Translational potential of nanocarriers for ocular medication delivery.

David Penson*

Department of Urologic Surgery, Vanderbilt University, Nashville, USA

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Abstract

The eye can be broadly divided into the anterior and posterior segments. The anterior segment includes the cornea, conjunctiva, iris, ciliary body, lens, and aqueous humour, while the posterior segment includes the sclera, choroid, retina, and vitreous body. The anterior and posterior segments of the eye are affected by several vision-threatening diseases. To treat eye diseases, topical administration is the preferred non-invasive technique. However, 90% of currently available conventional ophthalmic formulations are eye drops, which are principally administered into the conjunctival cul-de-sac and exhibit poor ocular bioavailability because various anatomical and physiological constraints impede drug delivery to both the anterior and posterior regions of the eye. Physiological barriers (nasolacrimal drainage, lacrimation rate, blinking) are among them, as are anatomical barriers (static and dynamic), efflux pumps, and ocular tissue metabolism. The tear film also serves as a barrier, preventing drug absorption when applied topically. An outside lipid layer, a middle aqueous layer, and an inner mucus layer make up the tear film. As a result, the medication is diluted and wiped away by the tear film. Furthermore, mucin in the tear film produces a hydrophilic layer on the ocular surface's glycocalyx, protecting the eye from cell debris and external substances while also functioning as a barrier to medications delivered.

Keywords: Bruch's membrane, Corneal epithelium, Anti-glaucoma, Collagen fibres.

Introduction

Drug entrance into the anterior chamber of the eye is limited by static (corneal epithelium, stroma, and blood–aqueous barrier) and dynamic (conjunctival blood, lymph flow, and lachrymation) barriers in the anterior segment. Epithelium, Bowman's membrane, stroma, Descemet's membrane, and endothelium are the five layers of the human cornea, each with a different polarity [1]. The cornea epithelium is made up of 5–6 layers of tightly packed cells with tight junctions that keep microbes and drugs out. Clear transparent fluid fills the posterior and anterior chambers of the eye (aqueous humour). The ciliary body's epithelium produces aqueous humour, which gives nutrition to the cornea. The aqueous humour travels from the posterior chamber to the anterior chamber via the pupil.

The static barriers (sclera, choroid, Bruch's membrane, and blood–retinal barrier) and the dynamic barriers (sclera, choroid, Bruch's membrane, and blood–retinal barrier) limit drug transport to the posterior portion (choroidal blood and lymph flow). The sclera is the eye's outermost layer, which is made up of unevenly organised collagen fibres that prevent external substances from entering the posterior ocular structures [2]. As a result, medicines with a large molecular radius and high lipophilicity cannot pass through the aqueous scleral pores. Furthermore, the thickness of the sclera varies from 1 mm at the posterior pole to 25 to 250 nm in the equatorial region, indicating low drug permeability in the posterior region. The choroid removes medicines from the bloodstream before they reach Bruch's membrane. The clogging of Bruch's membrane with cell debris inhibits the exchange of nutrients and medicines. The blood–retinal barrier tight junctions with the inner retinal vascular endothelium and outer retinal pigment epithelium make up the posterior segment. These prevent medications from penetrating into the intraocular chambers once they've been given [3].

The conjunctiva is made up of multilayered epithelium and stroma, and there are fewer intercellular gaps than in the corneal epithelium. As a result, for hydrophilic medicines, the cornea and conjunctiva serve as a rate-limiting step. Blood capillaries and lymphatics make up the conjunctival stroma, which contributes to medication leakage into the systemic circulation. Furthermore, efflux proteins hinder antiviral and anti-glaucoma medications from entering the body. Metabolic enzymes, on the other hand, prohibit xenobiotics from entering the body. The degree to which the aforementioned barriers have an impact on drug bioavailability is determined by the route of delivery.

Cataracts, glaucoma, dry eye, and other infectious illnesses of the anterior segment can all contribute to poor vision or blindness. Eye drops are commonly prescribed to treat these disorders, however tear fluid generation, lacrimal drainage, and barrier functions limit the efficiency of the medications delivered. The ocular residence duration may be improved by using films, hydrogels, and implants to administer drugs

[4]. These methods, however, can restrict eyesight and cause discomfort to patients. Long-term interaction with the carrier material in implants could jeopardise the ocular tissue's safety.

Nanomedicine can remain in the vitreous region for an extended period of time, delivering beneficial medication concentrations to the target site. Intravitreal nanomedicine administration can minimise the dose and frequency of dosing, and using less invasive techniques can lessen the medical burden on patients and healthcare providers. When nanocarriers larger than 300 nm are delivered to the back of the eye, they produce aggregation and vision disruption. A particle size of less than 300 nm reduced the likelihood of aggregation while simultaneously improving release and drug loading, both of which are critical. All of these factors combine to create a bottleneck in nanoparticle distribution to the eye.

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***Correspondence to:**

David Penson
Department of Urologic Surgery,
Vanderbilt University, Nashville,
USA Stanford, CA 94305, USA
E-mail: Penson.David@gmail.com

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