LITERATURE REVIEW

EFFECTS OF CATARACT SURGERY ON THE CORNEAL ENDOTHEL

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ABSTRACT

Introduction: *Manual cataract surgery techniques such as SICS and ECCE are still used today but not as many as phacoemulsification. Corneal endothelium can be damaged due to various factors during surgery such as intraoperative manuver, excessive ultrasound power, pressure during irrigation, collision between lens fragments and corneal endothelium, large air bubbles, and increased temperature during surgery.*

Methods: *Journal articles and books in this paper were searched through various available search engines, including using searches through the sites Google Scholar, Medline, Proquest. The search method uses one or a combination of keywords, namely cataract surgery, corneal endothelial damage, corneal endothelium, specular microscope. Articles in this paper are found in English and Indonesian.*

Results: *From several studies it can be concluded that the risk factors that greatly affect the corneal endothelium include age, race, use of contact lenses, surgery, trauma, refractive errors and anatomical abnormalities on the surface of the eyeball.*

Conclusion: *Cataract surgery technique is significantly associated with the incidence of bullous keratopathy because the maneuvers are very prone to injuring the corneal endothel. The average percentage of damage to endothelial cells reaches 15%. This is what underlies the need for further research to find new methods that can protect the corneal endothelium.*

Keywords: *Corneal Endothel, SICS, ECCE, Phacoemulsification*

INTRODUCTION

The function of the corneal endothelium is vital for maintaining the integrity of the cornea and the clarity of vision. Endothelial cells cannot regenerate, therefore, the gradual decline in endothelial cells is the result of damage compensation, endothelial cells repair themselves by enlarging or shifting to cover the gaps in damaged cells. A highly popular and proven operation is phacoemulsification. Manual cataract surgery techniques such as SICS and ECCE are still used today but not as many as phacoemulsification. Phacoemulsification is commonly use because of the minimal size of the incisions and provides more satisfactory visual results for the patient. Many literatures have compared the effects of cataract surgery with manual methods or phacoemulsification on corneal endothelial damage. Corneal endothelium can be damaged due to various factors during surgery such as intraoperative manuver, excessive

ultrasound power, pressure during irrigation, collision between lens fragments and corneal endothelium, large air bubbles, and increased temperature during surgery.[1]

METHODS

Journal articles and books in this paper were searched through various available search engines, including using searches through the sites Google Scholar, Medline, Proquest. The search method uses one or a combination of keywords, namely cataract surgery, corneal endothelial damage, corneal endothelium, specular microscope. Articles in this paper are found in English and Indonesian.

RESULTS

From several studies it can be concluded that the risk factors that greatly affect the corneal endothelium include age, race, use of contact lenses, surgery, trauma, refractive errors and anatomical abnormalities on the surface of the eyeball. Age greatly affects the corneal endothelium because, as previously mentioned, the number of corneal endothelial cells or ECD can decrease with the passage of life. The reduction of the corneal endothelium ranges from 0.6% per year beginning in the 2nd to 8th decades of life. Trauma also has a significant impact on corneal endothelial damage. As we know, if the impact is very hard or if there is a rupture in the cornea, the layers on the cornea will automatically be damaged.[2]

The refractive error mentioned in several studies is myopia, but it is still being debated whether it can result in a decrease in the number of corneal endothelial cells. As with the use of contact lenses, there are several confounding variables that accompany this refractive error.[3] Damage to the corneal endothelium, apart from being caused by a wound that penetrates the corneal layer, can also be caused by focal and rapid damage to the cellular layer of the corneal endothelium. This damage is the same as the damage due to turbulence effects in phacoemulsification. In a study it was stated that the turbulence that occurs due to the aspiration irrigation process can damage the corneal endothelium. In a study on the eyes of rabbits, the height of the bottle has been tested which affects intraocular pressure. Clinical trials have shown minimal damage if the operator can maintain intraocular pressure at a low bottle height during operation. Another influential factor during surgery is the increased temperature of the aqueous humor caused by the energy from the ultrasound device. With a phacoemulsification device at a power setting of 60% or more, it can increase the temperature to more than 400C if used continuously. this indicates the operator must be able to determine the power setting correctly and be able to use it at the right time so that the temperature rise is not too drastic.[4]

The types of cataract surgery that are often used these days are ECCE, SICS and phacoemulsification. Of the three types of surgery above, with the development of increasingly modern tools, phacoemulsification is still the first choice because it has a very minimal effect on endothelial cell loss, between 5-10%, this percentage can increase to 15% if the grading of the cataract nucleus is too harsh. In a study it was stated that torsional tips have a slight advantage with a phaco needle time of 83 seconds compared to transverse tips with a phaco needle time of 99 seconds and longitudinal with a phaco needle time of 110 seconds. These findings are consistent with previous reports that torsional tips are more efficient than longitudinal and transverse tips because they have less phaco needle time and cumulative dissipated energy, thereby minimizing damage to the corneal endothelium.[5]

In the 1990s the divide and conquer technique was introduced. The advantage is the safety factor during surgery because it injures the corneal endothelium very little. However, in 1993 a new technique appeared, namely phaco-chop introduced by Nagahara. The phaco chop technique is to eliminate the middle part by sculpting, providing good speed and safety during the phaco process. This technique has the disadvantage of lack of space during operation especially when the nucleus is too hard. Koch and Katzen modified the phaco chop technique into a stop and chop by starting sculpting from the middle to provide space when breaking the nucleus. From several studies, it was stated that there was no significant difference in endothelial damage. It was stated that endothelial damage due to the phaco chop technique was at 6.3% and 5.7% in the divide and conquer technique.[6]

The setting for phaco surgery also has an impact on endothelial damage. In a study that compared the hydrodynamic effect of large and small vacuums using the stop and chop technique, US power was 60% in all phases, in the sculpting phase a vacuum was used of 40mmHg and the flow rate was set at 20 cc/minute. During this phase, the delivery mode, the power is linear but the vacuum and flow rate are fixed. In the chop phase, the vacuum uses 200mmhg (threshold 100mmHg) for a small vacuum and 400mmhg (threshold 200mmHg) for a large vacuum and flow rates are 20 cc/minute and 40 cc/minute. During this phase, the power and vacuum are linear but the flow rate is fixed. Aspiration irrigation uses semi-automatic with a flow rate of 30 cc/minute. It was concluded from this study that the size of the vacuum had an impact on the corneal endothelium, but the difference was not too significant between the groups using a large vacuum and a small vacuum.[7]

Prior to the invention of the phaco machine all cataract surgeries were performed using the ICCE, ECCE, and SICS methods and using a polymethylmethacrylate (PMMA) IOL. The materials of the PMMA IOL can be tolerated by the body and used for a long period of time.

At that time the IOL installation process was very influential on the damage to the corneal endothelium. A study revealed data that PMMA coatings use heparin and sodium hyaluronate to protect the corneal endothelium from damage. Coating the PMMA IOL with sodium hyaluronate makes the IOL surface hydrophilic. The hydrophilic surface reduces the electrostatic forces of the IOL which can cause contamination by attracting airborne particles. The hydrophilic layer can also be added with heparin which is often used in plastic tube intravenous treatment. The heparin layer prevents the formation of blood clots.[8]

In today's modern era, with the development of surgical techniques and tools used in cataract surgery, one of the materials used as a protective cornea is the ophthalmic viscoelastic device (OVD). OVD was first used in 1972 by Balazs et al. The content of OVD itself is hydroxypropyl methylcellulose (HPMC), chondroitin sulfate, or Sodium hyaluronate.[9]

In a study it was stated that Hydrogen used as an irrigation fluid can also protect the corneal endothelium. Hydrogen as an irrigation fluid has an effect as a free radical scavenger which has been studied previously in vitro or in vivo. During the phacoemulsification process, the corneal endothelium is damaged due to the oxidative stress that occurs. Considering the effect of hydrogen as a free radical scavenger and the consequences during sonolysis ($H2O \rightarrow OH + H$) during phacoemulsification, hydrogen as an irrigation fluid is an alternative that can be used to protect the cornea during surgery.[10]

Table 1. Summary of research results on the effects of cataract surgery on the corneal endothelium

Name of Researcher, Year	Title	Result
Bourne W.M et al, 2004	Effects of cataract surgery on the corneal endothelium, modern phacoemulsification compared with extracapsular cataract surgery.[11]	Both of these operations caused damage to the endothelium, but the differences were not significant. In certain cases where phacoemulsification cannot be optimal, ECCE is still the operation of choice.[11]
Choi J.Y et al, 2019	Long term effects (>10 years) of corneal endothelial damage after cataract surgery.[12]	Corneal endothelial damage due to cataract surgery can result from friction of the lens mass and the corneal endothelium which causes corneal edema. The level of thickness and hardness of the lens and corneal edema can predict corneal endothelial damage 10 years after cataract surgery.[12]
Takahashi H, 2016	Corneal endothelium and phacoemulsification.[13]	Phacoemulsification is a factor for corneal endothelial damage. However, due to very minimal complications and superior safety factors, this technique is still an option. Factors that cause endothelial damage include lens fragments hitting the cornea, formation of free

		radicals due to oxidative stress, increased IOP, and increased temperature during surgery.[13]
Perone J.M et al, 2018	Relationship between central corneal thickness and endothelial damage after cataract surgery with phacoemulsification.[14]	Postoperative central corneal thickness measurement should be performed as one of the markers of how severe the corneal endothelial damage is after phacoemulsification.[14]
Lundberg B et al, 2005	Postoperative Corneal Swelling Correlates Strongly to Corneal Endothelial Cell Loss After Phacoemulsification Cataract Surgery.[3]	In this study there were many variations of postoperative corneal edema on the first day, the degree of severity of corneal edema reflects the degree of damage to the corneal endothelium. Measurements on the first day using pachymetry can help determine the degree of corneal endothelial damage.[3]
Ianchulev T et al, 2019	Corneal endothelial cell count and morphology after phacoemulsification in patients with primary open angle glaucoma.[15]	Postoperative corneal endothelial damage only occurred in the first 3 months after surgery and then gradually stabilized. However, in this study there was no further monitoring after 24 months postoperatively.[15]
Reuschel A et al, 2010	Comparison of corneal damage between torsional and longitudinal machine settings during phacoemulsification.[16]	Endothelial damage occurred after phaco surgery with both settings, but the torsional machine is safer than the longitudinal machine for age-related cataracts.[16]
Storr-Paulsen A et al, 2008	Corneal endothelial damage after cataract surgery using the Divide and Conquer vs Phaco chop method.[6]	The phaco chop technique is proven to be safer than the divide and conquer technique because it uses less phaco power.[6]
Gogate P et al, 2010	Comparison of corneal endothelial damage after cataract surgery Phacoemulsification vs manual small incision cataract surgery (SICS).[5]	There was no significant difference in corneal endothelial damage between SICS or phacoemulsification..[5]

CONCLUSION

Epidemiologically, it is estimated that between 1 - 2% of the population undergoing cataract surgery will experience postoperative edema which eventually becomes bullous keratopathy. Cataract surgery technique is significantly associated with the incidence of bullous keratopathy because the maneuvers are very prone to injuring the corneal endothel. In this study, it was stated that the damage to the corneal endothelial cells was getting worse as the grade of the lens nucleus became harder. The average percentage of damage to endothelial cells reaches 15%. This is what underlies the need for further research to find new methods that can protect the corneal endothelium.

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