IJPSR (2024), Volume 15, Issue 7 **(Review Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 24 August 2023; received in revised form, 14 June 2024; accepted, 06 July 2024; published 01 August 2024

A NOVEL APPROACH TO TREAT NEUROLOGICAL DISORDER BY USING LIPID-BASED DRUG DELIVERY SYSTEM

Pooja Agarwal * and Vasudha Bakshi

School of Pharmacy, Anurag University, Venkatapur, Ghatkesar, Medchal District, Hyderabad - 500088, Telangana, India.

Keywords:

Neurological disorder, Lipid, Polymer, Lipid-Based Drug delivery systems, Epilepsy, Treatment

Correspondence to Author:
Pooja Agarwal

Research Scholar,
School of Pharmacy,
Anurag University, Venkatapur,
Ghatkesar, Medchal District, Hyderabad - 500088, Telangana, India.

E-mail: pharmacy.pooja.agarwal@gmail.com

ABSTRACT: One in every three people suffers from some kind of neurological disorder. Considering the huge burden of the disease, it is imperative to develop and treat such conditions. Because of time constraints and obstacles, treating neurological disorders remains challenging for medical professionals. The number of new pharmacologically active lipid compounds discovered using current drug development methods is steadily growing, but these compounds are water-insoluble. Having a drug for oral administration with optimal bioavailability was a huge risk. Epilepsy is a serious medical condition that requires immediate treatment. We need to make lipid-based formulations to improve their bioavailability. Surface tension-lowering agents can result in a water-insoluble formulation. Niosomes and nanoparticles will pass freely along the blood-brain barrier. The key goals in the development of nanomedicine are safety, high therapeutic effectiveness, drug targeting to specific locations to avoid off-target toxicity and increased pharmacokinetic behaviour through prolonged drug release with a significant safety margin. As a result, the highest clinical effectiveness can be reached by combining lipid and protein therapies.

INTRODUCTION: Neurological disorders are diseases of the nervous system. They include epilepsy, Parkinson's disease, dementia, Alzheimer's disease, multiple sclerosis, stroke, etc., and they are the leading cause of ill health and disability worldwide. Over 1 in 3 people suffer from some form of neurological condition. Disorders of the nervous system are the second leading cause of death globally, accounting for 9 million deaths per year [1].

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.15(7).2222-29

This article can be accessed online on www.ijpsr.com

DOI link: https://doi.org/10.13040/IJPSR.0975-8232.15(7).2222-29

Many neurological disorders are being examined for treatment, with most relying on hyper synchronous activation of neurons in the cerebral cortex or a neurochemical imbalance in the brain. Every year, more than 500,000 patients around the world are diagnosed with epilepsy and 80% of these live in low- and middle-income countries [2]. Considering such huge burden associated with these conditions, it is imperative to develop and treat them.

Serotonin, dopamine, adrenaline, acetylcholine, GABA, and glutamate are neurochemicals that are affected in neurologic disorders and play critical roles [3-15].

Glutamate: Glutamate is an excitatory neurotrans-mitter that promotes hyperactivity in the cortex

when there is too much of it [16]. It contributes to learning, memory, and synaptic plasticity. It is implicated in neurodegenerative diseases like Alzheimer's and Parkinson's. Dysregulation can lead to disorders like epilepsy, migraines, and mood disturbances.

GABA: It's an inhibitory neurotransmitter that decreases neuron activity, resulting in lapses in concentration, mood swings, and drowsiness [16].

Serotonin: 5-Hydroxytriptamine is a substitute for serotonin. It is the pleasure hormone that has a large impact on a person's mood and activities. It controls the brain's autonomic responses, such as body temperature, vasoconstriction, vasodilation, sleep, hormonal control, and the level of serotonin in depression. It's a psychoactive substance that plays a variety of roles in mental illnesses. There are various categories of drugs available to treat such conditions. A drug elicits its pharmacological action when the optimum concentration reaches the site of action rather than other tissues. Concentrations of such medications in places that are not intended lead to toxicities. There are barriers to the transport of drugs to the site of action. One such major barrier is the blood-brain barrier.

Blood-brain Barrier and Challenges to Delivery of Drugs: The blood barrier is a protective barrier of the brain that allows the transport of ions, chemicals, and cells between the blood and the brain. It selectively allows certain molecules to enter the brain and restricts others to maintain brain homeostasis. BBB shows selective permeability, i.e., it permits only lipophilic molecules with low molecular weight (less than 400-500 Da) to enter the brain from the bloodstream through the transcellular route. Unfortunately, approximately 98% of small molecules and nearly all large therapeutic molecules (such as monoclonal antibodies, antisense oligonucleotides, or viral vectors) cannot pass through this barrier [17]. Due to the BBB's prohibitive nature, conveying drugs to the brain remains a major challenge. Recent reports suggest that less than 10% of therapeutic agents for neurological diseases enter clinical trials because of poor brain penetration [18]. Because of the molecular mechanism, drug tolerance is high in neurological disorders [19, 20, 21]. Only neurological symptoms can be cured with a drug that can cross the BBB. The lipophilic molecule with a low molecular weight will easily penetrate or cross the BBB. Transporters play a key role in preventing molecules from reaching the brain. Few transporters, in particular, require therapeutic drug molecules to enter the brain [22-25]. One of the ABC family's most studied BBB transporters is the ATP binding cassette transporter (ABC Transporter) & P-glycoprotein. NRx opioid molecules such as phenytoin, phenobarbital, and levetiracetam can be eliminated by P-glycoprotein [26-28]. Another transporter, known as the solute carrier (SLC) transporter, is found in neurons and contains organic anion transporter. The presence of the BBB and different efflux transporters contribute significantly to the poor penetration of drugs to the brain and contribute to drug tolerance.

Even though many drugs are available to treat such conditions, the protective structural and physiological barriers hinder the delivery of drugs to the target tissue. The development of novel therapeutic strategies also faces obstacles to the delivery of drugs to the central nervous system due to the lack of understanding of the disease biology, low predictive value of animal models, variability in study population, lack of pharmacodynamic markers, and scarce trial-ready patients. Therefore, there is a need for alternative delivery systems that overcome these barriers and obstacles and provide predictable drug delivery [29]. **Fig. 1** represents factors responsible for the low bioavailability of poorly water-soluble drugs.

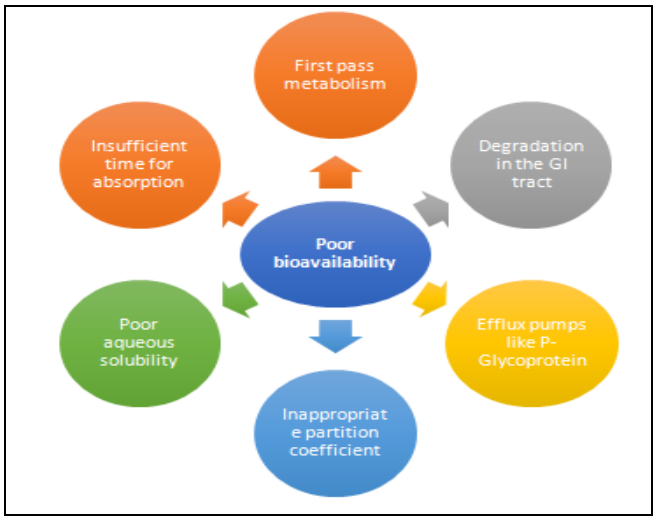

FIG. 1: REASONS FOR POOR BIOAVAILABILITY OF WATER-INSOLUBLE DRUGS

Lipid-based Drug Delivery Systems: Drug delivery systems are one of the many approaches for accomplishing targeted delivery and controlled release of pharmacological agents in the body. One such targeted delivery system is the Lipid-Based Drug Delivery System (LBDDS). Lipid-based drug delivery systems consist of a various group of formulations, each having different properties that are open to changes achieved by varying the configuration of lipid excipients and other additives, thus increasing the bioavailability of lipophilic drugs. In addition, lipid nanoparticles release the drug slowly from the lipid matrix into circulation, protecting it from enzymatic and chemical degradation thereby improving therapeutic profiles compared to free drugs. Therefore, due to their physiological and biodegradable properties, LBDDS decreases adverse effects and toxicities when compared to others of a polymeric nature [30]. Lipid nanoparticles, liposomes, solid lipid nanoparticles, and non-structured lipid carriers are a few examples of LBDDS. **Fig. 2** represents the different classes of LBDDS. They are promising tools for the treatment of neurological diseases because of their ability to overcome biological barriers, increase solubility, and provision of targeted drug delivery. They improve drug transport across BBB through passive diffusion, receptor-mediated transcytosis, and adsorptive-mediated transcytosis. They improve drug solubility and stability thereby enhancing bioavailability and drug efficacy. Lipid matrices may provide sustained release of drug, prolonging the duration of action. Some Lipid excipients used in these systems are triglycerides, mixed glycerides, polar oils, cosolvents like ethanol, Polyethylene glycol, and surfactants. Lipid systems inhibit efflux transporters and promote intestinal lymphatic transport. Solid lipid nanoparticles provide improved solubility and stability. Nanostructured lipid carriers are advanced solid nanoparticles which combine both solid and liquid lipids, enhancing drug loading and release [31].

Polymer nanoparticles are effective in drug delivery, imaging, and therapy. They provide controlled release, targeted therapy, and stability enhancement.

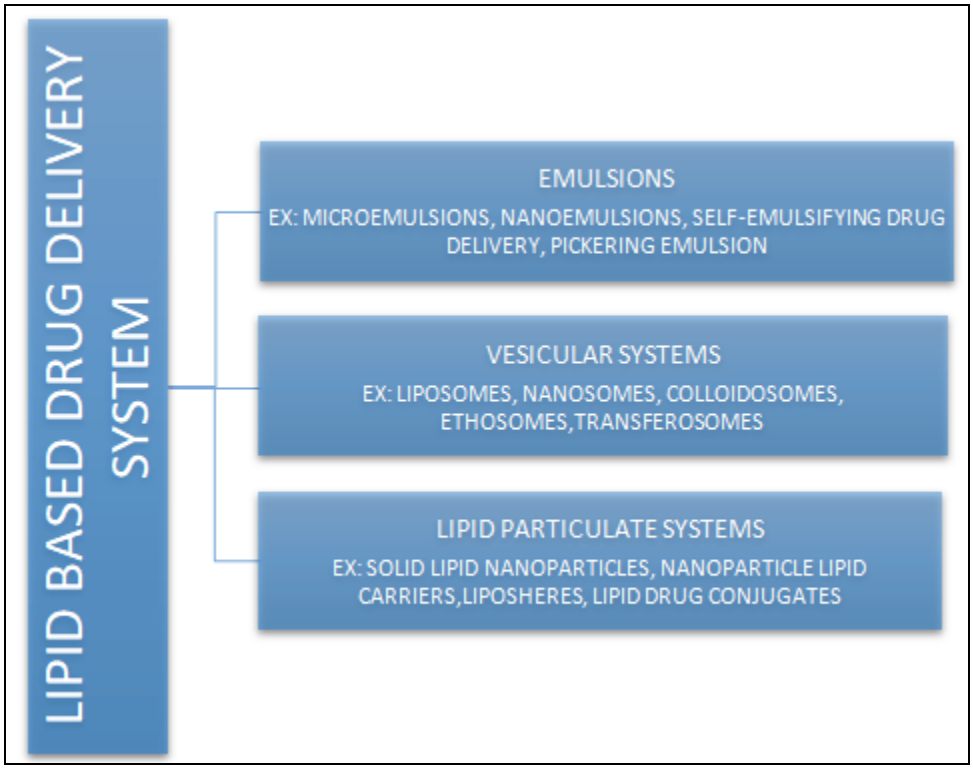

FIG. 2: TYPES OF LIPID-BASED DRUG DELIVERY SYSTEMS

Formulation of Lipid and Polymer Delivery Systems: SLNs are formulated with solid lipids, emulsifiers, and water/solvents. The lipids used may be triglycerides (tri-stearin), partial glycerides, fatty acids (stearic acid, palmitic acid), steroids (cholesterol), and waxes (cetyl palmitate). Various

emulsifiers and their combination have been used to stabilize lipid dispersion. Solid lipid nanoparticles (SLN) are colloidal carriers, where the liquid lipid (oil) has been substituted by a solid lipid. SLN offers unique properties such as small size, large surface area, high drug loading, and the interaction of phases at the interfaces. They are more slowly released and elicit superior pharmacological action than the conventional formulations [32]. Their disadvantage is limited drug loading capacity. To increase drug loading capacity and prevent drug expulsion, nanostructured lipid carriers (NLC) were developed.

Drugs showing higher solubility in oils can be dissolved in oil and coated with solid lipid outside which prevents its degradation by formulating it as NLC. Lipid drug conjugates (LDC) are one more form of LBDDS where an insoluble drug-lipid conjugate bulk is first prepared either by salt formation or by covalent bonding. The product is then treated with an aqueous surfactant and homogenized using a high-pressure homogenizer to a nanoparticle formulation. This will increase the drug loading capacity. The accompanying points will help you develop compelling frameworks for the conveyance of lipids and polymers. The main components of the frameworks are formulating frameworks for the separation of lipids and polymers, for example, dissolving point and unsaturated lipids frameworks [33-35]. This ought to be reasonable with API and prepared to additionally foster a definition trustworthiness plan of appropriate animal models to test in vivo execution of the picked enumerating and work on the definition with the suitable prescription stacking and deterioration profile [36, 37]. Careful selection of lipid components, optimization of formulation parameters, and thorough evaluation of toxicity profiles are essential to ensure patient safety. Preclinical studies have demonstrated the feasibility and efficacy of LBDDS in animal models, paving the way for clinical trials in humans.

Silica-Based Materials for Solid Carriers: Silica-based items have customarily influenced the conveyance of lipids and polymers. Silica is an exceptionally critical excipient that expands surface region and lifts drug absorbance. Mesoporous materials incorporate MCM-41 and SBA-15. Silica-based materials have provoked specialists' curiosity as conveyance instruments for a wide scope of hydrophilic and hydrophobic medication substances [36]. The organic attributes of silica-based materials make it successful in streamlining the disintegration paces of medication and oral assimilation of medication by different instruments, including (i) safeguarding medication particles in the microscopically scattered (for example indistinct) structure, (ii) keeping the medication in touch with the strong surface and equilibrium intermolecular collaborations in watery media since silica-based materials are hydrophilic (iii) It works with drug assimilation by permitting supersaturated medication solubilization [37, 38].

Challenges in Lipid and Polymer Delivery Systems: The ability to control the movement of the drug in the brain could help improve its penetration. This system could be used for the treatment of various neurological conditions. Due to the higher benefits of lipid and polymer delivery systems, they are leading from the front [39-43]. Various biocompatibility and bio-economic factors help deliver better formulations for a variety of products. Delivery systems such as polymers and lipids have been studied to improve drug solubility and bioavailability. They have low cost, fewer side effects, and are more convenient for patients. The development of LBBDS has led to the discovery of new drug molecules with promising potential. However, the key issue is that these new drugs have high molecular weights and are classified as biotherapeutics under the BCS-II classification system [44-47]. The lack of dissolved oxygen and low solubility of drugs are known to have a negative effect on the absorption and dissolution properties of tablets. This impairs the drug's ability to provide a high level of oral bioavailability [48-54]. A small number of drugs can improve the bioavailability of many drugs. However, to develop effective and safe drugs, the developers must first find ways to minimize toxicity and body disposition issues.

The bioavailability of orally regulated medications is tested by these two qualities. The items, then again, have low solvency, which brings about helpless disintegration and ingestion properties [55-59]. The atoms' feeble solvency brings about low oral bioavailability, yet in addition in high between and intracellular inconstancy, and an absence of

portion reactions. At the point when given food, few medications can further develop bioavailability [60-64]. To foster such medications that are both viable and safe, we should find some kind of harmony between bioavailability, body demeanor, and poisonousness. Micronization, complexation with cyclodextrins, strong scatterings, surfactants, and pervasion enhancers are a portion of the strategies that have been recognized to handle penetrability and dissolvability issues [65-74].

Assessment of Safety and Toxicity Concerns of Delivery Systems in Neurological Disorders: The utilization of novel materials for lipid and polymer conveyance frameworks would hold an assortment of administrative difficulties, including guaranteeing biocompatibility and human well-being. Although oral organization is viewed as more secure than different types of organization (for example parenteral), Because of ongoing progressions in the field of nanomedicine, administrative organizations have set a more noteworthy accentuation on the assurance of nanostructured materials [75, 76].

For instance, repurposing existing and bio-compatible excipients like montmorillonite starch and carbonate salts for cementing lipid and polymer conveyance frameworks faces insignificant administrative obstacles when seeking advertising endorsement. Lipid and polymer conveyance frameworks are a minimal-expense, biocompatible way to deal with growing new neurologic treatments [77-79].

CONCLUSION: Lipid and polymer conveyance frameworks intend to develop the bioavailability of ineffectively water-dissolvable medications further while reducing costs. Both hydrophobic and hydrophilic medications can be conveyed utilizing lipid and polymer conveyance frameworks. Lipid and polymer conveyance frameworks, for example, silica-based, work on the district of assimilation of medications, bringing about more advantageous ingestion. On the off chance that the medication is caught up in the ideal way, the penetrability and smooth transportation of the medication through the obstructions would be satisfactory. There are some administrative obstructions to survival, however, when they are survived, the ideal restorative activity can be accomplished with less mischief and prescription waste. The medication's biopharmaceutical effectiveness is improved by lipid and polymer conveyance frameworks.

ACKNOWLEDGMENT: The authors thank the faculty of the School of Pharmacy, Anurag University, Hyderabad, Telangana for the encouragement of review work.

CONFLICTS OF INTEREST: The authors declare there are no conflicts of interest.

REFERENCES:

1. Global health estimates 2020: Disease burden by cause, age, sex by country and by region, 2000–2019. Geneva: World Health Organization 2020.
2. Epilepsy: a public health imperative. Geneva: World Health Organization; 2019.
3. Alhakamy NA, Fahmy UA, Ahmed OAA, Caruso G, Caraci F, Asfour HZ, Bakhrebah MA, Alomary MN, Abdulaal WH, Okbazghi SZ, Abdel-Naim AB, Eid BG, Aldawsari HM, Kurakula M & Mohamed AI: Chitosan coated microparticles enhance simvastatin colon targeting and pro-apoptotic activity. Marine Drugs 2020; 18(4): 226.
4. Gershkovich P, Wasan KM and Barta CA: "A review of the application of lipid-based systems in systemic, dermal/ transdermal, and ocular drug delivery," Critical Reviews in Therapeutic Drug Carrier Systems 2008; 25(6): 545–584.
5. Hasnain MS, Kiran V, Kurakula M, Rao GK, Tabish M & Nayak AK: Use of alginates for drug delivery in dentistry. In Alginates in Drug Delivery 2020; 387–404. Elsevier.
6. Barkat MA, Das SS, Pottoo FH, Beg S and Rahman Z: Lipid-based nano system as intelligent carriers for versatile drug delivery applications. Current Pharmaceutical Design 2020; 26(11): 1167-80.
7. Salunke S, O'Brien F, Cheng Thiam Tan D, Harris D, Math MC, Ariën T, Klein S, Timpe C & European: Paediatric Formulation Initiative EuPFI. Oral drug delivery strategies for development of poorly water-soluble drugs in the paediatric patient population. Advanced Drug Delivery Reviews 2022; 190: 114507.
8. Hasnain MS, Nayak AK, Kurakula M & Hoda MN: Alginate nanoparticles in drug delivery. In Alginates in Drug Delivery 2020; 129–152). Elsevier.
9. Jacobsen AC, Kabedev A, Sinko PD, Palm JE, Bergström CAS & Teleki A: Intrinsic lipolysis rate for systematic design of lipid-based formulations. Drug Delivery and Translational Research 2023; 13(5): 1288–1304.
10. Hosny KM, Aldawsari HM, Bahmdan RH, Sindi AM, Kurakula M, Alrobaian MM, Aldryhim AY, Alkhalidi HM, Bahmdan HH, Khallaf RA & El Sisi AM: Preparation, Optimization, and Evaluation of Hyaluronic Acid-Based Hydrogel Loaded with Miconazole Self-Nanoemulsion for the Treatment of Oral Thrush. AAPS Pharm Sci Tech 2019; 20(7): 297.
11. Strickley RG: "Solubilizing excipients in oral and injectable formulations," Pharmaceutical Research 2004; 21(2): 201– 230.
12. Cannon JB, Long MA: "Emulsions, microemulsions, and lipid-based drug delivery systems for drug solubilization and delivery, part II," in Oral Applications 2008; 16: 227–254.

13. Kurakula MA and Ahmed T: Co-Delivery of Atorvastatin Nanocrystals in PLGA based *in-situ* Gel for Anti-Hyperlipidemic Efficacy. Current Drug Delivery 2015; 13(2): 211–220. https://doi.org/10.2174/1567201813666151109102718
14. Afzal O, Altamimi ASA, Nadeem MS, Alzarea SI, Almalki WH, Tariq A, Mubeen B, Murtaza BN, Iftikhar S, Riaz N and Kazmi I: Nanoparticles in Drug Delivery: From History to Therapeutic Applications. Nanomaterials (Basel) 2022; 12(24): 4494.
15. Pandey S, Shaikh F, Gupta A, Tripathi P and Yadav JS: A Recent Update: Solid Lipid Nanoparticles for Effective Drug Delivery. Adv Pharm Bull 2022; 12(1): 17-33.
16. Howard CB: "Kindling in Alcohol Withdrawal, Alcohol health and research world" Published by University of California 2018; 22(1): 25-32.
17. Ghosh A, Majie A, Karmakar V, Chatterjee K, Chakraborty S, Pandey M, Jain N, Roy Sarkar S, Nair AB and Gorain B: In-depth Mechanism, Challenges, and Opportunities of Delivering Therapeutics in Brain Using Intranasal Route. AAPS Pharm Sci Tech 2024; 25(5): 96.
18. Teleanu RI, Preda MD, Niculescu AG, Vladâcenco O, Radu CI, Grumezescu AM and Teleanu DM: Current strategies to enhance delivery of drugs across the blood–brain barrier. Pharmaceutics 2022; 14(5): 987.
19. Sandeep K and Mohan Varma M: "Oral lipid-based drug delivery systems". Acta Pharmaceutica Sinica 2013; 3(6): 361–372.
20. Roger E and Lagarce F: "Development and characterization of a novel lipid nanocapsule formulation of Sn38 for oral administration". European Journal of Pharmaceutics & Biopharmaceutics 2011; 79: 181–188.
21. Abdelhady S, Honsy KM & Kurakula M: Electro spun-nanofibrous mats: a modern wound dressing matrix with a potential of drug delivery and therapeutics. Journal of Engineered Fibers and Fabrics 2015; 10(4): 155892501501000. https://doi.org/10.1177/155892501501000411.
22. Arik D and Amnon H: "Rationalizing the selection of oral lipid-based drug delivery systems by an *in-vitro* dynamic lipolysis model for improved oral bioavailability of poorly water-soluble drugs". Journal of Controlled Release by Elsevier 2008; 6: 1-10.
23. Ahmed OAA, Kurakula M, Banjar ZM, Afouna M & Zidan AS: Quality by design coupled with near infrared in formulation of transdermal glimepiride liposomal films. J of Pharmaceutical Sciences 2015; 104(6): 2062–2075.
24. Stielow M, Witczyńska A, Kubryń N, Fijałkowski Ł, Nowaczyk J, Nowaczyk A. The Bioavailability of Drugs the Current State of Knowledge. Molecules 2023; 28(24): 803
25. Constantinides PP: "Lipid micro emulsions for improving drug dissolution and oral absorption physical and biopharmaceutical aspects". Pharmaceutical Research 2007; 12(11): 1561-1572.
26. Alhakamy NA, Ahmed OAA, Kurakula M, Caruso G, Caraci F, Asfour HZ, Alfarsi A, Eid BG, Mohamed AI, Alruwaili NK, Abdulaal WH, Fahmy UA, Alhadrami HA, Eldakhakhny BM & Abdel-Naim AB: Chitosan-based microparticles enhance ellagic acid's colon targeting and proapoptotic activity. Pharmaceutics 2020; 12(7): 1–14. https://doi.org/10.3390/pharmaceutics12070652
27. Alrushaid N, Khan FA, Al-Suhaimi EA and Elaissari A: Nanotechnology in Cancer Diagnosis and Treatment. Pharmaceutics 2023; 15(3): 1025.
28. Gagliardi A, Giuliano E, Venkateswara Rao E, Fresta M, Bulotta S, Awasthi V and Cosco D: Biodegradable polymeric nanoparticles for drug delivery to solid tumors. Frontiers in Pharmacology 2021; 12: 601626.
29. Wu D, Chen Q, Chen X, Han F, Chen Z and Wang Y: The blood–brain barrier: structure, regulation, and drug delivery. Signal Transduction and Targeted Therapy 2023; 8(1): 217.
30. Kesharwani R, Jaiswal P, Patel DK and Yadav PK: Lipid-based drug delivery system (LBDDS): An emerging paradigm to enhance oral bioavailability of poorly soluble drugs. Biomedical Materials & Devices 2023; 1(2): 648-63.
31. Rezigue M: Lipid and polymeric nanoparticles: drug delivery applications. Integrative Nanomedicine for new Therapies 2020; 167-230.
32. Agarwal P and Vasudha B: Preparation and Evaluation of Primidone Solid Lipid Nanoparticle for Alleviating Seizure Activity in Wistar Rats. International Journal of Drug Delivery Technology 2023; 13(3): 919-925.
33. Raghavendra Naveen N, Kurakula M & Gowthami B: Process optimization by response surface methodology for preparation and evaluation of methotrexate loaded chitosan nanoparticles. Materials Today: Proceedings 2020. https://doi.org/10.1016/j.matpr.2020.01.491
34. Seko I, Şahin A, Tonbul H and Çapan Y: Brain-targeted nanoparticles to overcome the blood-brain barrier. Journal of Pharmaceutical Technology 2020; 1(1): 25-39.
35. Viegas C, Patrício AB, Prata JM, Nadhman A, Chintamaneni PK and Fonte P: Solid Lipid Nanoparticles *vs.* Nanostructured Lipid Carriers: A Comparative Review Pharmaceutics 2023; 15(6): 1593.
36. Vanitasagar S, Srinivas C, Subhashini NJP & Mallesh K: Solid dispersion-a comparative study on the dissolution rate of aceclofenac. International Journal of Pharmacy and Pharmaceutical Sciences 2012; 4(3): 274–278.
37. Mahor AK, Singh PP, Gupta R, Bhardwaj P, Rathore P, Kishore A, Goyal R, Sharma N, Verma J, Rosenholm JM and Bansal KK: Nanostructured lipid carriers for improved delivery of therapeutics *via* the oral route. Journal of Nanotechnology 2023; (1): 4687959.
38. Santra S and Majee SB: Lipid based Vehicles and Lipid-based Excipients in Drug delivery. Research Journal of Pharmacy and Technology 2022; 15(5): 2334-8.
39. Kurakula M, El-Hel AM, Sobahi TR & Abdelaal MY: Chitosan based atorvastatin nanocrystals: Effect of cationic charge on particle size, formulation stability, and *in-vivo* efficacy. International Journal of Nanomedicine 2015; 10: 321–334. https://doi.org/10.2147/IJN.S77731
40. Abouelmagd SA and Hyun H: "Extracellularly achievable nanocarriers for drug delivery to tumor". Expert Opinion Delivery 2014; 11: 1601-1618.
41. Kurakula M & Koteswara Rao GSN: Moving polyvinyl pyrrolidone electrospun nanofibers and bioprinted scaffolds toward multidisciplinary biomedical applications. European Polymer Journal 2020; 136: 109919. https://doi.org/10.1016/j.eurpolymj.2020.109919.
42. Agrawal S, Giri TK, Tripathi DK and Alexander AA: "A review on novel therapeutics strategies for the enhancement of solubility for hydrophobic drugs through lipid and surfactant based self-micro emulsifying drug delivery system: a novel approach". American Journal of Drug Discovery & Development 2012; 2: 143–183.
43. Kurakula M, Naveen NR & Yadav KS: Formulations for Polymer Coatings. Polymer Coatings 2020; 415–443. https://doi.org/10.1002/9781119655145.ch19
44. Aungst BJ: "Novel formulation strategies for improving oral bioavailability of drugs with poor membrane

permeation or pre systemic metabolism". Journal of Pharmaceutical Science 1993; 82: 979–987.
45. Kurakula M & Raghavendra Naveen N: In situ gel loaded with chitosan-coated simvastatin nanoparticles: Promising delivery for effective anti-proliferative activity against tongue carcinoma. Marine Drugs 2020; 18(4): 201. https://doi.org/10.3390/md18040201
46. Brannon-Peppas L and Blanchette JO: "Nanoparticle and targeted systems for cancer therapy". Advance Drug Delivery Review 2004; 56: 1649–1659.
47. Burkersroda FV, Schedl L and Göpferich A: "Why degradable polymers undergo surface erosion or bulk erosion". Biomaterials 2002; 23: 4221–4231.
48. Kurakula M, Rao GK, Kiran V, Hasnain MS & Nayak AK: Alginate-based hydrogel systems for drug releasing in wound healing. In Alginates in Drug Delivery 2020; 323–358. Elsevier. https://doi.org/10.1016/b978-0-12-817640-5.00013-3
49. Chang C, Wei H, Quan CY and Li YY: "Fabrication of thermosensitive PCL-PNIPAAm-PCL triblock copolymeric micelles for drug delivery". Journal of Polymer Science Part A 2008; 46: 3048–3057.
50. Kurakula M & Rao GSNK: Pharmaceutical assessment of polyvinylpyrrolidone (PVP): As excipient from conventional to controlled delivery systems with a spotlight on COVID-19 inhibition. Journal of Drug Delivery Science and Technology 2020; 60: 102046. https://doi.org/10.1016/j.jddst.2020.102046
51. Kaity S, Isaac J and Ghosh A: "Interpenetrating polymer network of locust bean gum-poly (vinyl alcohol) for controlled release drug delivery". Carbohydrate Polymer 2013; 94: 456–467.
52. Knepp VM, Hinz RS and Szoka FC: "Controlled drug release from a novel liposomal delivery system". International Investigation of transdermal potential". Journal Control Release 1987; 5: 211–221.
53. Korsmeyer RW, Gurny R and Doelker E: "Mechanisms of potassium chloride release from compressed, hydrophilic, polymeric matrices: effect of entrapped air". Journal Pharm Science 1983; 72: 1189–1191.
54. Kurakula M, Sobahi TR, El-Helw A & Abdelaal MY: Development and validation of a RP-HPLC method for assay of atorvastatin and its application in dissolution studies on thermosensitive hydrogel-based nanocrystals. Tropical Journal of Pharmaceutical Research 2014; 13(10): 1681–1687. https://doi.org/10.4314/tjpr.v13i10.16
55. Anette M and Anayo O: "New perspectives on lipid and surfactant-based drug delivery systems for oral delivery of poorly soluble drugs". JPP Journal of Pharmacy and Pharmacology 2010; 62: 1622–1636.
56. Kurakula M, Srinivas C, Kasturi N & Diwan PV: Formulation and Evaluation of Prednisolone Proliposomal Gel for Effective Topical Pharmacotherapy. International Journal of Pharmaceutical Sciences and Drug Research 2012; 4(1): 35. www.ijpsdr.com
57. Cardoso FL, Brites D and Brito MA: "Looking at the blood brain barrier: Molecular anatomy and possible investigation approaches". Brain Research Review 2010; 64: 328–363.
58. Mallesh K, Pasula N & Kumar Ranjith CP: Piroxicam proliposomal gel: a novel approach for tropical delivery. Journal of Pharmacy Research 2012; 5(3): 1755–1763.
59. Begley DJ: "Delivery of therapeutic agents to the central nervous system: The problems and the possibilities". Pharmacology & Therapeutics 2004; 04: 29–45.
60. Mohd AB, A, PR & Diwan PV: Estimation of Prednisolone in Proliposomal formulation using RP HPLC method. Int J Chem Anal Sci 2011; 2: 11932(4): 1663–1669.
61. Mahar Doan KM and Humphreys JE: "Passive permeability and P-glycoprotein-mediated efflux differentiate central nervous system (CNS) and non-CNS marketed drugs". Journal of Pharmacology Experiments & Therapeutics 2002; 303: 1029–1037.
62. Mohd AB, A, PR & Diwan PV: Estimation of Prednisolone in Proliposomal formulation using RP HPLC method. Int J Res Pharm Biomed Sci 2011; 2: 6632(4): 1663–1669.
63. Levin VA: "Relationship of octanol/water partition coefficient and molecular weight to rat brain capillary permeability". Journal of Medicinal Chemistry 1980; 23: 682–684.
64. Bodor N and Buchwald P: "Brain-targeted drug delivery". American Journal of Drug Target 2003; 1: 13–26.
65. MacKay JA, Deen DF and Szoka FC: "Distribution in brain of liposomes after convection enhanced delivery; modulation by particle charge, particle diameter, and presence of steric coating". Brain Research 2005; 1035: 139–153.
66. Murali VP, Fujiwara T, Gallop C, Wang Y, Wilson JA, Atwill MT, Kurakula M & Bumgardner JD: Modified electrospun chitosan membranes for controlled release of simvastatin. International Journal of Pharmaceutics 2020; 584: 119438. https://doi.org/10.1016/j.ijpharm.2020.119438
67. Partridge B, Eardley A, Morales BE, Campelo SN, Lorenzo MF, Mehta JN, Kani Y, Mora JK, Campbell EO, Arena CB and Platt S: Advancements in drug delivery methods for the treatment of brain disease. Frontiers in Veterinary Science 2022; 9: 1039745.
68. Naguib GH, Hassan AH, Al-Hazmi F, Kurakula M, Al-Dharrabh, A., Alkhalidi, H. M., Al-Ahdal, A. M., Hamed, MT & Pashley DH: Zein based magnesium oxide nanowires: Effect of anionic charge on size, release and stability. Digest Journal of Nanomaterials and Biostructures 2017; 12(3): 741–749.
69. Chahar RK, Tiwari C, Malik P and Jaiswal PK: Brain-targeted drug delivery system: a novel approach. Journal of Drug Delivery and Therapeutics 2022; 12(6): 171-8.
70. Naguib, Ghada Hussein, Al-Hazmi FE, Kurakula M, Abdulaziz Al-Dharrab A, Mohamed Hosny K, Mohammed Alkhalidi H, Tharwat Hamed M, Habiballah Hassan A, Al-Mohammadi AM, Mohamed Alnowaiser A & Henry Pashley D: Zein coated zinc oxide nanoparticles: Fabrication and antimicrobial evaluation as dental aid. International Journal of Pharmacology 2018; 14(8): 1051–1059.
71. Pardridge WM, Golden PL and Kang YS: "Brain micro vascular and astrocyte localization of P-glycoprotein". Journal of Neurochemicals 1997; 68: 1278–1285.
72. Naveen NR, Gopinath C & Kurakula M: Okra-thioglycolic acid conjugate-synthesis, characterization, and evaluation as a mucoadhesive polymer. Processes 2020; 8(3): 316. https://doi.org/10.3390/pr8030316
73. Al Rihani SB, Batarseh YS and Kaddoumi A: The Blood–Brain Barrier in Health and Disease. International Journal of Molecular Sciences 2023; 24(11): 9261.
74. Reese TS and Karnovsky MJ: "Fine structural localization of a blood-brain barrier to exogenous peroxidase". Journal of Cell Biology 1967; 34: 207–217.
75. Mohite P, Singh S, Pawar A, Sangale A and Prajapati BG: Lipid-based oral formulation in capsules to improve the delivery of poorly water-soluble drugs. Frontiers in Drug Delivery 2023; 3: 1232012.

76. Yadav KS, Arora S, Yasaswi PS, Nirale P, Solanki A and Bhat J: Self-nano-emulsifying Drug Delivery Systems of Atorvastatin Calcium Liquid Filled in Hard Shell Capsules for Improved Oral Bioavailability in Rabbits. Current Nanoscience 2024; 20(4): 554-63.
77. Holm R, Kuentz M, Ilie-Spiridon AR and Griffin BT: Lipid-based formulations as supersaturating oral delivery systems: from current to future industrial applications. European J of Pharma Sciences 2023; 189: 106556.
78. Preeti, Sambhakar S, Saharan R, Narwal S, Malik R, Gahlot V, Khalid A, Najmi A, Zoghebi K, Halawi MA, Albratty M and Mohan S: Exploring LIPIDs for their potential to improves bioavailability of lipophilic drugs candidates: A review. Saudi Pharm J 2023; 31(12): 101870.
79. Rao GSNK, Kurakula M & Yadav KS: Application of Electrospun Materials in Gene Delivery. Electrospun Materials and Their Allied Applications 2020; 265–306.

How to cite this article:
Agarwal P and Bakshi V: A novel approach to treat neurological disorder by using lipid-based drug delivery system. Int J Pharm Sci & Res 2024; 15(7): 2222-29. doi: 10.13040/IJPSR.0975-8232.15(7).2222-29.