Glaucoma and Brain Nerve Relation

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Abstract: Glaucoma is a common eye condition where optic nerve damage, this is not only the pathological changes in the optic nerve its effect the brain nerve too, the human brain is a complex web of neurons and synapses, however the eye correlated with the brain in a specific way, therefore when people study the diseases of the eye the first thing that comes to mind is always the connection to the brain. Which means glaucoma lesions are not limited to the retinal nerves, its damage reaches the white matter areas that are involved in the processing and integration of visual information in the brain, which means that the damage caused by glaucoma can reach the brain. We found researchers who used the VBM method to study whole brain comparisons in glaucoma patients, to meticulously describing the effects of glaucoma lesions in the brain. These two methods allow the comparison of multiple images of the brain with voxels to measure differences in local concentrations of brain tissue, thus revealing intra cerebral differences between patients with glaucoma and the general. It is also the relationship between glaucoma and the nerves in the brain that is at the center of the title and exploration of this paper. The differences between the brains of glaucoma patients and the general will be mentioned, as well as the pathogenesis of glaucoma, the treatment of the glaucoma works through medical method and surgery are also be mentioned in this paper.

1 INTRODUCTION

Over 60 million people worldwide are diagnosed with glaucomatous optic neuropathy, which is a disease that could cause irreversible blindness. It is a leading public health concern given the high prevalence. Are large proportion of people with glaucoma still remained undiagnosed, since the accurate decision of glaucoma is challenging, particularly in early disease. Patients with early glaucoma are typically unaware of it, other patients with severer or more advanced disease may see a shadow in their vision or a reduction in their acuity of visual. There may be difficulties when diagnosing glaucoma without facilities to measure IOP and evaluate optic discs and visual fields. A proportion of patients may experience headache, ocular pain, nausea, vomiting, and blurred vision if they are diagnosed as angle closure glaucoma. Once diagnosed, glaucoma needs lifelong monitoring, IOP is need to be monitored and functional visual change is evaluated during the visual field testing especially in the secondary care. Glaucoma is referred to characteristic damage to the optic nerve and patterns of visual field loss. Degeneration of these nerves results in cupping, a characteristic appearance of the optic disc and visual loss. This results in the loss of Retinal ganglion cells(RGCs) which carries the visual information from the retina to the brain. After the damage, the RGC undergo apoptosis resulting in visual loss. Glaucoma can be classified into two broad categories: Open angle glaucoma and angle closure glaucoma. They can be classified by mechanism and appearance of the anterior chamber angle. As shown in figure 1. The dominant group of patients are diagnosed with open angle glaucoma. While the others with severe vision loss are diagnosed as angle closure glaucoma. Both of the glaucoma can be primary diseases.

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Secondary glaucoma can result from trauma or other conditions such as pigment dispersion. The treatment options for glaucoma are medical, laser, and surgical options for them to lower IOP. Usually, patients starts with glaucoma drop mono-therapy. However, if the case is too difficult to control, extra drops will be added as required. Furthermore, if the maximum tolerant treatment is unsuccessful, a laser intervention may be advised, in some cases, the patients may proceed directly to surgery. Our goal is to identify the connections between glaucoma and the brain, since our visual function depends mostly on our nerves in brain. Treatments for glaucoma and the nerves in our brain which links our eyes and visions together will be laid out.

2 GLAUCOMA

2.1 Profile of Glaucoma

Glaucoma is one of the major causes of irreversible blindness over the world and is associated with damages to the optic nerves and degeneration of the retinal ganglion cell (RGC). The major risk factor is Intraocular pressure (IOP) inside the eye. Over 60 million people worldwide are estimated with glaucomatous optic neuropathy, in which about 8.5 million are blind (Review and MetaAnalysis). The definition of clinical glaucoma could be defined as a various multifactorial ocular disorders, combined with clinically characteristic optic neuropathy, which the optic nerve head (ONH) has potentially progressive and clinically visible changes, including focal or generalized neuroretinal rim thinning, enlargement and excavation of the optic cups. This represents the neurodegeneration of retinal ganglion cell axons and the deformation of the lamina cribrosa; in the early stage of glaucoma, corresponding diffuse and localized nerve-fiber-bundle pattern visual field loss might not be able to be detectable; while visual acuity is initially spared, progression can lead to complete loss of vision; The collection of clinical features is diagnostic (Foster, Buhrmann, Quigley, Johnson 2002).

Open-angle or angle-closure are the two subtypes of glaucoma, where angle closure refers to the presence of appositional or synechial iridotrabecular contact leading to the obstruction of trabecular meshwork and elevated IOP(Foster, Buhrmann, Quigley, Johnson 2002).

2.2 The Human Visual Pathways

There are two parts in the human visual pathways; the anterior visual pathway is composed of the retina, optic nerve, and chasm and lateral geniculate nucleus (LGN), while the optic radiations and visual cortex are comprised in the posterior visual pathway. Over 90% of RGC axons in human project to the LGN, a relay station which in turn projects its axons to the visual cortex cia the optic radiation. The other 10% of RGCs project to brain structures, including the superior colliculus, which commands the movement of the eye, pretectal area (pupillary reflex) and the accessory optic system nuclei, that is the optokinetic nystagmus (Goebel, Muckli LARS, Kim DS 2004).

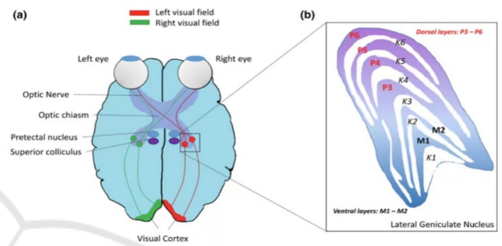

Figure 1: Overview of the human visual pathway. a Diagrammatic representation of the human visual pathway. b Overview of the structure of the lateral geniculate nucleus illustrating the organization of magnocellular (M-cells), parvocellular (P-cell), and Koniocellular cells (K-cells)

2.3 Visually Relates Imaginary Structure

Most visual functions are controlled by the occipital lobe, a small section of the brain near the back of the skull. However, processing eyesight is a complicated work, the other parts of the brain will also need to be involved. The occipital lobe is responsible for receiving the data from our visions. Thus, injuries or illnesses which could affect the occipital lobe can cause detrimental effects such as visual disturbances or even blindness.

The connections throughout the eye and the brain utilizes a structure in brain called the pons. It is shaped as a horse-shoe composed of transversed nerve fibres, lying above medulla oblongata and bellow cerebellum. It controls the movements of the eye, sending signals which helps the eye respond to the correct stimulus of light. The lights reflects into our eyes strikes photo-receptor cells in the retina called rods and cones. Rod cells only respond when the surrounding area is in a dim condition thus it is responsible for our peripheral vision and night vision, while cone cells react to brighter light, giving us

When light hits its corresponding rod or cone, the cell activates, then it transmits a nerve impulse through the optic nerve. This impulse ends up at the occipital lobe, where it's processed and perceived as a visible image. Occasionally, occipital lobe sends this visual information to the hippocampus in the temporal lobe, stored as a memory.

3 GLAUCOMA EXPERIMENT

3.1 Glaucoma Neuropathy

Glaucoma neuropathy is not limited to retinal ganglion cells, it can affect the entire visual system. In a series of studies conducted by Dr. Carlo Nucci, a full professor of ophthalmology at the University of Tower Vergara in Rome, and his colleagues observed that in patients with early glaucoma, the optic nerve damage is mainly located at the proximal end of the eyeball, while in patients with advanced glaucoma in the middle, the optic nerve damage is at the far back of the eyeball. They also found that glaucoma damage reaches the white matter areas, which are involved in the processing and integration of visual information in the brain. Because the retinal ganglion cell axon is extended from the retina through the optic nerve to the brain, the cells in its immediate vicinity can also be damaged by glaucoma. (Gupta, Neeru,. Yücel 2007)

3.2 Use VBM to Compare

In the retina, other cells, such as anapestic cells, regenerate and rejoin their connections after the retinal ganglion cells are lost.Recently, researchers have shown that glaucoma is not simply an eye disease, but may be a disease of the central nervous system. The central nervous system in glaucoma may have similar or dissimilar pathogenesis to other cranio-cerebral disorders. (Li, et al 2012) They are using the VBM method to study whole brain comparisons in glaucoma patients. When comparing patients with glaucoma to those with normal glaucoma, there were no differences in whole brain grey matter, white matter, or brain parenchyma volumes in patients with glaucoma. However in the left middle frontal gyrus, right superior frontal gyrus, right precuneus, and right angular gyrus, the volume of the grey matter area decreased and the grey matter-free area increased. While the volume of the white matter area in the right middle occipital gyrus decreased and the volume of the white matter area in the right precentral gyrus increased, the areas of local volume changes in brain structures in the NTG group all correlated with GSS staging, this suggests that glaucoma does not cause changes in the volume of grey matter, white matter and brain parenchyma in the whole brain, but the change have probability to displayed and the analysis was generally based on reduction. changes in brain structures in the NTG group were mainly concentrated in frontal lobe (left middle frontal gyrus, right superior frontal gyrus and right precentral gyrus), occipital lobe (right precuneus, right middle occipital gyrus) and parietal lobe (right angular gyrus). The frontal lobe is not only the processing and adjustment center for higher cognitive functions, but is also responsible for initiating, monitoring and modifying emotions. It has a specific role in emotional decision-making and emotional self-regulation and response inhibition. (Iau, Ptc, et al. 2004) Numerous studies agree that patients with glaucoma have varying degrees of deficits in emotion regulation, which may be associated with structural damage and dysfunction in brain regions. Another study found a close relationship between glaucoma and various degenerative diseases of the central nervous system, mainly manifesting as widespread brain atrophy. The processing of visual information has extensive connections with other brain regions and plays an important role in the integration of visual information with other sensory systems. Several studies have shown a reduction in the volume of the right middle gyrus of the group occipital lobe to support the NTG In patients, there is indeed localized atrophy of the occipital lobe, which is sufficient to suggest that glaucoma damage extends beyond the visual cortex and also affects the wider central nervous system. (Iau, Ptc , et al. 2004)

3.3 The Pathogenesis of Glaucoma

The pathogenesis of glaucoma can be grouped into two main categories: the mechanical theory and the vascular theory. The mechanical theory emphasizes the role of IOP and suggests that elevated IOP causes deformation and displacement of the layers of the sieve plate, resulting in shear forces that block the axoplasmic flow of optic nerve cells in the sieve plate area and reduced production and transport of axonal proteins, leading to impaired cellular metabolism.(Garaci, Francesco, et al., 2009) In contrast, the vascular theory suggests that due to various causes of impaired microcirculation in the optic nerve papilla, the supply of nutrients to the optic papilla and its surrounding tissues is reduced, causing the tissue there to become stunted or damaged, and damage to the optic nerve fibers occurs due to ischemia and hypoxia and loss of protection from surrounding tissues. A one-sided emphasis on the role of mechanical or vascular theories in the pathogenesis of glaucoma is biased. The mechanical theory does not fully explain the occurrence of normal Intraocular pressure glaucoma and signs of high Intraocular pressure, while the vascular theory does not exclude an important role for Intraocular pressure in the pathogenesis of glaucoma. Therefore, it is generally accepted that the pathogenesis of glaucoma is a multifactorial and integrated process. "Glaucoma is an optic neuropathy with characteristic optic nerve damage and corresponding impairment of visual function". (Gupta, Neeru, Yücel. 2001)This suggests that progressive damage to the optic nerve head is the essential feature of glaucoma and can therefore be divided into factors that cause damage to the optic nerve head and factors that resist damage to the optic nerve head according to the role of various factors in the pathogenesis of glaucoma Normal people are able to achieve a paradoxical balance between factors that cause damage to the optic nerve head and factors that resist damage to the optic nerve head making The optic nerve head is protected from damage. In patients with glaucoma, the balance is disturbed when the optic nerve head damaging factor is enhanced or the anti-optic nerve head damaging factor is weakened for some reason unilaterally, resulting in progressive damage to the optic nerve head.(Garaci, Francesco, et al. 2009)

4 MEDICAL TREATMENT FOR GLAUCOMA

4.1 Glaucoma Drops

The goal of treating glaucoma is to slow down the disease's progression and preserve the quality of life. Intraocular pressure reduction is the only proven method to achieve this objective. Several multicenter trials have shown that this procedure can prevent the development and slow the disease's progression. The initial target pressure should be decreased gradually over time to a level that is considered ideal for patients. It should also be adjusted depending on the evolution of the condition. For instance, even though the target pressure has been set, it may still need to be lowered due to disease progression. Several classes of pressure-lowering drugs are available. They can be used with or without a schedule of events. The choice of medication can be influenced by the cost, safety, and efficacy of the drug.(Weinreb, Aung , Medeiros 2014) Glaucoma drops have the ability to lower the IOP by changing the production or the out flow of outflow of aqueous humour from the eye. Primary treatments are usually Prostagladin analogues since they possess the greatest ability to lower the IOP, furthermore, profiles showcased that they also have the smallest side effects. These side effects from using the drops often causes blurring and transient stinging, some may also cause discomfort in eyes, redness or stimulating the growth of eyelashes. Adherence to glaucoma drops is variable and difficult to evaluate. (Kass, Gordon, Meltzer 1986) This causes it to be hard to evaluate whether if the effects of therapeutic is not enough or if the patients fail to use the drops properly. If the IOP have not been controlled, once the amount of drops a patient can have exceeds, laser or surgical invention may be needed.

4.2 Laser Treatment

Laser trabeculoplasty could be considered as as a primary selection for the patients. It lowers the IOP for open angle glaucoma by increasing the out flow. This procedure of Laser trabeculoplasty is clinically based.A recent systematic review of laser trabeculoplasty highlighted the lack of data comparing the effectiveness of this procedure with modern medical and surgical options. (Rolim de Moura, Paranhos, Wormald, 2007) The process of which it opens the drainage tube, allowing more fluid to drain from the eye, therefore reducing the pressure. Another laser treatment could be cyclodiode laser treatment, which it destruct some of the tissues with in the eye that produces the liquid that is causing pressure.

4.3 Surgery

This option is often suggested when the formal treatments cannot succeed in lowering the IOP. Yet, it could be used earlier if the patient have difficulties in using the drops or whose presenting with advanced glaucoma. The standard operation of glaucoma creates aguarded fistula into the wall of the eye (sclera), which allows a slow egression of aqueous humour from the anterior chamber into the subconjunctival space. (Wong, Husain, Ang, Gazzard, Foster, Htoon, et al 2013) Trabeculectomy is the commonest surgical method of reducing eye pressure. It involves debridement of a small portion of the trabecular meshwork, or adjacent corneal and scleral tissue, to provide a drainage pathway for water to drain from the eye into the conjunctiva and be absorbed under the conjunctiva. Anti-scarring drugs are often used at the surgical site to reduce the fibrotic response and improve the success of the procedure, but may increase the incidence of complications such as infection and very low intraocular pressure damage. A recent meta-analysis comparing trabeculectomy with non-penetrating procedures (deep sclerectomy, mucosal ostomy and catheter angioplasty) concluded that although trabeculectomy was more effective in reducing blood pressure, the risk of complications was higher. (Weinreb, Aung, Medeiros 2014)

5 CONCLUSIONS

Glaucoma is not limited to retinal ganglion cells, it can affect the entire visual system. Damage reaches the white matter areas involved in processing and integration of visual information in the brain. we integrated the studies of VBM and Dartel methods of whole brain comparisons in patients. Which suggest that glaucoma damage extends beyond the visual cortex and also affects the wider central nervous system. Glaucoma damage is complex and widespread. What we need to do in the future is to pay more attention to the effects of glaucoma on the central nervous system, and to study and compare the differences between patients In order to better understand the central nervous system glaucoma in different disease stages, more methods are needed to treat eye diseases. Strategies to prevent the progression of glaucoma disease should also take into account the degeneration of the central nervous system other than wisdom and optic nerve head.

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