Original Article

Comparison of CoQ10 & L-Carnitine in Remyelination of White Matter in a Rat Model of Multiple Sclerosis

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Abstract

Objective: To compare the therapeutic effects of coenzyme Q10 and L-carnitine on remyelination of the anterior commissure in a cuprizone-induced rat model of multiple sclerosis.

Methods: Forty male Sprague Dawley rats were randomly divided into four groups. Group 1 was given a normal diet, and the remaining three groups were MS models and were administered 0.2% cuprizone for 12 weeks. After four weeks, Group 3 received 150 mg/kg/day CoQ10, Group 4 was administered 100 mg/kg/day L-carnitine, and cuprizone treatment continued until week 12. The rats were then dissected, and their brains were removed. Coronal sections were stained with Luxol Fast Blue to demonstrate remyelination.

Results: CoQ10 promoted remyelination more effectively than L-carnitine, as evidenced by significantly reduced areas of demyelination.

Conclusion: CoQ10 demonstrates greater effectiveness in promoting remyelination compared to L-Carnitine.

Keywords: Coenzyme Q10, Carnitine, Multiple Sclerosis, Remyelination

Contributions:
TQ SA AY MH TF AMQ - Conception, Design
TQ SA AY MH TF AMQ - Acquisition, Analysis, Interpretation
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Introduction

Multiple sclerosis (MS) is a persistent neurodegenerative condition that affects the central nervous system (CNS). It is thought to stem from an autoimmune response, in which autoreactive lymphocytes breach the blood-brain barrier and infiltrate the CNS. Once inside, they induce local inflammation, leading to the breakdown of myelin, loss of oligodendrocytes, and axon degeneration.[1] Myelin loss results in altered tissue excitability, leading to cognitive deficits without obvious locomotor impairment.[2]

MS affects more than 2 million individuals worldwide,[3] whereas in Pakistan, it is documented as 10 cases per 100,000.[4] However, with advancements in diagnostic capabilities, this figure is increasing. MS is recognised as a primary cause of neurological disability among young adults. Although there is no definitive treatment for MS, certain medications are deemed beneficial in promoting myelination, thereby mitigating symptoms and neurological deficits. The burgeoning role of antioxidants is seen as groundbreaking in this regard.[5] Several established animal models have been employed to investigate MS, with some mimicking the autoimmune response observed in the actual disease, while others, such as neurotoxin models, concentrate on the mechanisms and alterations accountable for demyelination and subsequent remyelination in the white matter.[6] Cuprizone, a widely recognised animal model of MS, has been particularly emphasised in studies focusing on remyelination processes and gliosis. These alterations mirror the histological changes observed in patients with MS, albeit without any immune system involvement.[7]

Cuprizone (CPZ) serves as a specific copper-chelating agent, inducing oxidative stress, oligodendrocyte apoptosis, and eventual demyelination. The demyelination process initiates within the first week of CPZ exposure, with certain brain regions, such as the anterior commissure, completing demyelination by the 5th to 6th week. After 12 weeks of CPZ exposure, a chronic model is formed, characterised by severe neuroinflammation and intense gliosis, mimicking multiple sclerosis.[8]

Coenzyme Q10 (CoQ10), a naturally occurring nutrient in the body, is increasingly utilised for its antioxidative properties. It operates by transferring electrons within the electron transport chain, generating a transmembrane electrochemical gradient in mitochondria, thereby promoting oxidative equilibrium. Numerous studies have demonstrated the beneficial effects of CoQ10 in patients with MS, with most investigations focusing on inflammatory markers and clinical parameters. However, limited data are available on histological parameters.[9]

L-Carnitine, an amino acid, holds promise as a neuroprotective therapy. Its primary role involves facilitating the transport of activated long-chain fatty acids into the mitochondria for degradation via β-oxidation. Several studies have demonstrated clinical enhancements in patients with MS following L-carnitine administration.[10]

Since both agents prevent oxidative damage at the mitochondrial level, this study aimed to provide histological evidence of the comparative effects of coenzyme Q and L-carnitine on remyelination in the anterior commissure of the rat brain in the CPZ model of MS.

Materials And Methods

This was an experimental study conducted in the Anatomy Department of the Islamic International Medical College in collaboration with the National Institute of Health (NIH) after approval by the Institutional Review Committee (Ref. No.: Riphah/IRC/21/63). The study included 40 adult male Sprague Dawley rats, aged 6 to 8 weeks, weighing between 250 and 300 g. Female rats exhibiting noticeable pathology or being underweight were excluded from the study.

After 12 weeks, the rats were dissected, and their brains were removed, fixed in formalin, and cut into sections at the level of the optic chiasma. To conduct LFB staining, the sections underwent deparaffinization followed by hydration to 95% alcohol. They were then stained in LFB solution at 57°C overnight and subsequently rinsed in 95% alcohol and distilled water. Next, the slides were differentiated in a saturated lithium carbonate solution for 3 min, followed by further differentiation in a 70% alcohol solution until differentiation between gray and white matter was achieved. Following this, the slides were dehydrated in absolute alcohol, cleared in xylene, and finally mounted with resin.[13]

Each slide was examined at 4 ×, 10 ×, and 40 × using a light microscope. The percentage of demyelinated area in the anterior commissure relative to its total surface area was calculated using the freehand tool in ImageJ.[14] The data extracted from the calibrated images were entered and analysed using the Statistical Package for the Social Sciences (version 21). One-way analysis of variance was employed to compare the means of quantitative variables, which are presented as mean ± standard deviation.

Table 1: Distribution of the rats in control and experimental groups with the diet given.

Group 1 (n=10)	Group 2(n=10)	Group 3(n=10)	Group 4(n=10)
Negative Control	Positive Control (MS Model)	MS Model with CoQ10	MS Model with L-Carnitine
Standard rodent pellet	Standard rodent pellet blended with 0.2% CPZ w/w for twelve weeks[11]	Standard rodent pellet blended with 0.2% CPZ w/w for twelve weeks, supplemented with 150 mg/kg/day CoQ10 from the fifth week.[11]	Standard rodent pellet blended with 0.2% CPZ w/w for twelve weeks, supplemented with 100 mg/kg/day L-Carnitine from the fifth week.[12]

Results

Data normality was assessed using the Shapiro–Wilk test. The mean ± SD for area of demyelination was 0 ± 0, 32 ± 2.1, 13.7 ± 1.5, and 20.1 ± 1.4 for groups 1, 2, 3, and 4, respectively (Table 2). Analysis of variance was highly significant; the post hoc Tukey test showed a significant difference between groups 3 and 4 ($p \leq 0.05$).

Table 2: Mean Area of Demyelination with its Standard Deviation

Groups	Mean ± SD Area of Demyelination (%)
Group 1	0.0 ± 0.0
Group 2	32 ± 2.1
Group 3	13.7 ± 1.5 *
Group 4	20.1 ± 1.4 *
***Significant = p-value ≤ 0.05**	

Discussion

Multiple sclerosis (MS) is characterised by autoimmune inflammation affecting the central nervous system (CNS), potentially inducing oxidative harm at the mitochondrial level within oligodendrocytes. This process triggers a robust glial reaction. Histologically, there is an increase in the number of astrocytes and microglia, which become activated and release numerous proinflammatory cytokines, such as TNF-α and IL-6. Consequently, this sequence of events leads to neuroinflammation and demyelination.

The cuprizone (CPZ) model serves as a mimetic of MS, inducing inflammatory alterations and a glial response. In this investigation, two antioxidants were administered to observe the reversal of CPZ-induced changes. The impact of each agent on neuronal tissue remyelination was compared with the combined effect of both agents to ascertain a more favourable outcome.

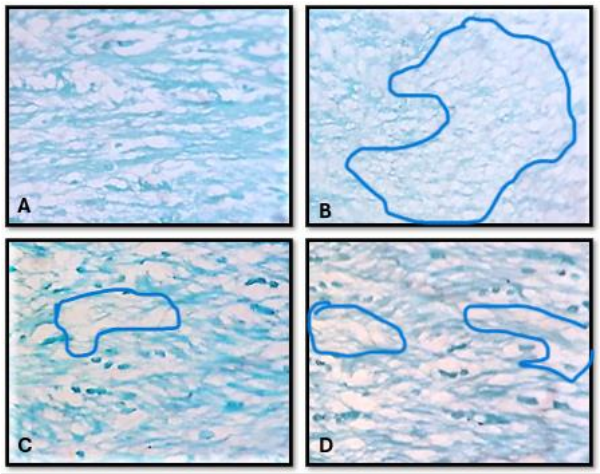

Figure 1: Coronal sections of rat brain showing Anterior Commissure stained with Luxol Fast Blue stain (400X), areas of demyelination are outlined

A: Control group showing normal myelinated white matter, B: CPZ group showing weak staining areas suggestive of demyelination, C: CoQ10 group, remyelination is evident. D: L-Carnitine group demonstrating remyelination.

Previous studies have combined CoQ10 and L-carnitine to demonstrate the synergistic potential of both agents owing to their similar antioxidant properties.[15,16] The findings of previous studies prompted the authors to compare the antioxidant actions of CoQ10 and L-carnitine on remyelination. CoQ10 was found to be more effective in controlling demyelinating areas and promoting remyelination.

Prior studies by Khalilian in 2021 and Pradhan in 2021 also demonstrated the antioxidant efficacy of CoQ10 in a rat model of MS, increasing superoxide dismutase (SOD) and total oxidative capacity (TAC).[11] Additionally, Zidan in 2018 provided histological evidence of enhanced myelination with L-carnitine, by a decrease in MDA, caspase-3, and a significant increase in GSH.[17] More recently, in 2024, Gharighnia elucidated the role of L-carnitine in promoting remyelination in a mouse model by increasing the reduced glutathione and catalase activity levels in the corpus callosum.[18] A comparison of these two agents has not been conducted in patients with MS; however, L-carnitine was found to be more effective in idiopathic male infertility when compared with CoQ10.[19] Another study used CoQ10 and L-carnitine concurrently for oxidative stress in obese and polycystic females, but did not comment on the comparative effects of these two antioxidants.[20] All previous research has demonstrated the antioxidant potential of CoQ10 and L-carnitine, rationalising their use in MS.

The present study showed marked improvement in myelination of white matter by CoQ10 and L-carnitine when compared with demyelination caused by CPZ in Group 2. However, remyelination by CoQ10 was significantly better than that caused by L-carnitine. The difference between the effects of the two drugs may be due to differences in doses. Therefore, further studies should be conducted with a wider range of doses to establish a better comparative analysis.

Conclusions

CoQ10 may be more efficient than L-carnitine in controlling demyelination and promoting remyelination.

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References

1. Tobore TO. Towards a comprehensive etiopathogenetic and pathophysiological theory of multiple sclerosis. Int J Neurosci. 2020;130(3):279–300. https://doi.org/10.1080/00207454.2019.1677648
2. Haki M, Al-Biati HA, Al-Tameemi ZS, Ali IS, Al-Hussaniy HA. Review of multiple sclerosis: Epidemiology, etiology, pathophysiology, and treatment. Med (United States). 2024;103(8). https://doi.org/10.1097/MD.0000000000037297.
3. Walton C, King R, Rechtman L, Kaye W, Leray E, Marrie RA, et al. Rising prevalence of multiple sclerosis worldwide: Insights from the Atlas of MS, third edition. Mult Scler J. 2020;26(14). https://doi.org/10.1177/1352458520970841
4. Shah Z, Wasay M, Chaudhry BZ, Fredrikson S. Multiple sclerosis in Pakistan: Current status and future perspective. J Neurol Sci [Internet]. 2020;418(418):117–26. Available from: https://doi.org/10.1016/j.jns.2020.117066
5. Dighriri IM, Aldalbahi AA, Albeladi F, Tahiri AA, Kinani EM, Almohsen RA, et al. An Overview of the History, Pathophysiology, and Pharmacological Interventions of Multiple Sclerosis. Cureus. 2023. https://doi.org/10.7759/cureus.33242.
6. Galbusera R, Bahn E, Weigel M, Schaedelin S, Franz J, Lu PJ, et al. Postmortem quantitative MRI disentangles histological lesion types in multiple sclerosis. Brain Pathol. 2023;33(6). https://doi.org/10.1111/bpa 13136.
7. López-Pedrera C, Villalba JM, Patiño-Trives AM, Luque-Tévar M, Barbarroja N, Aguirre MÁ, et al. Therapeutic potential and immunomodulatory role of coenzyme Q10 and its analogues in systemic autoimmune diseases. Vol. 10, Antioxidants. 2021. https://doi.org/10.3390/antiox10040600.
8. Vega-riquer JM, Mendez-victoriano G, Morales-luckie RA. Five Decades of Cuprizone, an Updated Model to Replicate Demyelinating Five Decades of Cuprizone, an Updated Model to Replicate Demyelinating Diseases. 2017;(July). https://doi.org/10.2174/1570159X15666170717120343.
9. Rauchová H. Coenzyme Q10 effects in neurological diseases. Physiol Res. 2021 Dec 30;70(Suppl4):S683-S714. https://doi.org/10.33549/physiolres.934712.
10. Al-Shammari AH, Abbood ZA, Lateef HF. Assessing the impacts of L-carnitine and modafinil on fatigue in Iraqi multiple sclerosis patients. J Adv Pharm Technol Res. 2023;14(3). https://doi.org/10.4103/JAPTR.JAPTR_225_23.
11. Khalilian B, Madadi S, Fattahi N, Abouhamzeh B. Coenzyme Q10 enhances remyelination and regulate inflammation effects of cuprizone in corpus callosum of chronic model of multiple sclerosis. J Mol Histol [Internet]. 2021;52(1):125–34. https://doi.org/10.1007/s10735-020-09929-x
12. Zedan OI, Bashandy MA. Comparing effects of L-carnitine and sildenafil citrate on histopathologic recovery from sciatic nerve crush injury in female albino rats. Folia Morphol (Warsz). 2021. https://doi.org/10.5603/FM.a2021.0037.
13. Método E, Luxol M De, Blue F, Mielina T De. The Modified Method of Luxol Fast Blue for Paraffin-Embedded Myelin Sheath Staining. 2020;38(5):1197–200. https://doi.org/10.4067/S0717-95022020000501197
14. Fahad T, Ali S, Qureshi T, Khan NF. Maternal Hypothyroidism-Induced Impaired Development of Neurons in Rat Offspring: Insights for Antenatal Care. Life Sci. 2024;5(1):07. https://doi.org/10.37185/LnS.1.1.525
15. Qureshi T, Ali S, Fahad T. Synergistic Effect of Coenzyme Q10 and L-Carnitine on Gliosis and Anhedonia , in a Rat Model of Multiple Sclerosis : An Immunohistochemical Study. Clin Psychopharmacol Neurosci. 2024;22:1–9. https://doi.org/10.9758/cpn.23.1150
16. Qureshi T, Ali S, Shahid A, Beenish H, Khurshid T, Fahad T. Synergistic Effects of Coenzyme Q10 & L-Carnitine on Oligodendrocyte Necrosis and Myelination, In A Rat Model of Multiple Sclerosis. Life and Science. 2024; 5(4): 471-476. http://doi.org/10.37185/LnS.1.1.547
17. Zidan A, Hedya SE, Elfeky DM, Abdin AA. The possible anti-apoptotic and antioxidant effects of acetyl L-carnitine as an add-on therapy on a relapsing-remitting model of experimental autoimmune encephalomyelitis in rats. Biomed Pharmacother [Internet]. 2018;103(31527):1302–11.https://doi.org/10.1016/j.biopha.2018.04.173
18. Gharighnia S, Omidi A, Kashani IR, Sepand MR, Beiranvand SP. Ameliorative Effects of Acetyl-L-Carnitine on Corpus Callosum and Functional Recovery in Demyelinated Mouse Model. Int J Neurosci. 2024;134(4):1–16. https://doi.org/10.1080/00207454.2022.2107515.
19. Ma L, Sun Y. Comparison of L-Carnitine vs. Coq10 and Vitamin E for idiopathic male infertility: a randomized controlled trial. Eur Rev Med Pharmacol Sci. 2022;26(13):4698–704. https://doi.org/10.26355/eurrev_202207_29194.
20. Shah FA, Murtaza S, Bukhari S, Emal E, Shah M. Effects of integrative administration of acetyl-L-carnitine , arginine , and Co-Q10 in mitigating oxidative stress in over-weight / obese PCOS women. 2025;15(04):274–82. https://doi.org/10.7324/JAPS.2025.70521