Medical Surveillance of radiological workers

Refresher Course 28 Irpa 2018

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Emphasis on medical surveillance of the eye lens

Member work group NCS (Netherlands Commission on Radiation Dosimetry):
Guidelines for Radiation Protection and Dosimetry of the Eye Lens (to be published soon, see radiationdosimetry.org)

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Refresher course medical surveillance

Subjects:

- Legal and instrumental aspects of medical surveillance in general
- Practice in the Netherlands of medical surveillance of radiological workers
- Background of (radiation induced) cataract of the eye.
- Proposed surveillance of the risk of the eye in radiological health surveillance.

Legal base (NL)

BBS Besluit Basisveiligheidsnormen Stralingsbescherming:

Dutch Radiation Protection Act, 16-2-2018

- Article 7.11
- Radiological Worker class A:
- **1°.** Possible effective dose > 6 milliSievert in one year; or
- **2°.** Possible equivalent dose > 15 milliSievert on the eye lens in one year or
- **3°.** Possible equivalent dose > 150 milliSievert on the skin (average on any exposed skin of 1 cm^2 or
- **4°.** Possible equivalent dose > 150 milliSievert on the extremities in one year

Legal base (NL)

Medical Surveillance BBS 2018 art. 7.21

- The employer has to make sure there is medical surveillance for Radiological Workers class A
- by a registered specialist in both occupational health and radiation hygiene (stralingsarts, art. 7.22), “radiation physician”
- The employer should provide all relevant information to the physician that he/she needs, to have insight on the health and the working conditions of the employees he/she has under surveillance

Legal base (NL)

BBS art.7.21

- **Medical Surveillance** includes:
  - The medical examinations by the radiation physician prior to radiological work class A
  - Periodic medicals, by the radiation physician, as often as he/she indicates as necessary and at least once every year. Goal is to (re)evaluate the aptitude for the radiological job of the worker.
  - Prolonged medicals after conclusion of the radiological work class A, if and as long as the radiation physician indicates this as necessary
  - Medical examination has to take place furthermore when by an incident or accident dose limits are exceeded

Medical file

Art7.26. (medical file)

- The employer has to make sure that the "radiation physician" keeps medical files of all A-workers. The file has to be stored until he/she reaches the age of 75 years, but at least 30 years after termination of the radiological work
- In the medical file at least these records are registered:
  - **a.** kind of work that is at stake
  - **b.** the results of all examinations mentioned (in article 7.21 and 7.24)
  - **c.** the results of individual dose monitoring (art 7.12 to 7.14, 7.31)
  - **d.** other relevant medical data, collected before and during the class A work

Kinds of Medicals in general: GPO: compulsory, specific

GPO: Periodic Function Fitness focused Medicals

- offer based on:
  - specific law
  - (inter)national regulations
  - company policy;
- compulsory for employee
- individual report to employer (fit, unfit, conditionally fit)

Examples: fireman, diver, truck driver and **radiological work**)

Kinds of Medicals in general: Pago: voluntarily, risk based, prevention of occupational disease

PAGO: periodic work-risk based examinations

Base is general occupational health and safety law, “ arbowet”

- if risk is relevant and the proposed examination is proportional, and examination is adequate to control risk (subsidiarity)
- Monitoring early signs of occupational diseases and workability in general
- offer by employer is compulsory
- participation by employee is voluntary
- no individual report, aggregated report on group level

Examples: noise exposition: hearing tests, physical load: “loadability”, stress questionnaires

Kinds of Medicals in general health check: voluntarily

Health Check:

- general health management,
- Company policy
- employee benefit
- Relevance, subsidiarity and proportionality is at stake

Examples: cholesterol, blood sugar, blood pressure, step tests

Combinations of all mentioned are called: PMO (Preventive Medical Examination)

” moral”

International Labour Organization (ILO – WHO)

- “to assess the health of individual workers; to ensure compatibility between health and work;
- to provide reference data in case of accidental exposure
- to diagnose and signalize radiation induced occupational diseases
- to give opportunity for consultation on presumed effects and resulting fear?

More goals of medical surveillance

- to provide insight on the health of groups of workers on company level and professional group level?
- information and instruction, especially for vulnerable groups like youngsters, elderly and (potential) pregnant women
- To archive data related to individual exposition to radiation

Surveillance on?

- Risk of irradiation
- Risk of contamination :
  - external
  - internal

- aptitude/prevention/monitoring on tissue effects (deterministic)
- aptitude/prevention/monitoring on stochastic effects (mutagenity)
- aptitude/prevention/monitoring on conditions for radiological work (f.e. wearing personal protective gear)

Dilemma

- (Annual) medical examination is compulsory (law)
- content, usefulness and necessity varies with the kind of radiological work

Practice in NL

- Radiological medical varies
- At least yearly questionnaire
- If contamination is part of radiological work :
  - Blood sample in relation with potential exposure blood count, liver- and kidney functions, thyroid
  - Other function tests in relation to the job like inspection tasks, vigilance, breath protection, rescue tasks : eye, ear, hart, lungs, muscle-skeletal

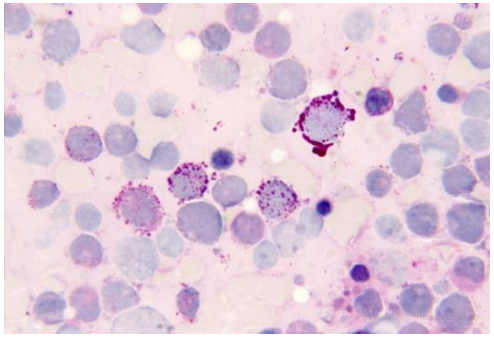
Stochastic effects

Is about mutagenity (cancer risk and risk for offspring)

- Fundamentally linear effect (no threshold)
- Dose in work additional to background
- Individual sensitivity
- Human body has a lot of regenerative power (potential mutagens are always there and everywhere)
- Estimation of individual sensitivity is very difficult (little evidence)
- Yearly medical is not a cancer investigation!
- Causality is not to prove!
- Dose standards are based on 1% extra mortality (from cancer) with 1 Sv long term low dose exposure (50 yrs X 20 mSv). = Standard mortality risk is 40%, +1 Sv 41%

Tissue with high cell turnover

- Blood-cell generation
  -> anemia
- Intestinal Mucosa
  -> diarrhea, bleeding
- Airways/lungs
  -> dyspnea, blood cough

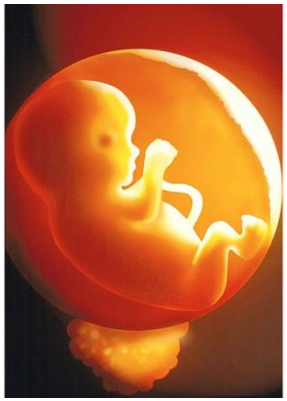


Internal contamination with alfa or beta radiating nuclides: blood count is an important measure for severity and prognosis of the contamination parameter -> is this sufficient ground for (annual) blood count?

Offspring

- Pre-conception: mutations in ovum or sperm cell: effects on offspring (stochastic)
- Post-conception: effects on unborn fetus (deterministic effect)
  - Tissue reactions
  - Chromosome damage (per definition fast mitoses) –early pregnancy most effects (2-8 weeks)

  Threshold dose: > 100mSv



Deterministic effects

- Organ dose and total body dose to be extracted from ICRP models. (lung model, digestive track-model etc.)
- (chronic) disease and anatomic aberrations influence the results of the models. Examples:
  - COPD vs. Lung model
  - hypothyroidism vs. burden of I^{131}-isotopes on thyroid gland
  - M. Crohn, cirrhosis of the liver, colitis vs. DigestiveTrack-model
  - Etc.
- This can cause considerations and eventually fine tuning with responsible radiation hygienist at appointment as radiological worker, at annual examination and when incidents occur.

Conclusion: “Stakeholders”

- Legal requirements
- Broad and integral concern for the health of the radiological worker
- Liability, needs and demands of employer
- International context (different countries: different insights and approaches)
- Viewpoint of health and safety as a whole versus radiation related H& S (other legislation, other starting points)

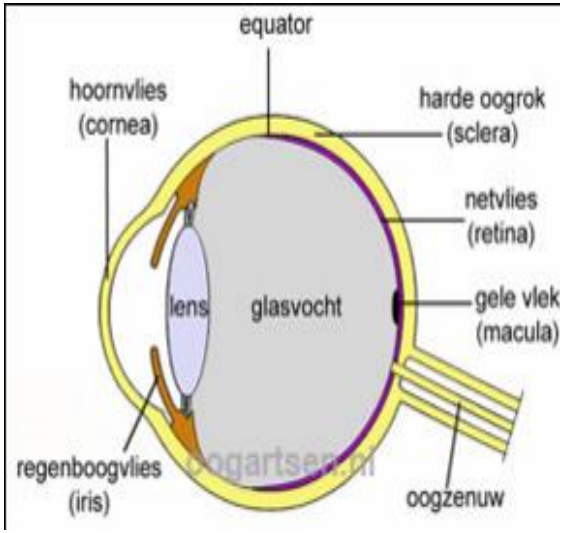
cataract

- cataract= grey stare=opacity of the eye lens
- Kataracta καταρράκτη = greek = waterfall

Origin

- ICRP, 2012. *ICRP Statement on Tissue Reactions / Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context*. ICRP Publication 118. Ann. ICRP 41(1/2).

- Cataract
  - Turbidity of lens
  - ⬇
  - Light beams get aberrated
  - ⬇
  - Image on retina gets upset

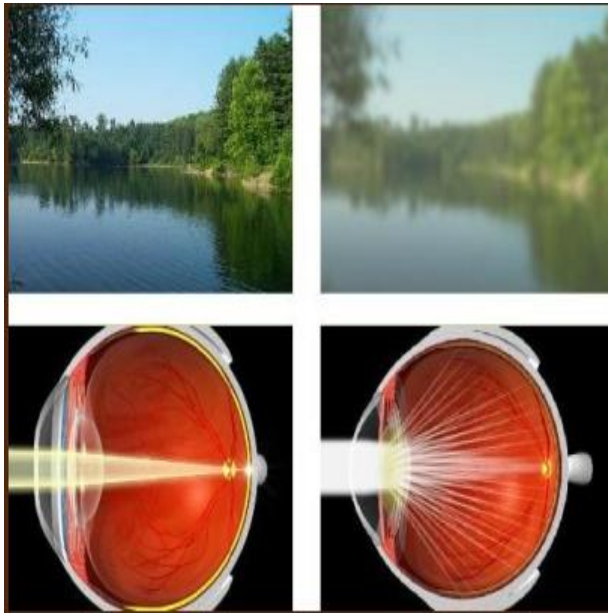


- Often both sides, but asymmetric

Clinical appearance

- (very) slow progression
- Often bilateral but asymmetric
- Doesn’t hurt

- Blurred vision
- Change of color vision
- Double pictures in one eye
- glares or halos
- Changes in refraction
- Decreasing night vision



What is the incidence of cataract?

- Cataract is quite common:
- in the Netherlands the incidence is about 10 new cases that lead to visiting a specialist and a treatment, per 1000 inhabitants per year
- asymptomatic cataract of 15-30% above the age of 40 to approximately 60% above 70 years.
- significant delay between the start of the disease and the recognition of it by the patient.

- 30 miljon blind people world wide: 50 % caused by cataract

Cataract pathogenesis

- Hydration of the lens
- denaturation of proteins in lens
- -> increase in insoluble proteins
- lens sclerosis
- **Developing Cataract is irreversible!**

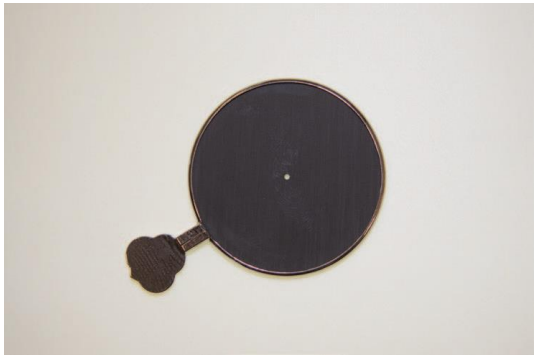
- **Causes**
  - uv light?
  - genetic?
  - immunologic?
  - nutrition?

Risk factors

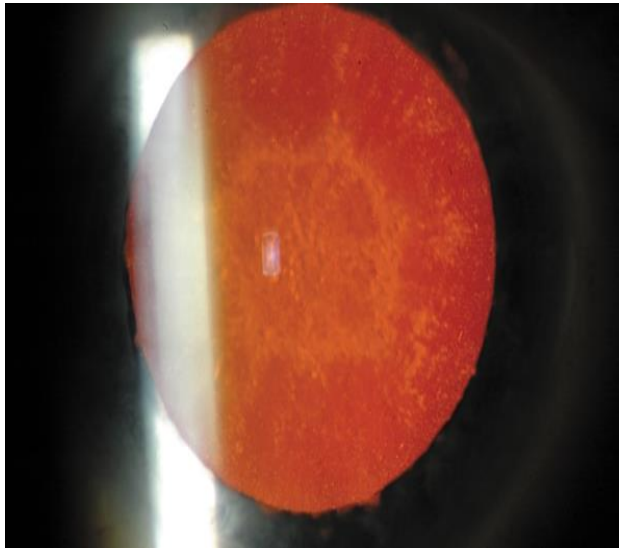
- High age
- Diabetes mellitus
- Smoking
- Sun light
- Malnutrition

Diagnosis

- age
- Anamnesis of gradual decline of vision, no pain.
- Vision improves looking through small hole (stenopeic vision)



- Slitlamp examination
  - Ophthalmologist
  - (specialist work)



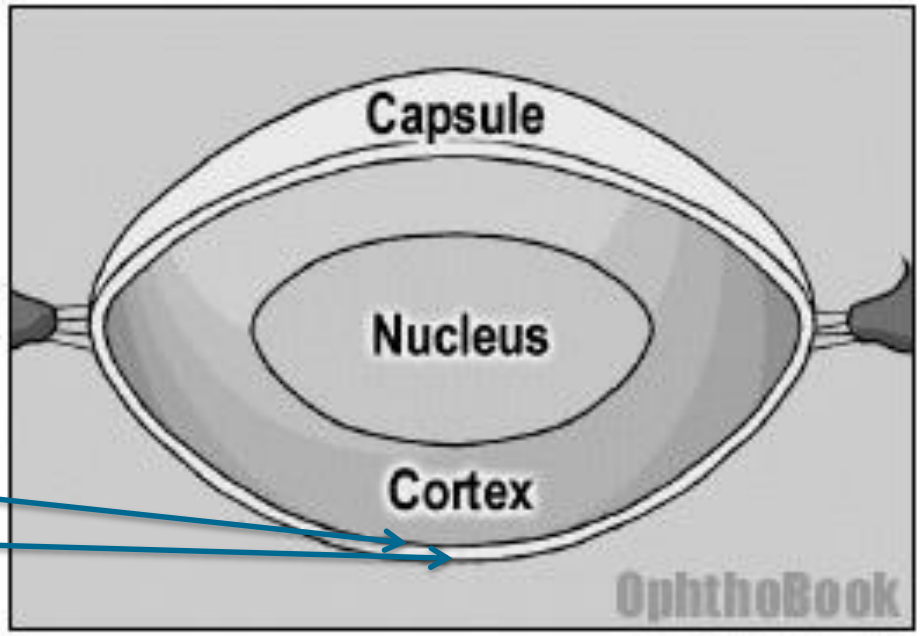
Differential diagnosis

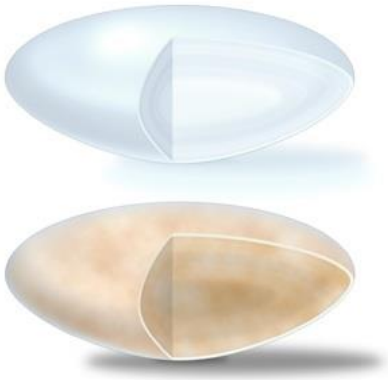
- Painless, gradual decline in vision
  - Other forms of cataract (traumatic, complicata)

  - Disturbed Refraction
  - Macula degeneration
  - Retinopathy f.e. caused by diabetes or hypertension
  - Cornea dystrophy
  - Glaucoom
  - Opticus atrophy

localisation

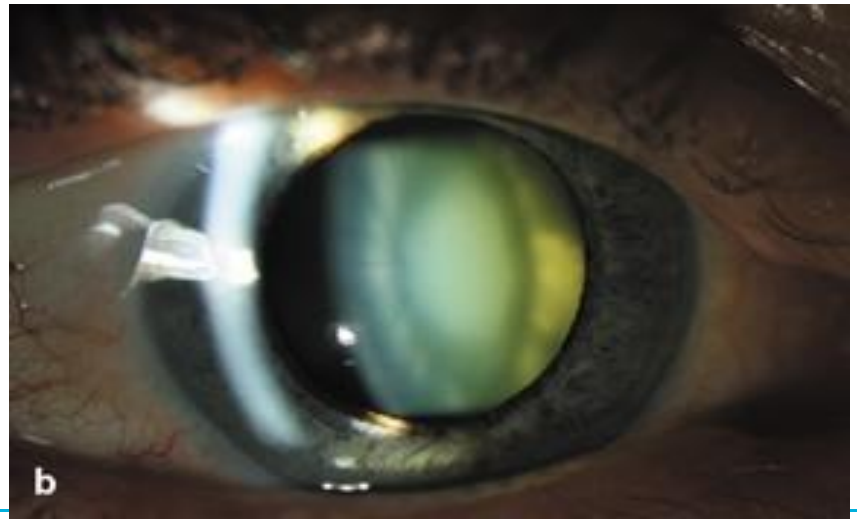
- nuclear
- cortical
- subcapsular
- polar





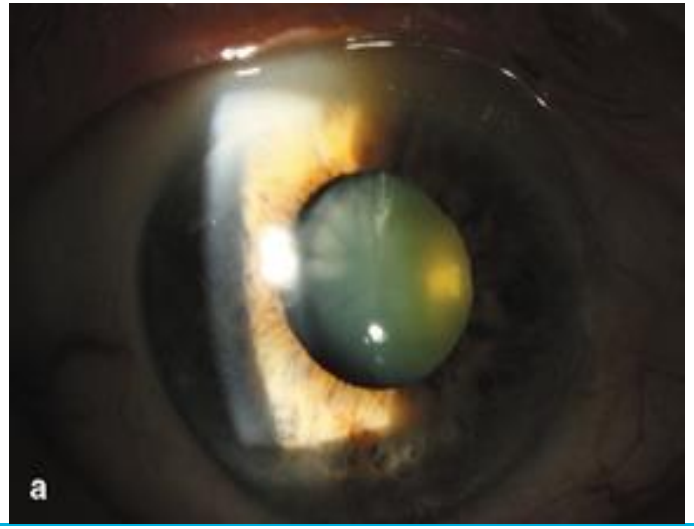
nuclear cataract

- Gradual progressive
- Myopia, near sight (temporary) increased (Lens more convex, refractive index increases)
- Color sight diminishes (more grey, less color)

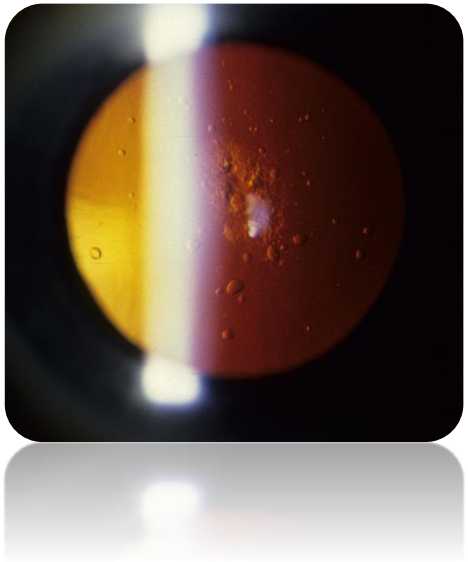


cortical cataract

- local structure disturbances mature (threads, blisters, spokes)
- bilateral, but asymmetrical
- monocular double sight (blurred spoke through pupil)
- Complaints of glare (scattering of light)



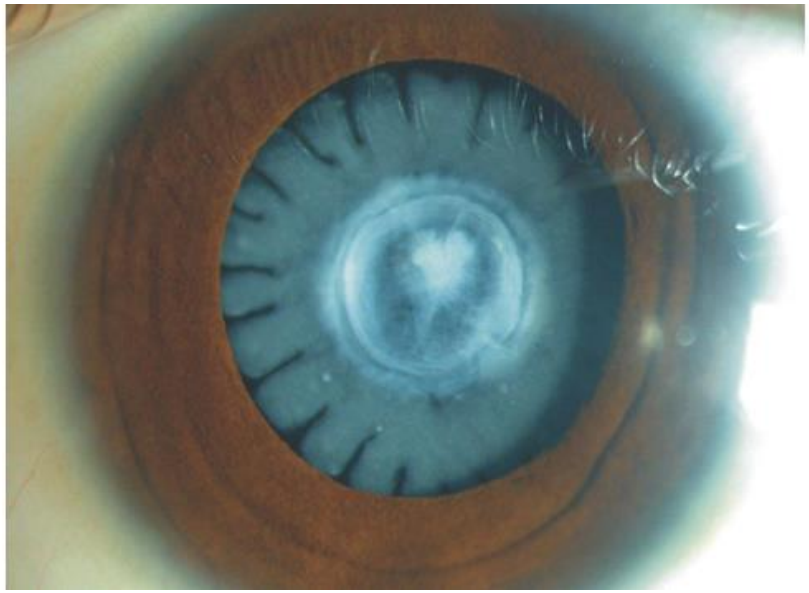
subcapsular cataract



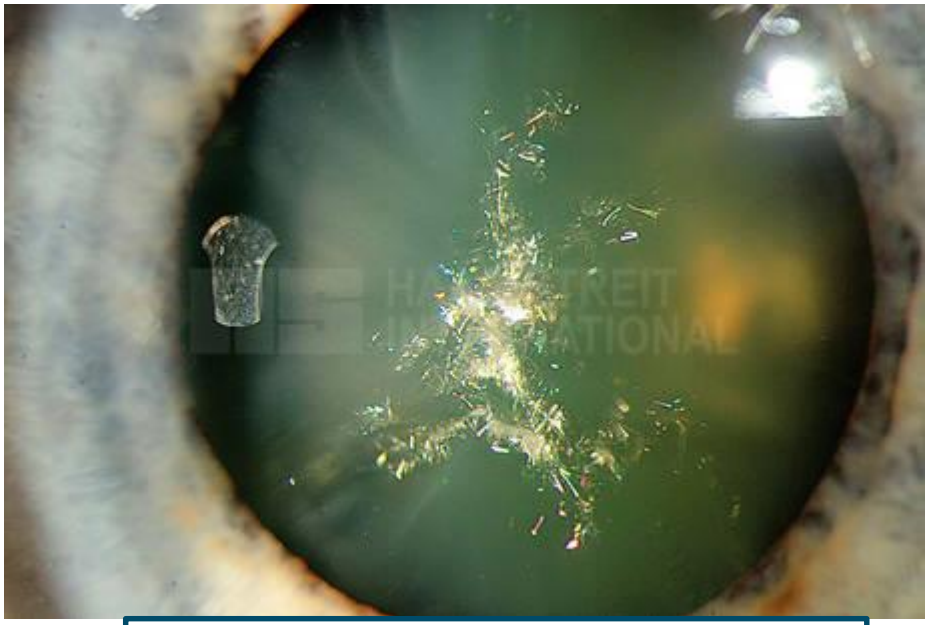
- Rare
- Younger patients
- In the axe of posterior cortex
- complaints near sight worse than far

- causes
  - trauma, corticosteroids, inflammation, ionization, alcoholism

- histologic: migration and swelling of epithelia cells under the lens capsule



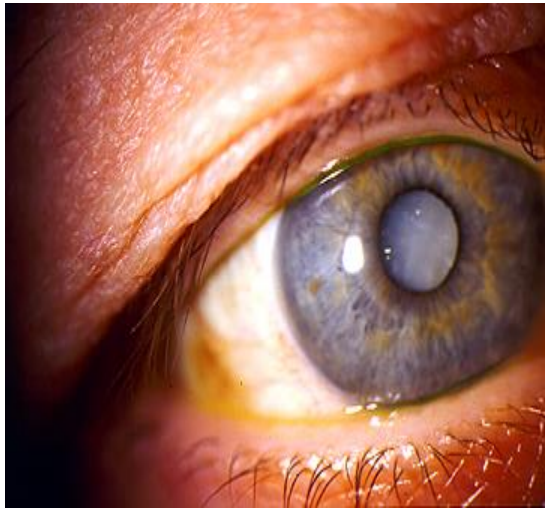
sunflower cataract
M.Wilson



christmas tree cataract
Myotone dystrofie

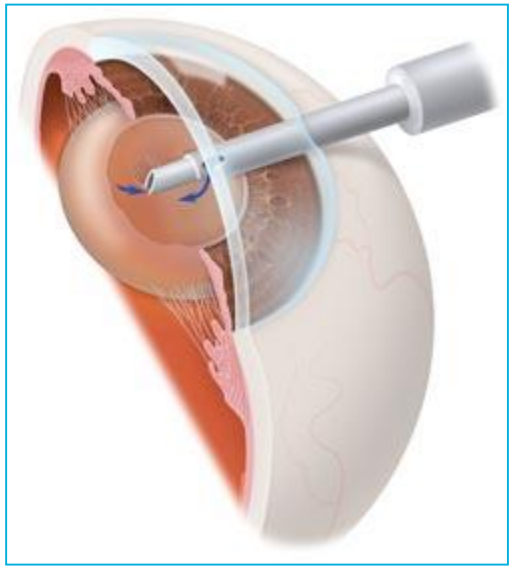
Course

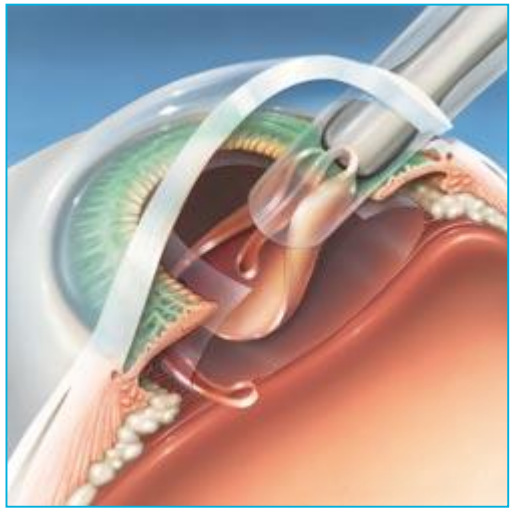
- Cataracta incipiens (visus > 0,5)
- Cataracta immatura (visus >0,3)
- Cataracta matura (visus 1/300)



Treatment of cataract

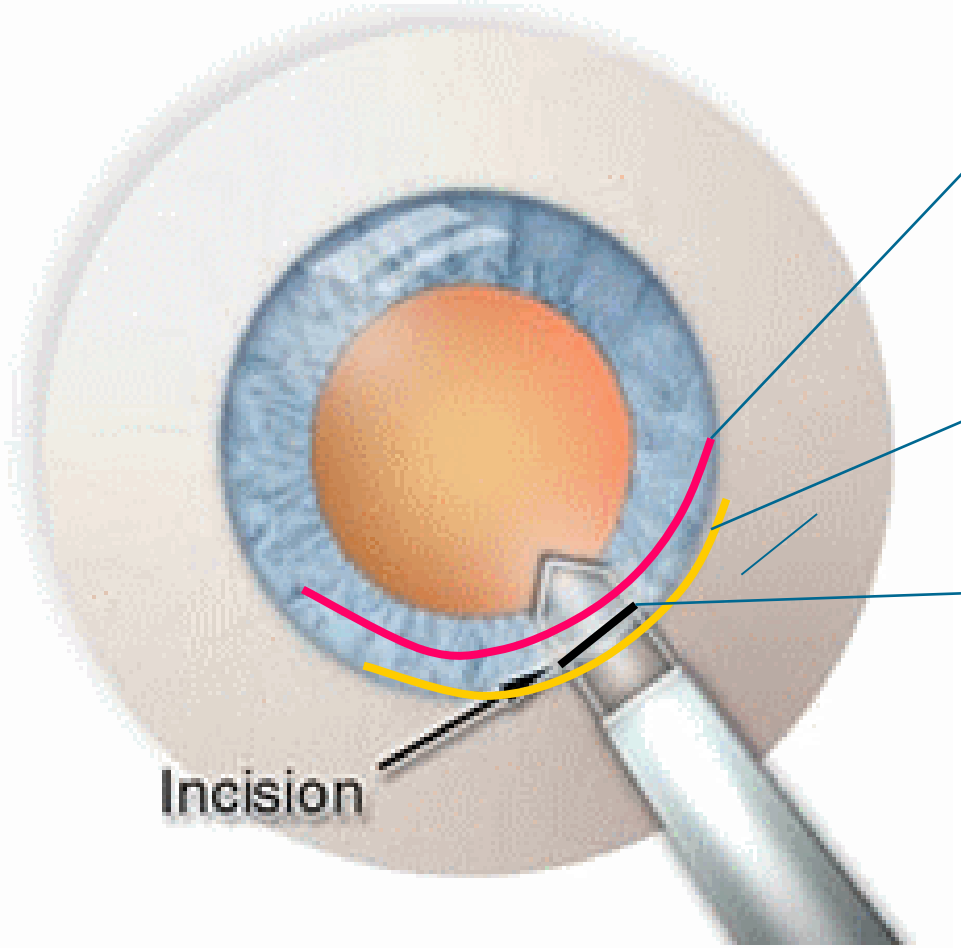
- removing cloudy eye lens and implantation of artificial lens





Progression of cataract surgery

- **intracapsular cataract surgery (ICCE):** 1960-1980
  - Lens + capsule removed
- **extracapsular cataract surgery (ECCE):** 1970-1990
  - Capsula remains intact
- **phacoemulsification**: 1990 to today
  - Emulsification of the lens with Ultrasound energy, with immediate implantation of the artificial lens
- **Femtosecond laser guided cataract surgery:** **since** 2011

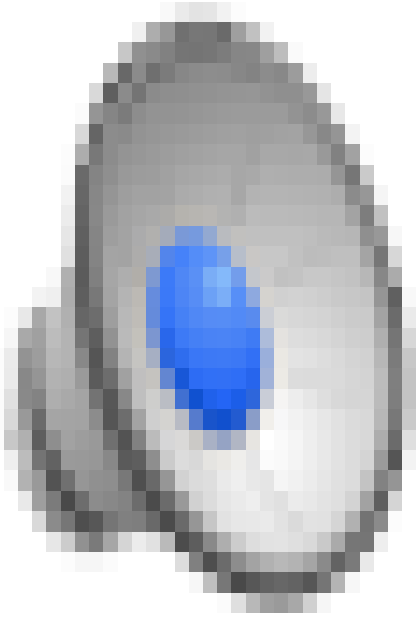


ICCE

ECCE

Phaco & femtosecond

video

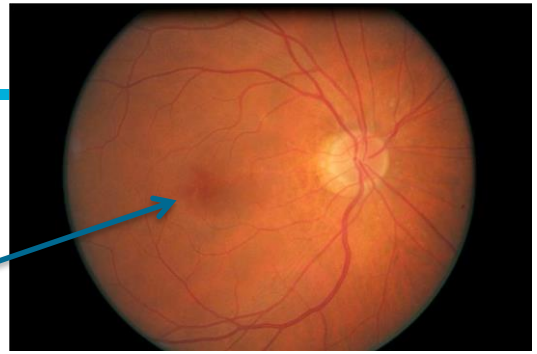


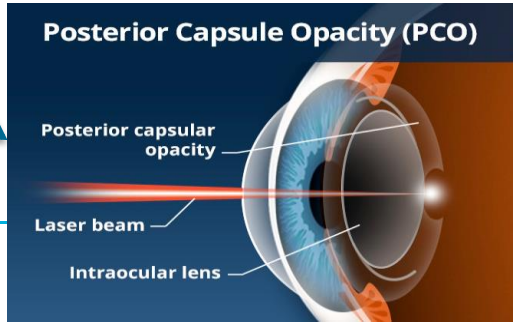
Artificial lens implantation

- Monofocal To prefer for 3 D sight!
  - One distance sharp, near or far
- Monofocal; alternated
  - One eye far, one eye near (experience neccesary)
- Multifocal
  - Both near and far sharp

Complications

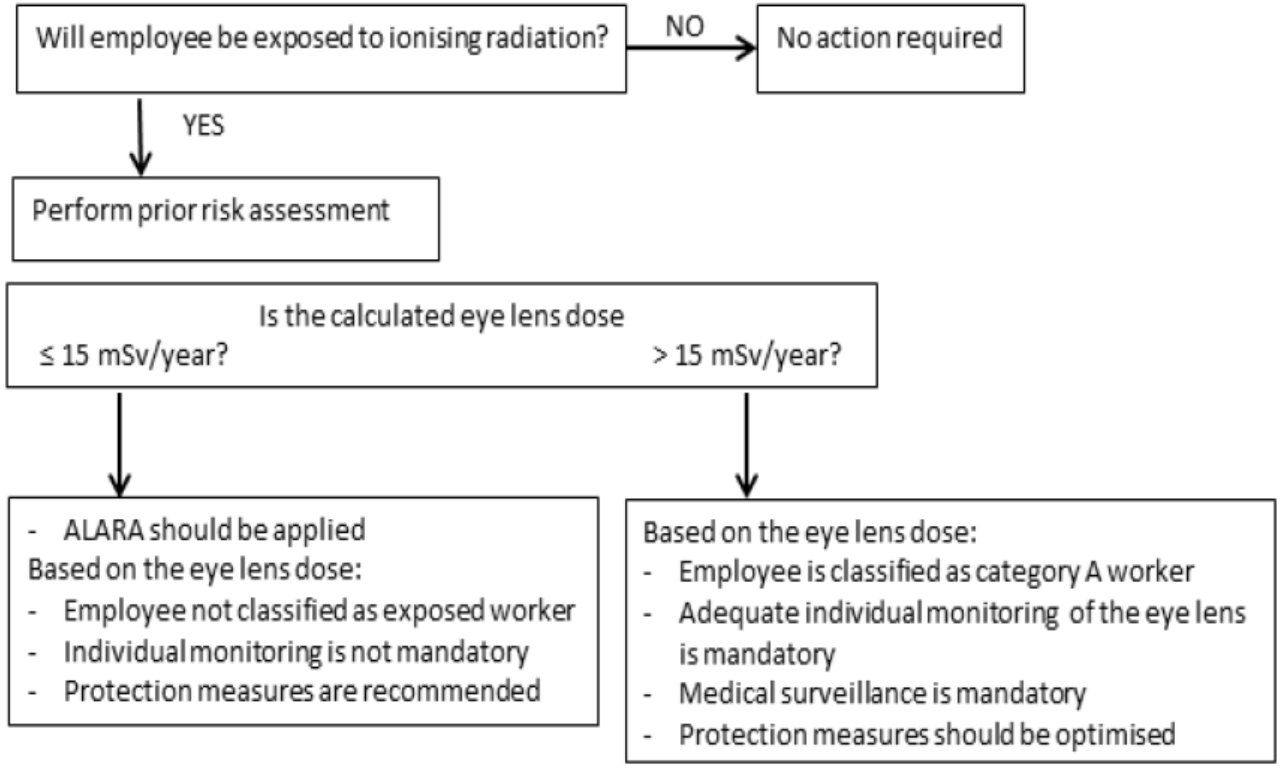
- Post operation:
  - CME(cystoid macula oedeem)
  - Endophthalmitis(0,05-0,1%)
  - Ablatio retinae on long term (1%)
  - “ Nastaar” relapse on long term (5-10%)





Medical Surveillance of the lens

The following flow chart[1] can be used:



Medical Surveillance of the lens

- The new dose limits for the eye make it necessary to re-evaluate the role of eye examination in the periodical medicals for the groups of workers that are defined with possible exposure of > 15 mSv on the eye

- Medical Surveillance is mandatory for organs at risk

Guidelines for Radiation Protection and Dosimetry of the Eye Lens

- (to be published soon, see radiationdosimetry.org)
- Workers at risk (> 15 mSv)
- Dosimetric consequences, monitoring
- Shielding personal protection
- Medical Surveillance

Workers at Risk > 15 mSv on the eyes

- The largest group of involved workers is found in
  - interventional radiology
  - Interventional cardiology.

  Incidentally:
  - workers in other fluoroscopy- guided procedures,
  - nuclear medicine,
  - veterinary practice,
  - non-destructive testing
  - isotope production

Shielding, personal protection

- Shielding No 1
- Training and instruction
- PPE

Medical Surveillance of the lens

- (possible) Goals of medical surveillance:
  - establish the state of the eye lens before exposure (entrance examination)
  - as reference to later results (zero-measurement); description of absence or existence of abnormalities
  - determine early changes in the lens as a base for consultation on individual base on exposure, measures for dose reduction,
  - establish fitness or unfitness for the job
  - determine onset of cataract, making arrangements for follow-up and/or treatment
  - check potential of the worker to carry (and cope with) the necessary personal protection equipment.

Medical Surveillance of the lens

- High incidence of “natural” occurrence of cataract makes the attributive occurrence by (chronic low dose) radiation relatively insignificant: Evidence:
  - RR of cataract from 0,5 to 5,3
  - Biggest study (Chodick): age related RR 1,18
  - No significant differences in kind of cataract (nuclear, cortical, subcapsular) -> radiation induced cataract seems not to be specific
- Restriction (for work) is lack off visual acuity
  - by stare
  - or age related other vision impairments?

Medical Surveillance of the lens

- Dutch radiation physicians:
  - Monitor vision-impairment in questionnaires
  - Give the opportunity for visual acuity measurement every 1 or 2 years (in periodical medical at occupational health service)
  - Give the opportunity for slit-lamp examination at least once in 10 years

(both in Dutch law: PAGO = mandatory offer by employer, voluntary use by employee)

Conclusions

- (small) attribution of long term low dose radiation to the development of cataract
- Precepted diminished vision and visual acuity measurement are suitable for monitoring
- Periodic slit-lamp examination can’t be denied (advice once in 10 years)