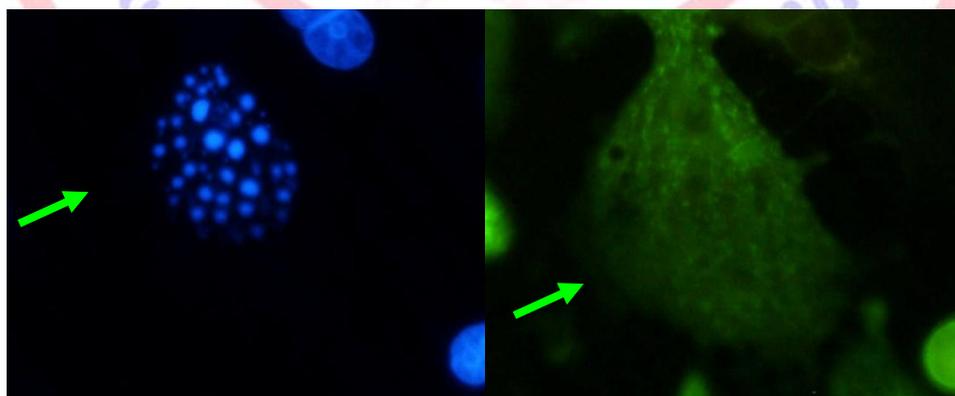
**Figure (2):** Microtubules of H<sub>22</sub> cell line treated with vinblastine at a concentration of 80  $\mu\text{g/ml}$  for 60 min. The network of cytoplasmatic microtubules is thinned down, and individual fibres have a wavelike shape.



**Figure (3):** Microtubules of H<sub>22</sub> cell line treated with vincristine at a concentration of 400 µg/ml for 60 min. The network of cytoplasmic microtubules is thinned down, and individual fibres have a wavelike shape.



**Figure (4):** Cells of H<sub>22</sub> cell line treated with vincristine at a concentration of 400 µg/ml for 60 min. There are blebs formed on the periphery of the cells.



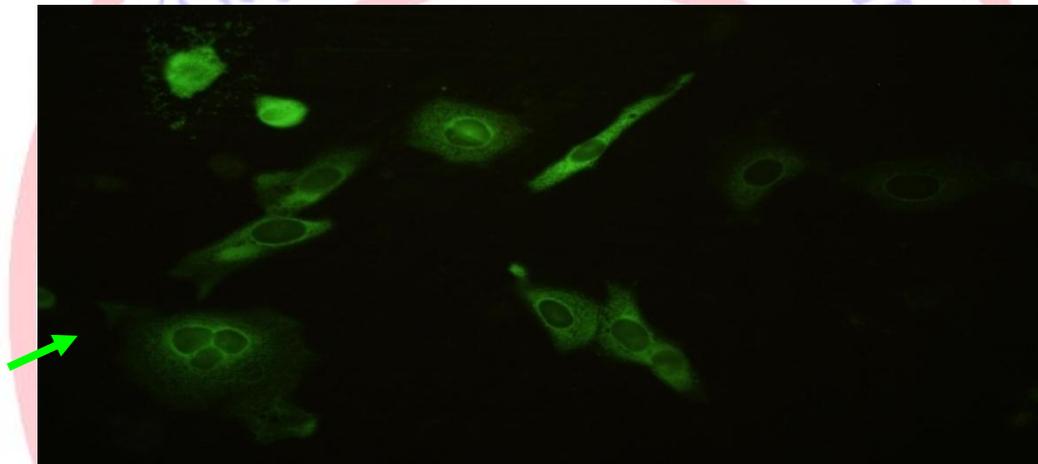
**Figure (5):** H<sub>22</sub> cells treated with vincristine at a concentration of 1000 µg/ml for 60 min. Paracrystals are formed.

When cells were exposed to vincristine at a concentration of 20 µg/ml for 6, 8, or 10 hrs, no noticeable changes occurred in the microtubule network. But in the 12 hrs

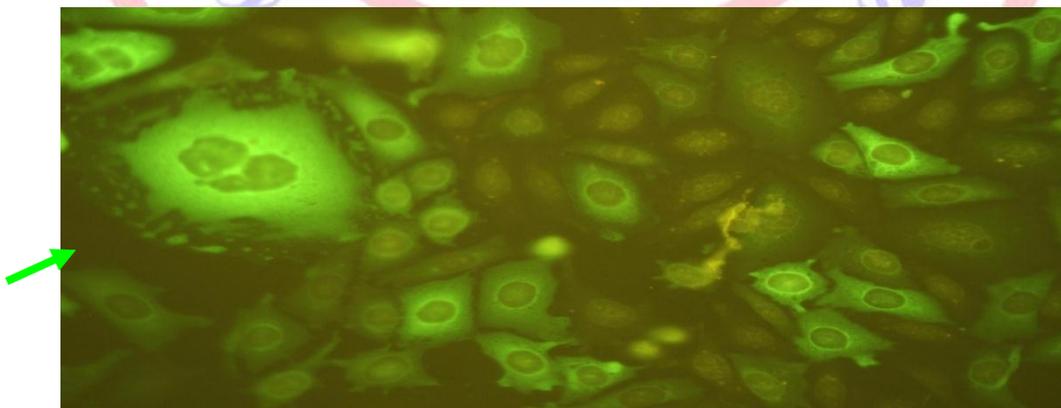
treatment at a concentration of 20 µg/ml caused disruption of microtubules. The network was thinned down, and individual fibres had a wavelike shape.

The cells exposed to vincristine at a concentration of 400  $\mu\text{g/ml}$  for 10 minutes showed a severely defective microtubular network. All the cells with the recovering period of 12 hrs in a drug-free growth medium following vincristine treatment showed damage of microtubules. The cells after a 12 hrs recovery period had their microtubular network either fully restored or still damaged. After recovery for an 12 hrs period, some cells showed a partly defective (thinned-down) network, but the majority of the cells showed restored microtubules. When the cells were allowed to recover for 12 hrs, the microtubules were spread out

comparably to those observed in untreated control cells. The control cells showed their microtubule network regularly distributed along the whole cell volume. The microtubules were thinned down, and individual fibres had a wavelike shape. After a recovery period of 12 hrs, the network was also damaged (Fig. 6). When cells were recovered after treatment with vincristine at a concentration of 400  $\mu\text{g/ml}$  for 10 min, the cytoskeleton was partially restored afterwards (Fig. 7).



**Figure (6):** Microtubules of H<sub>22</sub> cell line treated with vincristine at a concentration of 20  $\mu\text{g/ml}$ . Microtubules recovered for 12 hrs. The network is nearly restored.



**Figure (7):** Microtubules of H<sub>22</sub> cell line treated with vincristine at a concentration of 400  $\mu\text{g/ml}$  for 10 min. Microtubules were recovered and network is nearly restored.

## Discussion

The interaction of antitumour agents with compounds of the cytoskeleton is a theme

studied in several studies [22, 26]. Lobert [23] studied the interaction of Vinca alkaloids with tubulin, and compared

vinblastine and vincristine. She studied e.g. the affinity of the drug for tubulin heterodimers.

Vincristine exhibited a higher overall affinity for porcine brain tubulin than vinblastine, but the affinity of the drug for tubulin heterodimers was identical for the two drugs. Under our experimental conditions we did not mark any differences between the two drugs. Some authors also studied the recovering processes of the cytoskeleton after treatment of cell cultures with physical factors or agents interfering with cytoskeleton compounds. Vincristine caused a sequence of morphological changes in sensitive cells from three pleiotropic resistant MCF-7 human breast carcinoma cell lines mixed with vaginal adenocarcinoma cells. The cells were selected in serially increasing drug concentrations.

The changes occurred initially within 6 hrs of incubation, but were expressed in all cells after 12 hrs. If, after 6 hrs of drug exposure, the cells were subcultured in drug-free media, the cytoskeletal structure reformed within 12 hrs. The maximal recovery of the cytoskeletal structure occurred 12 hrs after drug removal and was sustained up to 12 hrs eliminated the microtubule bundles, leaving only tubulin paracrystals. Within 12 hrs after washing out the vincristine, [24]. Treatment with vincristine [25] the microtubule bundles repolymerised in cultured hippocampal neurons. [27] they investigated quantitative changes after application of the microtubule inhibitor nocodazole. They presented a decrease of the assembled tubulin after treatment with nocodazole and a less delicate structure of the remaining microtubules. This was indicated by a reduction of the parameters used. They also showed significant differences between the high and low metastatic cell lines. They used confocal laser scanning microscopy. We have no possibility of comparing the mathematical approach because the description of image

analysis is not detailed in this paper, but we suppose to have probably a more appropriate approach on account of using histogram expansion, gamma correction [20].

## References

- [1] Schliwa, M. 1986. The Cytoskeleton. An Introductory Survey. Springer-Verlag Wien. 326.
- [2] Huang, Y, Fan W. 2002. InB kinase activation is involved in regulation of paclitaxel-induced apoptosis in human tumor cell lines. *Mol Pharmacol*, 61:105–13.
- [3] Nogales, E. A. 1999. structural view of microtubule dynamics. *Cell Mol Life Sci.*, 56(1–2):133–142.
- [4] Mays, R. ; Beck KA, Nelson JW. 1994. Organisation and function of the cytoskeleton in polarised epithelial cells: A component of the protein sorting machinery. *Curr Opin Cell Biol.*, 6: 6–24.
- [5] Shinohara, T.; Miki T, Nishimura N, et al. 2002. Nuclear factor- $\kappa$ B-dependent expression of metastasis suppressor KA11/CD82 gene in lung cancer cell lines expressing mutant p53. *Cancer Res.*, 61:673–8.
- [6] Rosenblum ,M.D.; Shivers RR. 2000. Rings of F-actin form around the nucleus in cultured human MCF7 adenocarcinoma cells upon exposure to both taxol and taxotere. *Comp Biochem Physiol C Toxicol Pharmacol.*, 125(1): 121–131.
- [7] Nogales, E.; Medrano F.J.; Diakun G.P.; Mant GR, Towns-Andrews E, Bordas J. 1995. The effect of temperature on the structure of vinblastine-induced polymer of purified tubulin: detection of a reversible conformational change. *J Molec Biol.*, 254(3): 416–430.
- [8] Le Chevalier, T. 1997. Vinorelbine (Navelbine) in non-small cell carcinoma. *Lung Cancer*; 18(2):60–61.
- [9] Kobayashi, J.; Hosoyama H.; Wang X. et al. 1997. Effects of taxoids from *Taxus cuspidata* on microtubule depolymerisation



and vincristine accumulation in MDR cells. *Bioorg Medicinal Chemistry Letters*; 7(4): 393–398.

[10] Lopez, L.A.; Bertini F1989. The in vivo effect of low body temperatures on the degree of polymerization of tubulin in brain and testes: A comparison among some species of vertebrates. *Comp Biochem Physiol A.*, 83(2): 317–320.

[11] Garcia, P.; Braguer D. Carles G.; Briand C. 2002. Simultaneous combination of microtubule depolymerising and stabilising agents acts at low doses. *Anticancer Drugs*; 6(4): 533–544.

[12] Finzer, P.; Aguilar-Lemarro, A.; Rösl F.2000. The role of human papillomavirus oncoproteins E6 and E7 in apoptosis. *Cancer Lett* 188: 15-24.

[13] Klener, P. Protinadorova. 1996.chemoterapie [Antitumour Chemotherapy]. Praha: Galen.,344–348.

[14] Amon, A. The spindle checkpoint. *Curr Opin Genet Dev.*, 9: 69–75. 1999.

[15] Rudner, AD.; Murray AW. 1996.The spindle assembly checkpoint. *Curr Opin Cell Biol*; 8: 773–780.

[16] Burke, DJ. 2000. Complexity in the spindle checkpoint. *Curr Opin Genet Dev*; 10: 26–31.

[17] Sorger, PK.; Dobles M, Tournebize, R.; Hyman AA. 2002.Coupling cell division and cell death to microtubule dynamics. *Curr Opin Cell Biol.*,9(6): 807–814.

[18] Verdier-Pinard, P.; Gares M. Wight M. 1998. Differential in vitro association of vinca alkaloid-induced tubulin spiral filaments into aggregated spirals. *Biochem Pharmacol.*, 58: 959–971.

[19] Giannakakou, P.; Nakano M. Nicolaou KC, et al. 2002. Enhanced icrotubule-dependent trafficking and p53 nuclear accumulation by suppression of microtubule dynamics. *Pharmacology*; 99(16): 10855–10860.

[20] Novy, J. 2005. Discrete Fourier transform-based analysis of HeLa cell microtubules after ultrasonic exposure. *Microscopy Research and Technique*; 68: 1–5.

[21] Duncan, R.C.; Kanpp, R.G.; & Miller, M.C. 1955. Introductory baiostatstics for the health sciences,. Awileg medical publication. John Wiley & sons. pp. 161-179.

[22] Skorpikova, J.; Dolnikova, M.; Hrazdira I.; Janisch R.; Mornstein V. 1998.The combined effect of ultrasound and cytostatic treatment on the cytoskeleton of HeLa cells. *Folia boil.*,44: 14.

[23] Lobert, S.; Vulevic B.; Correia JJ. 1996.Interaction of vinca alkaloids with tubulin: A comparison of vinblastine, vincristine, and vinorelbine. *Biochemistry*; 35(21): 6806–6814.

[24] Mujagic, H.; Mujagic Z. 1991.Detection of pleiotropic drug resistance by the rapid immunofluorescence assay of drug effects on the cell skeleton. *Oncology*; 48(3): 202–209.

[25] Allison, WA.; Chervin AS, Gelfand VI, Craig AM. 2000. Postsynaptic scaffolds of excitatory and inhibitory synapsis in hippocampal neurons: maintenance of core components independent of actin filaments and microtubules. *J Neurosc*; 20(12): 4545–4554.

[26] Wilson, L.; Bamburg JR.; Mizel SB, Grisham LM, Creswell KM. 1974.

Interaction of drugs with microtubule proteins. *Fed Proc.*, 33(2): 158–166.

[27] Fink-Puches, R.; Hofmann-Wellenhof R.; Smolle J.; Helige Ch, Kerl H. 1997. Cytoplasmic microtubules in two different mouse melanoma cell lines: a qualitative and quantitative analysis using confocal laser scanning microscopy and computer-assisted image analysis. *J Cutan Pathol.*,24: 350–355.