Section: Anatomy

Original Research Article

NEUROTOXIC EFFECTS OF STREPTOMYCIN AND KANAMYCIN ON MEDIAL GENICULATE BODY OF ALBINO RAT – AN ELECTRON MICROSCOPIC INVESTIGATION

Farah Ghaus[1], Nusra Rahman[2], Rajalakshmi. R[3], Rati Tandon[4], Nafis Ahmad Faruqi[5]

[1]Professor, Department of Anatomy, J.N. Medical College, Faculty of Medicine, A.M.U., Aligarh, India.
[2]Assistant Professor, Department of Anatomy, J.N. Medical College, Faculty of Medicine, A.M.U., Aligarh, India.
[3]Junior Resident, Department of Anatomy, J.N. Medical College, Faculty of Medicine, A.M.U., Aligarh
[4]Assosiate Professor, Department of Anatomy, Mahatma Gandhi Medical College & Hospital, Sitapur, Jaipur
[5]Retired Professor, Department of Anatomy, J.N. Medical College, Faculty of Medicine, A.M.U., Aligarh, India.

Received : 04/06/2026
Received in revised form : 16/07/2026
Accepted : 01/08/2026

Keywords:
Streptomycin, kanamycin, medial geniculate body, perikaryon, myelin, electron microscopy.

Corresponding Author:
Dr. Nusra Rahman,
Email: nranatomy@gmail.com

DOI: 10.47009/jamp.2026.8.4.268

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (4); 1587-1592

ABSTRACT

Background: Streptomycin and kanamycin are aminoglycoside antibiotics with well-documented ototoxic properties. Aminoglycosides are known to cross the blood-brain barrier, potentially exerting toxic effects on central auditory pathways including the medial geniculate body. **Aim:** Purpose of our study is to authenticate the toxicity of streptomycin and kanamycin to medial geniculate body of albino rats, if any. In case of positive results by both the drugs, their preferential and differential effects will also be observed. **Materials and Methods:** Thirty male adult albino rats (170±15 g) were randomly divided into three equal groups (n=10 each). Group I received streptomycin sulphate (30 mg/kg, IM, daily x 21 days); Group II received kanamycin sulphate (400 mg/kg, IM, daily x 21 days); Group III (control) received physiological saline. Medial geniculate bodies were processed for transmission electron microscopy using glutaraldehyde-osmium tetroxide fixation, araldite embedding, and ultramicrotomy. The perikaryon, myelin sheath, axon and nucleus morphology of medial geniculate body were observed in the control and experimental group (streptomycin and kanamycin group). **Results:** Control group showed normal perikaryon, dispersed organelles and intact myelinated axons. Streptomycin-treated animals showed enhanced osmiophilic bodies in capillary endothelium, disrupted dendritic organelles, and disrupted myelin lamellae. Kanamycin-treated animals exhibited numerous perikaryal lysosomes, oligodendrocyte changes and myelin disruption. **Conclusion:** Both drugs are injurious to the MGB. Streptomycin preferentially affects capillaries and myelin; kanamycin predominantly involves the perikaryon. This is the first electron microscopic study of aminoglycoside toxicity in the medial geniculate body.

INTRODUCTION

Efficacy and utility of streptomycin, an aminoglycoside antibiotic, is still unquestionable and therefore drug of choice by many scientists for their research purpose.[1,2] Similarly kanamycin is another aminoglycoside antibiotic primarily used to treat severe life-threatening bacterial infections that are resistant to other drugs, as well as multidrug resistant tuberculosis (MDR – TB). However, the toxicity of these drugs is a concern to the treating physician. The experimental studies in animals have established that the neurotoxicity of aminoglycosides (streptomycin and kanamycin) is not confined to the auditory pathways, but extends beyond to include cerebellum, spinal cord and vestibular nuclei.[3-5] These drugs lead to significant structural alterations and cellular degeneration in above mentioned central nervous system regions. In particular, streptomycin is known to destroy the ventral cochlear nuclei of the brain stem.[6] At the same time ototoxicity is a well known side effect of kanamycin.[7] Scope of ototoxicity of both

ISSN (O): 2687-5365; ISSN (P): 2753-6556

streptomycin and kanamycin is further highlighted due to facts that aminoglycosides are known to cross the blood brain barrier.[8] Hence, the window for potential central nervous related adverse events is very narrow. Therefore these drugs, especially kanamycin, became centre of investigation for many researchers.[3-5]

In view of the fact that both streptomycin and kanamycin are ototoxic, doing research on organs forming auditory pathway is justified. In this study we have selected medial geniculate body of central auditory pathways, an oval elevation on the inferior aspect of the pulvinar of the thalamus, lateral to superior colliculus for exploring the effects of these antibiotics.[9] Previous studies on the aforementioned subject were based on biochemical findings.[3,4,10] The current study is different from the available literature as it is based on electron microscopic minutiae, not performed by former researchers at so much high magnification.

Aim: Purpose of our study is to authenticate the toxicity of streptomycin and kanamycin to medial geniculate body of albino rats, if any. In case of positive results by both the drugs, their preferential and differential effects will also be observed.

MATERIALS AND METHODS

Sample size calculation

As our experimental study on albino rats involves three groups (control, streptomycin and kanamycin group), a standard approach is to use 6 to 8 rats per group to satisfy the widely accepted "Resource Equation" threshold for statistical validity. However, we used 10 rats per group to poise statistical methods, study design and practical implementation. Moreover, the sample size of ten animals per group was determined based on established precedents in aminoglycoside neurotoxicity research, consistent with the minimum number required for statistically valid results in studies of comparable design.[11-13]

Therefore, thirty male adult albino rats weighing 170±15 g were divided into three groups of ten each. They were fed gram ad libitum with ready access to tap water. First group of rats received streptomycin sulphate (Ambistryn-s, Sarabhai) in dose of 30 mg/kg body weight, im, daily for 21 days. The second group received kanamycin sulphate (Kancin, Alembic), im (400mg /kg body weight daily) for 21 days. Physiological saline was injected to the third group, which served as the controls for the same duration. The doses of antibiotics used were selected on the basis of earlier studies in mice,[11] guinea pigs,[12] and monkeys.[13]

Animal tissues were fixed by transfusion technique by using 3% gluteraldehyde in 0.1 M phosphate buffer (Ph: 7.3 – 7.4). Medial geniculate bodies were dissected out from all animals. Central regions of all the organs were localized under light microscope and the sections of 0.5 micrometer thick were cut on an ultratome using glass knives and stained with toluidine blue. Subsequently, tissues were post-fixed in 1% osmium tetroxide (OsO_4) in 0.1 M phosphate buffer for 2 hours at 4°C, dehydrated through ascending concentrations of acetone (30%, 50%, 70%, 90%, 100%), and embedded in araldite epoxy resin. Ultrathin sections (60-90 nm) were cut using a diamond knife on an ultramicrotome, mounted on 300-mesh copper grids, and stained with 2% aqueous uranyl acetate for 20 minutes followed by Reynolds' lead citrate for 10 minutes at room temperature. Sections were examined under a transmission electron microscope at magnifications ranging from 4,000X (low magnification) to 32,000X (high magnification) to analyze the morphology. Photomicrographs were taken from representative fields for each experimental and control group.

RESULTS

The perikaryon, myelin sheath, axon and nucleus morphology of medial geniculate body were observed in the control and experimental group (streptomycin and kanamycin group).

Control Group (figure: 1 & 2)

Ultrastructural analysis of the medial geniculate body in control rats revealed normal neuronal morphology. The perikaryon featured an indented nucleus with well-dispersed, intact organelles. Background tissue adjacent to these neurons exhibited a large number of normal myelinated axons characterized by dense, tightly condensed myelin sheaths.

Streptomycin-Treated Group (figure: 3, 4, 5 & 6)

In contrast, streptomycin-treated rats demonstrated marked ultrastructural alterations in the medial geniculate body. Blood-brain barrier modifications were evident in the capillary endothelium, where enhanced vacuoles and osmiophilic bodies indicated active transendothelial transport. While some capillaries maintained a normal structural appearance, the adjacent background tissue showed severe pathology, including the disruption of organelles within dendritic processes. The myelin sheaths were heavily compromised, exhibiting a prominent disruption of the myelin lamellae. Additionally, the vicinity contained distinct myelin figures encompassing dendritic profiles, alongside widespread degenerated myelin and degenerated cellular profiles.

Kanamycin-Treated Group (figure: 7, 8 & 9)

The medial geniculate body of kanamycin-treated rats similarly demonstrated severe aminoglycoside-induced neurotoxicity. Within the perikaryon, high concentration of lysosomes was observed, indicative of intense lytic action. Glial cells were also impacted; oligodendrocytes were frequently noted directly adjacent to degenerated myelin sheaths. Consistent with the streptomycin group, widespread

ISSN (O): 2687-5365; ISSN (P): 2753-6556

disruption of the myelin morphology was a characteristic feature throughout the tissue.

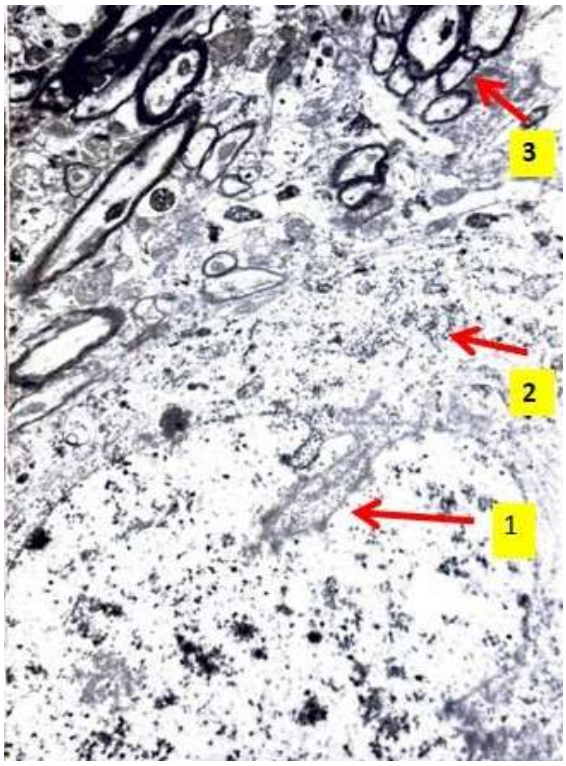

Figure 1: Shows photomicrograph of medial geniculate body of control rat with perikaryon in which nucleus is indented (1), and organelles are dispersed (2). Adjacent to neuron there are large number of normal looking axon with condensed myelin sheath around them (3)

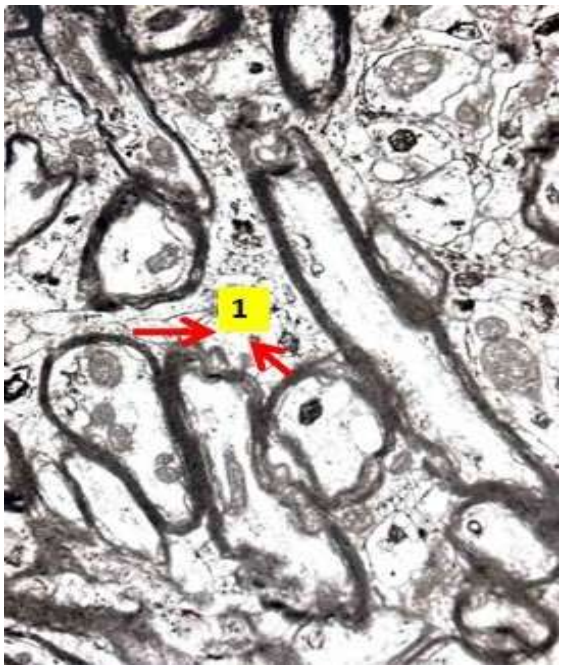

Figure 2: Control rat medial geniculate body showing electron microscopic pictures of large number normal myelinated axons (1)

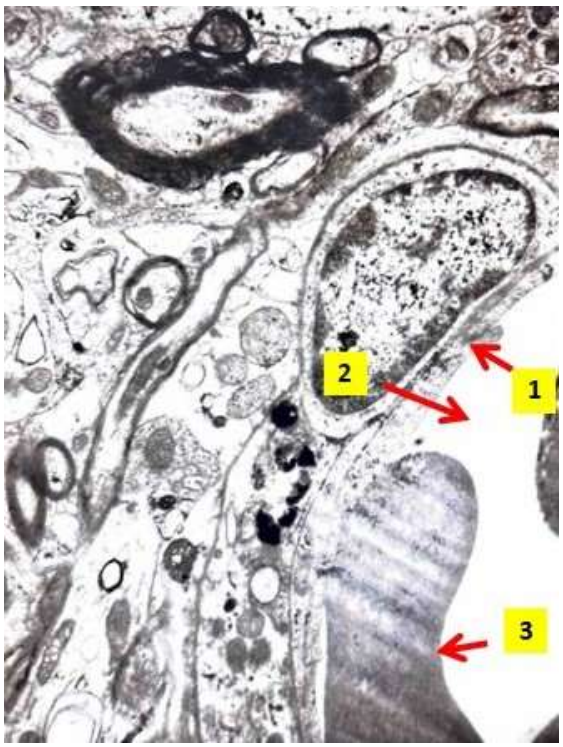

Figure 3: shows electron microscopic picture of medial geniculate body of streptomycin treated rats, Transendothelial transport is supported by the presence of enhanced vacuoles i.e. osmiophilic bodies in capillary endothelium. Osmiophilic Body (1); Capillary lumen (2); RBC (3)

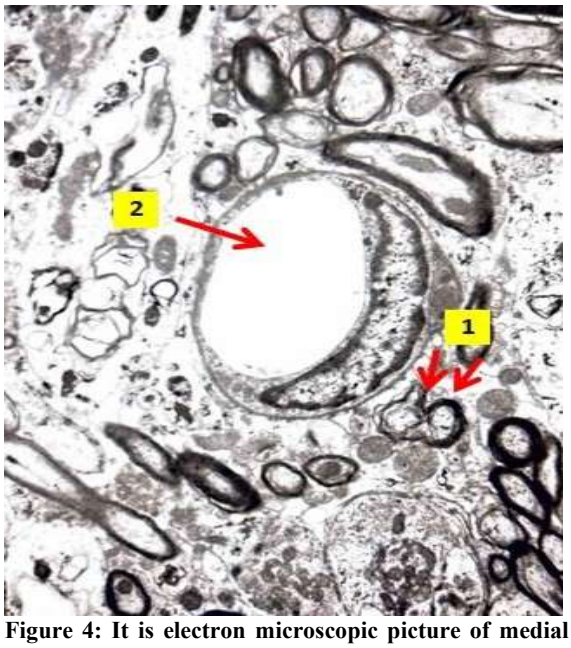

Figure 4: It is electron microscopic picture of medial geniculate body of streptomycin treated rats, showing disruption of organelles and dendritic processes adjacent to a normal looking capillary. Disruption of dendritic processes (1); Lumen of capillary (2)

ISSN (O): 2687-5365; ISSN (P): 2753-6556

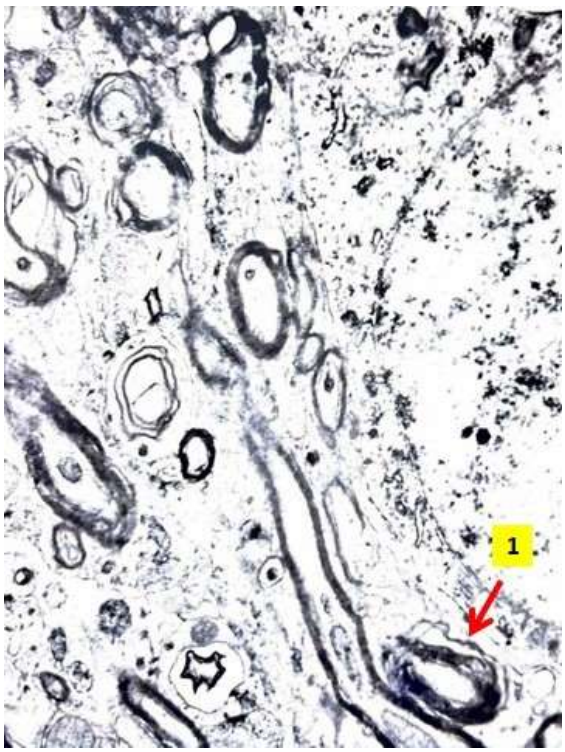

Figure 5: This is an electron microscopic picture of medial geniculate body procured from experimental rat injected with streptomycin showing disruption of myelin lamellae (1)

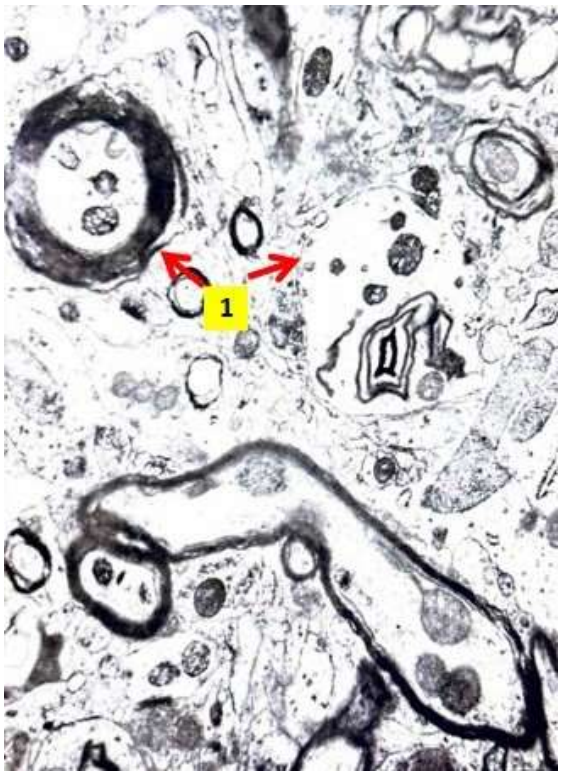

Figure 6: Electron microscopic picture of medial geniculate body from streptomycin treated rats showing myelin figure with dendritic profile and degenerated myelin in the vicinity (1).

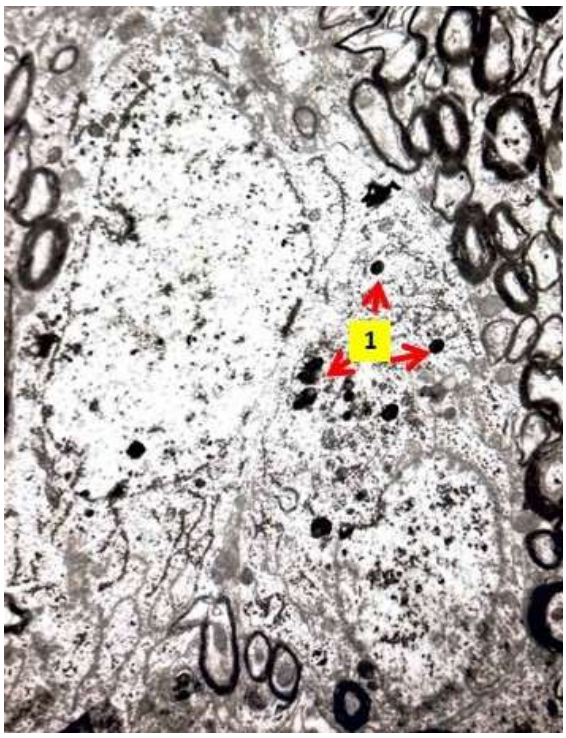

Figure 7: This is electron microscopic picture of medial geniculate body exposed to kanamycin. Numerous lysosomes (1) in the perikaryon are indicative of lytic activity.

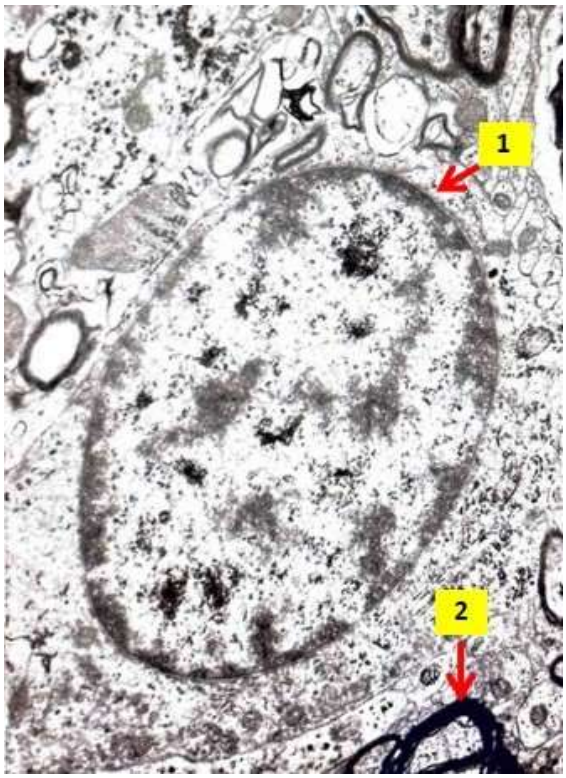

Figure 8: This is electron micrographic picture of medial geniculate body of kanamycin treated rat, showing an oligodendrocyte (1) along with degenerated myelin sheath (2) adjacent to it.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

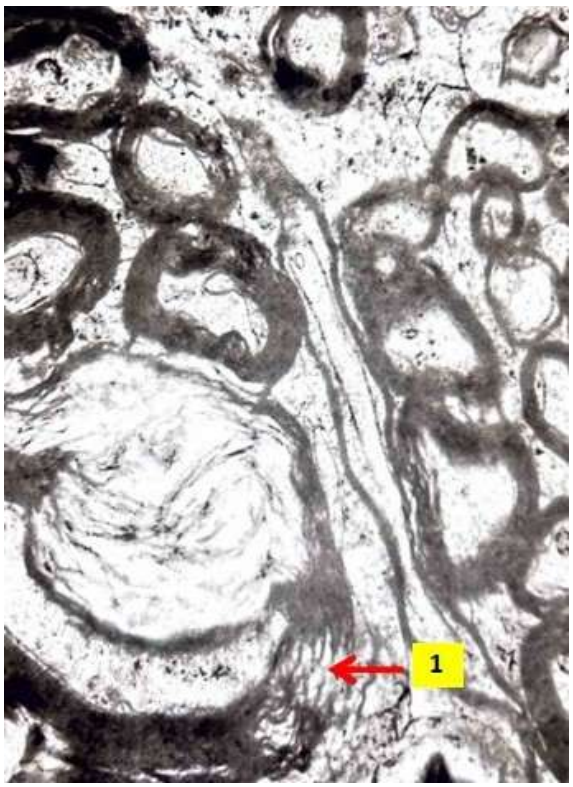

Figure 9: This is electron micrographic figure of medial geniculate body from kanamycin exposed rat, showing a disrupted myelin (1)

DISCUSSION

The neurotoxicity of aminoglycosides antibiotics is not only confined to the auditory pathways, but extends beyond to include cerebellum, spinal cord, vestibular and auditory nuclei leading to structural alterations and cellular degeneration.[3-5]As aminoglycosides are known to cross the blood brain barrier, more areas of brain can potentially be involved leading to adverse effects.[8] One of the probable areas for toxicity is medial geniculate body, an oval elevation on the inferior aspect of the pulvinar of the thalamus, lateral to superior colliculus. Thus it is an area of interest for the researchers. The MGB connects the limbic regions with the auditory network. The alteration in MGB plays an important role in the tinnitus neuropathophysiology, which is supported by the electrophysiological, neurochemical and neuroimaging studies. Moreover, increased thalamic spontaneous firing rate have been shown in auditory thalamus in animal model of tinnitus.[14] It shows the importance of medial geniculate body's insult by drugs known to cause ototoxicity (aminoglycoside antibiotics like Streptomycin and kanamycin). Studies have shown that the proposed mechanism of aminoglycosides toxicity is via entrance of drug in the inner ear, where it triggers the death of sensory hair cells. The process is driven by accumulation of drug, formation of free radicals and consequently triggering of apoptosis leading to permanent impairment of hearing and balance. Effect of kanamycin on central auditory pathways at molecular level have been reported.[3-5] Such studies have also been reported at light microscopic level.[10] Reports related to toxicity of aforementioned two drugs on medial geniculate body at electron microscopic level are lacking in literature. Hence there is paucity of available literature on this subject. The present study therefore is first of its kind and unique.

In our study, first two figures are showing electron microscopic features of normal medial geniculate body with perikaryon, dispersed organelles and normal neuronal processes with condensed myelin sheath. In figure three, which is streptomycin treated medial geniculate body, large number of vacuoles (osmiophilic bodies) in capillary endothelium indicated excessive transendothelial transport. In figure 4, again streptomycin intoxicated medial geniculate body, organelles dendritic processes are disrupted. Streptomycin intoxicated medial geniculate body in figure 5, shows disrupted myelin lamellae. Last figure of streptomycin treated medial geniculate body shows myelin figure with dendritic profile and degenerated myelin in the vicinity. All these findings indicate that streptomycin is highly toxic to medial geniculate body involving myelin sheath as well as capillaries.

Kanamycin intoxicated medial geniculate body also showed a lot of damage in the form of disruption of myelin similar to streptomycin treated animals. The accumulation of kanamycin in perikaryon disrupts normal lysosomal function, where the lysosomes leak destructive enzymes, ultimately leading to cell death indicative of lytic activity. This preferential effect was noticed in case of kanamycin, where the presence of numerous lysosomes in perikaryon is suggestive of its more affinity to perikaryon, and thus lytic activity.

CONCLUSION

1. Both streptomycin and kanamycin are injurious to medial geniculate body in terms of myelin sheath.
2. Streptomycin shows affinity with capillaries.
3. Kanamycin shows more affinity with perikaryon.

REFERENCES

1. Zhu M, Burman WJ, Jaresko GS, Berning SE, Jelliffe RW, Peloquin CA. Population pharmacokinetics of intravenous and intramuscular streptomycin in patients with tuberculosis. Pharmacotherapy. 2001 Sep;21(9):1037-45.
2. Mitnick CD, McGee B, Peloquin CA. Tuberculosis pharmacotherapy: strategies to optimize patient care. Expert OpinPharmacother. 2009 Feb;10(3):381-401.
3. Faruqi NA, Haider SS, Hasan M. Biochemical and histochemical studies on the effects of kanamycin on the central auditory pathway. Indian J Med Res. 1982 Dec;76:898-901.
4. Faruqi NA, Khan NA, Naim M. Ganglioside content in central nervous system after streptomycin and kanamycin intoxication in rat. Indian J Med Res. 1986 Jun;83:629-32.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

5. Faruqi NA, Khan HS. Effects of streptomycin and kanamycin on central nervous system – an experimental study. Indian J Exp Biol. 1986 Feb;24(2):97-9.
6. Weinstein L. Antimicrobial agents: streptomycin, gentamycin and other aminoglycosides. In: Goodman LS, Gilman A, editors. The pharmacological basis of therapeutics. 5th ed. New York: Macmillan Publishing Co.; 1975. p. 1167.
7. Ward PH, Fernandez C. The ototoxicity of kanamycin in guinea pigs. Ann OtolRhinolLaryngol. 1961 Mar;70(1):132-42.
8. Stupp H, Rauch S, Sous H, Brunn JP, Langer F. Kanamycin dosage and levels in ears and other organs. Arch Otolaryngol. 1967 Nov;86(5):515-20.
9. Singh V. Diencephalon and third ventricle. In: Textbook of Clinical Neuroanatomy. 1st ed. New Delhi: Elsevier; 2008. p. 167.
10. Faruqi NA, Hasan M, Hasan SA, Khan MA, Ekramullah. Neurohistological studies on the effects of kanamycin on central auditory pathway. Curr Med Pract. 1986 Nov;30(11):289.
11. Chen GS, Saunders JC. Effects of kanamycin on cochlear nucleus evoked responses and behavioral responses in C57BL/6J mice. Exp Neurol. 1984 Mar;83(3):461-73.
12. Cada K, Brunn JP, Rauch S. The streptomycin levels with and without ozothine in the blood and perilymph of the guinea pig. Z LaryngolRhinol Otol. 1968 Dec;47(12):929-35.
13. Hawkins JE, Johnsson LG. Histopathology of cochlear and vestibular ototoxicity in laboratory animals. In: Lerner SA, Matz GJ, Hawkins JE Jr, editors. Aminoglycoside ototoxicity. 1st ed. Boston: Little, Brown and Co.; 1981. p. 175-95.
14. Almasabi F, Janssen MLF, Devos J, et al. The role of medial geniculate body of the thalamus in the pathophysiology of tinnitus and implications for treatment. Brain Res. 2022 Mar 15;1779:147797. doi:10.1016/j.brainres.2022.147797.

ISSN (O): 2687-5365; ISSN (P): 2753-6556