

Comparative study of serum and aqueous humour electrolyte levels in cataract patients

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Abstract

Background and Objectives: There are about 50 million blind people in the world, a third of them being due to cataract. In India alone, cataract accounts for 80% of treatable blindness. Many factors such as ageing, altered blood electrolyte levels, nutrition and family history are involved in cataractogenesis. **Aim:** Comparative study of serum and aqueous humour levels in cataract patients. Objectives are to compare serum Na⁺, K⁺, Ca²⁺ and PO₄⁻³ levels with that of aqueous humour levels in patients with cataract and to establish a correlation between altered serum and aqueous humour electrolyte levels with the type of cataract. **Methods:** The study undertaken includes a total of one hundred cataract patients who visited VIMS and RC, White field, Bangalore between January 2012 and June 2013. It considered cataract patients of both sexes above the age of 40 years and excluded patients with any systemic disease, past ocular disease, or any drug intake known to cause electrolyte changes in the body. The patients were all routinely subjected to a detailed ocular examination including visual acuity, slit lamp examination to stage the type of cataract, fundoscopy, intraocular pressure recording. Serum and aqueous humour samples were collected intraoperatively in cataract patients and sent for Na⁺, K⁺, Ca²⁺ and PO₄⁻³ level measurement by Beckman Coulter Unicel DxC 600 and Synchron CX5PRO. The serum and aqueous humour electrolyte levels were compared with each other. **Results:** The aqueous humour, though a secretion of serum; shows a considerable difference in the electrolyte levels as compare to serum which is statistically significant (p<0.001). **Conclusion:** Aqueous sodium levels as compared to serum sodium levels were higher in patients with cataract. Aqueous potassium, calcium, phosphate levels were low compared to serum levels. Aqueous levels of potassium in cataract patients (50 % of cases) were raised when compared to normal aqueous levels.

Keywords: Serum, aqueous humour, electrolyte levels

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INTRODUCTION

OBJECTIVES OF THE STUDY

To compare serum Na⁺, K⁺, Ca²⁺ and PO₄⁻³ levels with that of aqueous humour levels in patients with cataract. To establish a correlation between altered serum

and aqueous humour electrolyte levels with type of cataract

MATERIALS AND METHODS

The present study is a cross-sectional study among diagnosed cases of cataract aged 45yrs(both males and females) and above attending Department of Ophthalmology, VIMS and RC, Nallurahalli, Whitefield, Bangalore from Jan 2012 to June 2013. This was a duration based study in which the aim was to take at least hundred cases as the sample size. Cases of cataract aged 45 years and above of both genders who attended the outpatient department or were admitted as inpatient in the department of Ophthalmology at VIMS and RC were considered for the study. A pre-structured proforma was used to collect the baseline data and an informed written consent was obtained after explaining about the need of the study and the procedures that were to be performed for the collection of data. Detailed history was taken and

examination, both ocular and systemic was performed as per the proforma for those who satisfied the inclusion and exclusion criteria.

Inclusion criteria

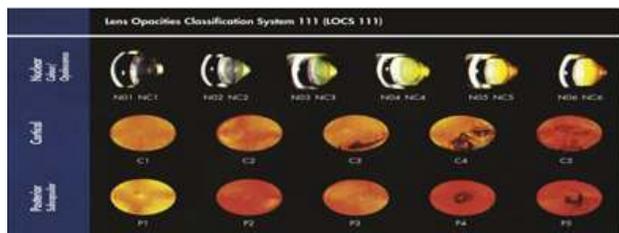
Established cases of Cataract cases aged >45 yrs (both males and females).

Exclusion criteria

Patients on steroids: oral/topical/ inhalational, diuretics. Traumatic and complicated cataracts. History of any past ophthalmic surgeries other than cataract. Severe chronic diarrhea/ dehydration/ vomiting/ gastroenteritis. History of heart failure/renal insufficiency/hepatic cirrhosis. History of any endocrine disorders.

Hypertensives

The following is done on diagnosed cases of senile cataracts: Visual acuity determination. Intraocular pressure measurement. Slit lamp examination after dilatation, to assess the type of cataract as per Lens Opacities classification III (LOCS III). Direct Ophthalmoscopic examination



Collection of aqueous humour sample

After local anaesthesia is administered, using a 30 gauge needle and a insulin syringe; a side port entry is made into the anterior chamber and 0.1-0.2 c.c of aqueous humour sample is drawn in a tuberculin syringe intraoperatively. Blood is collected using vacutome and sent for serum Na+, K+, Ca+2 and PO4-3 level estimation at the same time. Serum and aqueous humour sodium, potassium, calcium and phosphorous were compared with each other. The results obtained were also compared with the normal values as given below:

Table 1

Electrolyte	Sodium (meq/L)	Potassium (meq/L)	Calcium (mg/dl)	Phosphate (mg/dl)
Serum	135-145*	3.5-5.0*	8.5-10.5*	2.5-4.6*
Aqueous human	162.9*	2.2-3.9*	5.16-.32*	1.75-2.66*

STASTICAL METHODS

Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5 % level of

significance. The following assumptions on data is made, Assumptions: 1. Dependent variables should be normally distributed 2. Samples drawn from the population should be random. Cases of the samples should be independent. Student t test (two tailed, dependent) has been used to find the significance of study parameters on continuous scale within each group.

Single mean Z test has been performed to test the significance of serum and Aqueous Humour values with normal values.

1. Significant figures

+ Suggestive significance (P value: 0.05<P<0.10)

* Moderately significant (P value: 0.01<P ≤ 0.05)

** Strongly significant (P value: P≤0.01)

Statistical software: The Statistical software namely SAS 9.2, SPSS 15.0, Stata 10.1, MedCalc 9.0.1 ,Systat 12.0 and R environment ver.2.11.1 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

RESULTS

The present study titled “Comparative study of serum and aqueous humour electrolyte levels in cataract patients” was conducted in VIMS and RC, Whitefield, Bangalore on the subjects who were admitted in the departments of Ophthalmology at VIMS and RC. This was a duration based, cross-sectional study of diagnosed cases of cataract which took in to consideration a sample of hundred cases who satisfied the inclusion and exclusion criteria. Serum and aqueous humour samples in cataract patients were collected intraoperatively and sent for sodium, potassium, calcium and phosphorous level estimation by Beckman Coulter Unicel Dx C 600 and Synchron CX5PRO for biochemical analysis. The electrolyte values both in serum and aqueous humour were compared with each other. The results were expressed as mean ± standard deviation. Student t test (two tailed, dependent) has been used to find the significance of study parameters on continuous scale within each group. The Statistical software namely SAS 9.2, SPSS 15.0, Stata 10.1, MedCalc 9.0.1 ,Systat 12.0 and R environment ver.2.11.1 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs and tables.

Study design: An Evaluation Study

Table 2: Age distribution of patients

Age in Years	No. of Patients n=100	Percentage (%)
41-50	33	33.0
51-60	37	37.0
61-70	19	19.0
71-80	10	10.0
>80	1	1.0
Total	100	100.0

Mean ± SD: 57.17±9.34

The age-wise distribution of patients as analyzed showed a maximum number (thirty seven) of patients in the age group of fifty one to sixty while only one patient was above 80 years. The rest were distributed as follows:

- Thirty three patients were in the age group of forty one to fifty.
- Nineteen patients were in the age group of sixty one to seventy.
- Only ten patients were in the age group of seventy one to eighty.

Table 3: Gender distribution of patients

Gender	No. of patients N=100	Percentage (%)
Male	62	62.0
Femal	38	38.0
Total	100	100.0

Sixty two percent of the patients were males and thirty eight percent of the patients were females.

Table 4: Serum levels Electrolytes of patients

Serum Level	No. of patients (n=100)	Percent(%)	Mean=SD
Sodium(meq/L)			
<135	29	29.0	137.27±3.27
135-145	69	69.0	
>145	2	2.0	
Potassium(meq/L)			
<3.5	0	0.0	4.16±0.51
3.5-5	96	96.0	
>5	4	4.0	
Calcium(mg/dL)			
<8.5	21	21.0	8.81±0.41
8.5-10.5	79	79.0	
>10.5	0	0.0	
Phosphate(mg/dl)			
<2.5	36	36.0	3.01±1.15
2.5-4.6	53	53.0	
>4.6	11	11.0	

Following observations were made in the serum values:

1. Mean ± SD of sodium is 137.27±3.27
2. Mean ± SD of potassium is 4.16±0.51
3. Mean± SD of calcium is 8.81±0.41
4. Mean ± SD of phosphorous is 3.01±1.15

Sixty nine percent of the patients had serum sodium 135-145meq/L. Twenty nine percent of the patients showed serum sodium < 135meq/L. Two percent of the patients showed serum sodium >145meq/L. Considering 135-145 meq/L as the normal range, most of the serum sodium values were within the normal range. Ninety six percent of the patients showed serum potassium 3.5-5meq/L. Zero percent of the patients showed serum potassium < 3.5meq/L. Four percent of the patients showed serum potassium >5meq/L. Considering 135-145 meq/L as the normal range, most of the serum potassium values were within the normal range. Seventy nine percent of the

patients showed serum calcium 8.5-10.5mg/dl. Twenty one percent of the patients showed serum calcium < 8.5mg/dl. Zero percent of the patients showed serum calcium > 10.5mg/dl. Considering 8.5-10.5mg/dl as the normal range, most of the serum calcium values were within the normal range. Fifty three percent of the patients showed serum phosphate 2.5-4.6mg/dl. Thirty six percent of the patients showed serum phosphate < 2.5mg/dl. Eleven percent of the patients showed serum phosphate >5meq/L. Considering 2.5-4.6mg/dl as the normal range, most of the serum phosphate values were within the normal range.

Table 5: Aqueous humor levels of electrolytes studied

Aqueous humor Level	No. of patients (n.100)	Percent(%)	Mean±SD
Sodium(meq/L)			
<162.9	100	100.0	144.77±3.11
>162.9	0	0.0	
Potassium(meq/l)			
<2.2	0	0.0	3.91±0.28
2.2-3.9	50	50.0	
>3.9	50	50.0	
Calcium(mg/dl)			
<5.16	2	2.0	5.90±0.30
5.16-6.32	93	93.0	
>6.32	5	5.0	
Phosphate(mg/dl)			
<1.72-2.66	53	53.0	1.89±0.48
>2.66	5	5.0	

Following observations were made in the aqueous humour values:

1. Mean ± SD of sodium is 144.77±3.11
2. Mean ± SD of potassium is 3.91±0.28
3. Mean± SD of calcium is 5.90±0.30
4. Mean ± SD of phosphorous is 1.89±0.48.

Hundred percent of the patients showed aqueous sodium < 162.9 meq/L. Zero percent of the patients showed aqueous sodium > 162.9 meq/L. Fifty percent of the patients showed aqueous potassium 2.2-3.9 meq/L. Zero percent of the patients had aqueous potassium < 2.2meq/L. Fifty percent of the patients had aqueous potassium >3.9meq/L. Ninety three percent of the patients had aqueous calcium 5.16-6.32mg/dl. Two percent of the patients had aqueous calcium< 5.16mg/dl. Five percent of the patients had aqueous calcium > 6.32mg/dl. Considering 5.16-6.32mg/dl as the normal range, most of the aqueous calcium values were within the normal range. Fifty three percent of the patients had aqueous phosphate 1.72-2.66mg/dl. Fourty two percent of the patients had aqueous phosphate < 1.72mg/dl. Five percent of the patients had aqueous phosphate >2.66meq/L. considering 1.72-2.66 mg/dl as the normal range, most of the aqueous phosphate values were within the normal range.

Table 6: Comparison of Electrolyte levels in Serum and Aqueous humor

	Serum Level	Aqueoum Humor levels	differennce	95%CI	T value	P value
Sodium(meq/l)	137.27±3.27	144.77±3.11	-7.500	-8.222 to -6.778	-20.605	<0.001**
Potassium(meq/l)	4.16±0.51	3.91±0.28	0.256	0.153-0.359	4.914	<0.001**
Calcium(mg/l)	8.81±0.41	5.90±0.30	2.907	2.828-2.986	72.706	<0.001**
Phosphate(mg/dl)	3.01±1.15	1.89±0.48	1.118	0.894-1.343	9.883	<0.001**

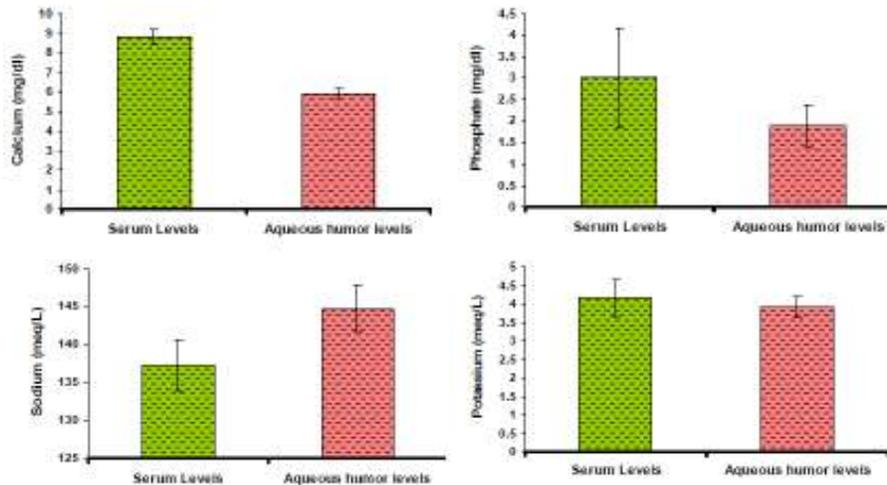


Figure 1: Showing Comparison of Electrolytes levels in Serum and Aqueous humor

It was observed that comparison of electrolyte levels in serum and aqueous humor was significant (P<0.001).

Table 7: Type of Cataract

Type of caract (IocsiIII classification)	No. pof patients N=100	Percent(%)
CO ₀ N ₁ PSC ₃	1	1.0
CO ₀ N ₃ PSC ₀	4	4.0
CO ₀ N ₃ PSC ₃	15	15.0
CO ₁ N ₀ PSC ₃	1	1.0
CO ₁ N ₁ PSC ₁	4	4.0
CO ₁ N ₁ PSC ₂	1	1.0
CO ₁ N ₁ PSC ₃	4	4.0
CO ₁ N ₂ PSC ₁	1	1.0
CO ₁ N ₂ PSC ₂	7	7.0
CO ₁ N ₂ PSC ₃	4	4.0
CO ₁ N ₄ PSC ₀	1	1.0
CO ₂ N ₁ PSC ₁	5	5.0
CO ₂ N ₂ PSC ₂	14	14.0
CO ₃ N ₁ PSC ₁	2	2.0
CO ₃ N ₁ PSC ₃	17	17.0
CO ₃ N ₃ PSC ₃	19	19.0
TOTAL	100	100.0

Nineteen percent of the cataracts were CO₃N₃Psc3. Seventeen percent of the cataracts were CO₃N₁Psc3. Fifteen percent of the cataracts were CO₀N₃Psc3. Fourteen percent of the cataracts were CO₂N₂Psc2. Five percent of the cataracts were CO₂N₁Psc1. Four percent of the cataracts were CO₀N₃Psc0, CO₁N₁Psc1,

CO₁N₁Psc3, CO₁N₂Psc3. Two percent of the cataracts were CO₃N₁Psc1. One percent of the cataracts were CO₀N₁Psc3 , CO₁N₀Psc3 , CO₁N₁Psc2 , CO₁N₂Psc1, CO₁N₄Psc0.

Table 8: Eye involved

Eyes involved	No.of patients n=100	Percent(%)
Left eye	37	37.0
Right eye	63	63.0
Total	100	100.0

Sixty three percent of the eyes were right and Thirty seven percent of the eyes were left.

Table 9: Visual Acuity

Visual acuity	No of patient N=100	Percent(%)
6/6-6/9	0	0.0
6/12-6/18	2	2.0
6/24-6/36	41	41.0
6/60	25	25.0
<6/60	32	32.0
Total	100	100.0

Forty one percent of the patients showed visual acuity 6/24-6/36. Thirty two percent of the patients showed visual acuity <6/60. Twenty five percent of the patients showed visual acuity 6/60. Two percent of the patients showed visual acuity 6/12-6/18.

Table 10: IOP (mm Hg)

IOP(Intraocular Pressure)	No. of Patients n=100	Percent (%)
<10	3	3.0
11-20	97	97.0
>20	0	0.0
Total	100	100.0

Mean \pm SD: 17.73 \pm 2.45**Table 11:** Fundus findings

Fundus	No. of Patients n=100	Percent(%)
Dry ARMD	9	9.0
Medica hazy	7	7.0
Normal	84	84.0
Total	100	100.0

Eighty four percent of the patients had normal fundus. Nine percent of the patients had Dry ARMD. Seven percent of the patients had hazy media.

DISCUSSION

Any opacification in the lens is called cataract. Cataract is the most common blindness in the world. Any factor, physical, chemical or biological which disturbs the critical intra and extracellular equilibrium of water and electrolytes or destroys the colloid system within the lens fibres tends to bring about opacification. Aqueous humour is a clear fluid secreted by the ciliary epithelium from the serum in the eye. Lens lies in close apposition with that of aqueous humour and derives its nutrition from the aqueous humour. Hence, any electrolyte imbalance in the serum can lead to changes in aqueous humour electrolytes which can affect the lens metabolism leading to cataract formation. The composition of aqueous humour has been studied in various animals. Few human aqueous humour studies were conducted so far. An attempt is made here to establish a range for the electrolytes mentioned i.e. sodium, potassium, calcium and phosphorous in the human aqueous humour in cataract patients and also compare it with serum electrolyte levels. Kim *et al*⁷³ showed that the level of phosphorus in the aqueous humour and serum of diabetics was significantly increased, especially in diabetics with proliferative diabetic retinopathy. This result may be related to opacification of the implanted hydrophilic acrylic IOL. The high concentration of serum and aqueous humour phosphorus in diabetics with proliferative diabetic retinopathy is thought to result from renal insufficiency. When high levels of phosphorus are maintained for long periods, the driving force for mineralization is increased, and calcium phosphate may be deposited in abnormal sites (ectopic calcification). Mirsamadi *et al*¹ compared serum sodium and potassium levels in senile cataract and in normal individuals and showed that serum sodium

levels were elevated in cataract patients. These are the following results of the electrolytes observed in the cases studied

Table 12: Showing mean and standard deviation of serum and aqueous electrolytes

	Serum	Aqueous Humour
Sodium	137.27 \pm 3.27	144.77 \pm 3.11
Potassium	4.16 \pm 0.51	3.91 \pm 0.28
Calcium	8.81 \pm 0.41	5.90 \pm 0.30
Phosphorous	3.01 \pm 1.15	1.89 \pm 0.48

The aqueous humour, though a secretion of serum; shows a considerable difference in the electrolyte levels as compare to serum which is statistically significant ($p < 0.001$).

Following observations have been made in our study:

1. Sodium levels in aqueous humour (144.77 \pm 3.11) were high as compared to serum levels (137.27 \pm 3.27).
2. Potassium levels in aqueous humour (3.91 \pm 0.28) were low as compared to serum levels (4.16 \pm 0.51).
3. Calcium levels in aqueous humour (5.90 \pm 0.30) were low as compared to serum levels (8.81 \pm 0.41).
4. Phosphate levels in aqueous humour (1.89 \pm 0.48) were low compared to serum levels (3.01 \pm 1.15).

The cation balance between inside and outside of the lens is the result, both of the permeability properties of the lens cell membrane and the activity of sodium pump that reside within the cell membranes of the lens epithelium and lens cell fibres. The sodium pump functions by pumping the sodium ions out while taking potassium ions in. This mechanism depends on Adenosine triphosphate (ATP) and is regulated by the Na⁺-K⁺ ATPase. During cataract formation, there is fall in the potassium and rise in the sodium content of the lens, thereby altering the cation balance in the lens⁴. Therefore, the rise in the sodium levels in aqueous when compared to serum levels can be attributed to raised sodium in the lens as a result of cationic imbalance, thus leading to cataract formation. We have also compared our results with the normal values and the following observations were made:

SERUM

1. 69 patients had serum sodium values within normal limit while 29 patients had serum sodium < 135meq/l (hyponatremia) and 2 patients had serum sodium > 145meq/l (hypernatremia).
2. 96 patients had serum potassium values within normal limit while 4 patients had serum potassium > 5meq/l (hyperkalemia).
3. 79 patients had serum calcium within normal limit while 21 patients had serum calcium < 8.5mg/dl (hypocalcemia).

4. 53 patients had serum phosphorous values within normal limit while 36 patients had serum phosphorous 2.5 < mg/dl (hypophosphatemia) and 11 patients showed serum phosphate >4.6mg/dl (hyperphosphatemia).

AQUEOUS HUMOUR

1. All the 100 patients had aqueous sodium values within normal limit.

2. 50 patients had aqueous potassium values within normal limit and 50 of them had > 3.9meq/l.

3. 93 patients had aqueous calcium values within normal limit while 5 patients had aqueous calcium >6.32 mg/dl and 2 patients had aqueous calcium <5.16mg/dl.

4. 53 patients had aqueous phosphorous values within normal limit while 42 patients had aqueous phosphorous <1.72 mg/dl and 5 patients showed >2.6 mg/dl.

Thus, most of the electrolyte values in the serum and aqueous humour in the cases studied were within normal limits. It was also observed that aqueous sodium levels were higher compared to serum sodium levels whereas aqueous potassium, calcium, phosphate levels were lower compared to serum electrolyte levels in normal cataract patients. Aqueous levels of potassium in cataract patients were raised (in 50% of cases) when compared to normal aqueous levels. However, since most of the electrolyte levels in serum and aqueous humour were not altered when compared to normal values, it was difficult to establish a correlation between electrolyte levels and the type of cataract.

CONCLUSION

There is a significant difference between serum and aqueous humour electrolyte levels in normal cataract patients. Aqueous sodium levels as compared to serum sodium levels were higher in patients with cataract. Aqueous potassium, calcium, phosphate levels were low compared to serum levels. Aqueous levels of potassium in cataract patients (50% of cases) were raised when compared to normal levels. However, from the practical point of view, we could study the electrolyte levels only in cataract patients visiting our hospital and not in the normal individuals. As there is a paucity of studies on human aqueous humour, further studies are required to establish a normal range of electrolytes present in the aqueous humour of the normal individuals and compare it with that of the disease state.

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